The Origin of the *Origin* Revisited

SILVAN S. SCHWEBER

*Brandeis University,*
*Waltham, Massachusetts*

... nothing exists for one cause.
- Darwin, E notebook, p. 48

It is one thing to prove that a thing has been so, & another to show how it came to be so.
- Darwin, E notebook, p. 69

INTRODUCTION

Darwin, after his return to England from his fateful voyage on the *Beagle*, took lodgings on March 7, 1837, near his brother Erasmus’s house on Great Marlborough Street in London. He remained there for nearly two years until he was married. In his *Autobiography* he calls the period from the time of his return to his marriage “the most active ones which I ever spent.”

During his residence at 36 Great Marlborough Street Darwin finished his *Journal of Researches*, read several papers before the Geological Society, began preparing the manuscript for his *Geological Observations*, and edited and arranged for publication the *Zoology of the Voyage of the “Beagle.”* The *Autobiography* also indicates that “In July [1837] I opened my first note-book for facts in relation to the *Origin of Species*, about which I had long reflected, and never ceased working on for the next twenty years.” Soon after he opened the first notebook Darwin notes in the *Autobiography*:

I soon perceived that selection was the keystone of man’s success in making useful races of animals and plants. But how selection could be applied to organisms living in a state of nature remained for some time a mystery to me.

3. Ibid., p. 83; see also entry for July in the “Journal”.

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In October 1838, that is, fifteen months after I had begun my systematic inquiry, I happened to read for amusement Malthus on Population, and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved, and unfavourable ones to be destroyed. The result of this would be the formation of new species. Here, then, I had at last got a theory by which to work.  

The Autobiography, however, does not convey the intensity and extent of Darwin's activities. His initial apprehension of the theory of natural selection was formulated in the "Pencil Outline Sheet and Draft Chapter I," the "Sketch" of 1842, and the "Essay" of 1844. To obtain a perspective on the magnitude of Darwin's remarkable research connected with "his systematic inquiry," one has to study his "Journal," the transmutation notebooks (B, C, D, and E), the notebooks on "Man, Mind and Materialism" (the M and N notebooks), and in addition the

4. Autobiography, p. 120.
5. Peter J. Vorzimmer, "An Early Darwin Manuscript: The 'Outline and Draft of 1839,'" J. Hist. Biol., 8 (1975), 191-217. The dating Vorzimmer has attributed to these manuscripts has not been accepted by all Darwin scholars. Francis Darwin in 1909, when he published the pencil "Outline," related it to the "Pencil Sketch" of 1842. R.C. Stauffer has sent me a forthcoming article which identifies the "Draft" (when completed by restoring the separated section 9) as the original unrevised Chapter I of the 1844 "Essay." Stauffer refers to these manuscripts as the "Pencil Outline Sheet" and the "Draft Chapter I." For convenience I have dubbed them "Outline and Draft." The actual date of the manuscripts is not of crucial importance in my use of this material. I thank Prof. Stauffer for this information.
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“Old and Useless Notes” (OUN), and the “Essay on Theology and Natural Selection.” It is an astounding record.

Much effort has been spent in recent years to reconstruct the process by which Darwin reached “a theory by which to work.” Particular attention has been paid to the Malthusian episode, in order to ascertain whether it constituted a major conversion or whether Darwin was in fact in possession of the essential elements earlier and the Malthusian episode was the “precipitative factor” which enabled him to mold these elements into his theory of the “natural means of selection.”

It is my thesis that by August 1838 Darwin had indeed apprehended the essential features of the evolutionary mechanism. During the week of August 7, 1838, Darwin read David Brewster’s review of Comte’s *Cours de philosophie positive* in the July 1838 issue of the *Edinburgh Review.* The review gave Darwin added confidence and impressed him with the importance of having his evolutionary theory be predictive. It gave him insight in how the dynamic stability of a system can be explained in terms of its evolutionary history. The review clarified for Darwin some methodological points, particularly the roles of prediction and hypothesis, in the formulation of a theory. It also made clearer to him the role that “artificial selection” was to play in the “argument.”

Having read the Comte review, Darwin was searching for a quantitative statement of some aspect of his theory (possibly a quantitative formulation of the superfecundity principle or a quantitative statement relating

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13. Brewster’s review appeared as an unsigned article, the July 1838 issue of the *Edinburgh Review,* 67, no. 136, pp. 271-308.

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to variations). He turned to Quetelet's *Sur l'homme* 14 and to a review of this book in the *Athenaeum*; and it was in the latter that in mid-September 1838 he came across the Malthusian thesis of population growth stated in a *quantitative, mathematical* fashion: "Population tends to increase in a geometrical ratio." He was indeed well prepared to appreciate the consequences. Reading the Malthusian statement in the Quetelet review must have crystallized various aspects of his formulation and helped fit the separate elements into a coherent whole. The result would be a theory based on natural selection, with the Malthusian principle as the *force* behind the selective process. In that sense the Malthusian statement was critical. Darwin proceeded to read Malthus's *Essay on the Principles of Population* on September 28, 1838, and there for the second time he came across Malthus's mathematical statement of population growth, which this time included a time scale: "population, when unchecked, goes on doubling itself every twenty-five years, or increases in a geometrical ratio." That transmutation followed from natural selection must have been apparent to Darwin after reading the time-independent formulation. The time scale, however, challenged some of the views he held concerning the extinction of species. The clarification of the relation of the time scale for transmutation and that for extinction to that of geological change as indicated by the fossil record took Darwin until December of 1838.

Darwin also had to grapple with the problem of how to deal with variations that were "indefinite" – that is, random and indeterminate – yet that were central elements in a theory which was to be *deterministic*.

By August 1838 Darwin had convinced himself that man was part of the evolutionary process, and he was posing questions concerning the evolution of instinct, emotions, language, and intelligence. 15 But the questions did not stop there. Darwin also was asking how one can explain sociability, the evolution of human societies and their institutions. How is their stability achieved? To the best of my knowledge the M and N notebooks contain the first presentation of an evolutionary view of society based on an evolutionary view of nature.


15. For example, the entry "Origin of man proved... He who understands baboon would do more toward metaphysics than Locke" on page 84 of the M notebook is dated August 16, 1838. See also the entries in the C notebook, pp. 76-80, which Darwin wrote in the spring of 1838.
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The members of society are deemed to have free will — and Darwin ponders how the conception of free will could have evolved. The answer he gives in the M notebook, page 72, is that "free will is to mind, what chance is to matter," with chance and matter understood in the Laplacian sense. The question therefore becomes: Given that at the phenomenological level man has free will, how does justice get established in the moral sphere and how is the stability of the social order maintained? The premise of Scottish economic thought from Adam Smith onward is that all the actors on the economic scene are free agents. Yet, there are economic laws, and it is possible to predict the consequences of certain events, such as a change in prices or a cut in wages. How does this come about? I believe there is a parallel between the role freedom of choice and free will play in Scottish economic and moral science and the role played by random variations in the theory of evolution. Both are the "chance" elements which are coupled to strongly constraining (antichance) elements to give rise to a "lawful" theory.

This is how Darwin, by August 1838, came to study, among others, Hume, Burke, Dugald Stewart and Adam Smith. It is his study of Dugald Stewart and particularly of Adam Smith which reinforced his focus on the individual as the central element and unit in his theory and led him to adopt the Scottish view of trying to understand the whole in terms of the individual parts and their interactions.

I believe that by July 1839 Darwin had a unitary evolutionary view of everything around him: the planetary system, our own planet, its geology, its climate, its living organisms and their social organizations. More important, he had convinced himself that the mechanism of this evolutionary process was accounted for by the invariable laws of physics and chemistry and the principle of natural selection, without the necessity of divine intervention at any stage or level.

The acquisition of this vision from 1837 to 1839 entailed profound religious consequences, and the M and N notebooks and the Old and Useless notes are also an account of Darwin's search for God. He did not

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16. The "Journal" for August 1838 has the following entry: "Read a good deal of various amusing books paid some attention to Metaphysical subjects." The list of "Metaphysicians" studied while Darwin was writing the M and N notebooks (from July 1838 to July 1839) is most impressive. It includes, among others, Edmund Burke, James McIntosh, Henry Lord Brougham, Dugald Stewart, Gotthold Lessing, David Hartley, Thomas Reid and David Hume. See the notes by Paul Barrett in *Darwin on Man*, pp. 297 ff., pp. 353 ff., pp. 405 ff. See also the list of "Books To Be Read" at the end of the C notebook.

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find Him, and by 1839 Darwin was certainly an agnostic (and possibly an atheist). Conversely, his gradual agnosticism affected his scientific outlook. The change in his views of the balance of nature – whether the equilibrium is static or dynamic and how this equilibrium is maintained – is coupled to his conceptions of the role of the Deity in the operation of nature. 18

This article presents the evidence to substantiate the above account. It stresses methodological issues. Through the recent work of Gruber, and particularly that of Kohn, 19 a consensus is beginning to emerge on the status of scientific issues as of August 1838. This consensus is essentially my point of departure on the scientific questions. The stress on the metascientific issues stems from my conviction that Darwin was very much aware that methodological questions would be very important in convincing his scientific audience, particularly Lyell, who at that time would be the first to judge the scientific merit of his theory. Section 1 deals with the background to August 1838. Sections 2 and 3 deal with the Brewster review and its impact on Darwin. Section 4 presents Darwin's conception of chance and probability. Sections 5 and 6 relate Darwin to Adam Smith, Quetelet, and Malthus. Section 7 presents the synthesis. Section 8 focuses on the transformation of Darwin's religious thought during this crucial period. Section 9 speculates briefly on the relevance of my findings when trying to answer the question: Why did Darwin delay publishing his theory of evolution?

1. THE BACKGROUND

When Darwin opened his transmutation notebooks he was a convinced evolutionist and no longer believed in the fixity of species. By July 1837 he recognized the importance of variations: that variations were heritable ("with no tendency to go back") and that variations could be "indefinite," that is, unlimited in extent. This is attested by his marginal annotations to his copy of the fifth edition of Lyell's Principles of Geology, which he read in 1837 20 or early 1838. That variations result

18. That Darwin's changing attitude toward the balance of nature is important in understanding Darwin's genesis of his theory of the "natural means of selection" was first stressed by Limoges, La sélection naturelle.
19. Kohn, "Charles Darwin's Path to Natural Selection."
from sexual reproduction is noted in the first pages of the first notebook on transmutation. By July 1837, what Darwin then called his theory consisted of the hypotheses that variations were the direct response to environment and that isolation can protect variation, resulting in the offspring differing from the original population.21 In this theory variations enable organisms to adapt. To remain adapted in a slowly changing environment, species must change. It was adaptation which originally suggested to Darwin the notion of transmutation of species.

The transformation of Darwin’s “theory” of July 1837 to that he advocated about a year later is traced in the introductions Gavin de Beer wrote to his articles on the transmutation notebooks, in Limoges’s La sélection naturelle, in Gruber and Barrett’s Darwin on Man, and in E. David Kohn’s dissertation “Charles Darwin’s Path to Natural Selection.”22 From July 1837 to July 1938 Darwin’s conception of heritable variations altered in a fundamental way. In July 1837, such variations were adaptive and postulated to have an inherent direction toward progress. By July 1838 variations were accepted as a phenomenological fact. They are not necessarily adaptive: some variations may be useful and thus favor the organism’s chance of survival, others may be harmful or neutral.23 By July 1838 Darwin recognized that the ubiquity of variations was insufficient to account for evolution; selection would have to be added. Thus already in the spring of 1838, Darwin noted: “If varieties produced by slow causes, without picking become more and more impressed in blood with time, then generations will only produce an offspring capable of producing such as itself” (C, 34). (Recall that in the notebooks Darwin often refers to the process of “selecting” by the term “picking.”)

21. B, p. 17: “As I have before said isolate species, <& give even less change> especially with some change, probably <change> vary quicker.” The date of the entry is July 1837.

In the transcriptions the symbols used are the ones adopted by Barrett and Gruber. Darwin on Man, p. xxii: /a few words inserted by Darwin/; <crossed out by Darwin>; [Darwin’s own brackets]ed; 1 = end of MS page; e = part of MS excised.

22. De Beer, ed., “Darwin’s Notebooks on Transmutation of Species,” “Addenda and Corrigenda,” and “Pages Excised by Darwin,” Limoges, La sélection naturelle; Gruber and Barrett, Darwin on Man; and Kohn, “Charles Darwin’s Path to Natural Selection.”

From the fall of 1837 to the fall of 1838, Darwin constantly searched for the causes of heritable variations. He evidently believed that the elucidation of these factors would be the essential feature of a theory to account for the mechanism of evolution. A search for causes led Darwin to a study of hybridization and to his investigations of the breeding of plants and animals under domestication. The latter, in turn, suggested to him the analogy between artificial and natural selection. By mid-1838 Darwin had in fact appreciated a limited concept of natural selection from reading Sebright's and Wilkins's pamphlets on animal breeding. As perceived by Sebright, artificial selection acts analogously to "Nature's broom" by eliminating inferior variations.

Sometime in March or April of 1838, Darwin began investigating the possibility that functional changes might precede and induce structural changes, that is, that habits acquired in the life of the individual might be transformed into heritable changes in structures. By July of 1838 his interest in this subject had grown to the point that he started a new notebook. This notebook received his ideas and notes on his readings concerning the inheritance of habits and other characteristics acquired during the life of an individual. These notes grew into the M and N notebooks, containing Darwin's entries on behavior, memory, emotions, and thinking. They are the basis for his later work on the origin of instinct and emotion in the Origin, the Descent, and the Expression of Emotions in Man and Animals.

By the end of August 1838 Darwin had apprehended the separate components of what was to become his theory of evolutionary change: He recognized the ubiquity of variations, their heritability and irreversibility ("What has long been in blood will remain in blood," D, 13), their nondirectedness, and their copiousness; and he believed that they were unlimited. The analogy from breeders' use of selection in domesticated production had given him a notion of natural selection.

24. E.g., B, p. 123: "Race permanent, because every trifle hereditary, without some cause of change; yet such causes are most obscure without doubt."
25. Thus the entry on B, p. 227, written in January 1838, reads "With belief of \textit{change} transmutation & geographical grouping we are led to endeavor to discover \textit{causes of change}, - the manner of adaptation (wish of parent??) instinct & structure become full of speculation & line of observation."
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He was aware of the struggle for existence, as attested by the entry in February 1838 on page 61 of the C notebook:

Whether species may not be made by a little more vigour being given to the chance offspring who have any slight peculiarity of structure, hence seals take victorious seals, hence deer victorious deer, hence males armed & pugnacious all order; cocks all war like; . . .

and on page 73 of the C notebook:

Study the wars of organic being. – The fact of guavas having overrun Tahiti, thistle Pampas show how nicely things adapted.28

Darwin also appreciated the prodigious fertility of animals and plants (“superfecundity”),29 as indicated by the entry on page 143 of the C notebook:

When one reads in Ehrenberg’s paper on infusoria on the enormous production – millions in a few days – one doubt that one animal can really produce so great an effect.

The question therefore arises: “What did Darwin get from Malthus?” In his introduction to Darwin’s third transmutation notebook (D), Sir Gavin de Beer stated that Darwin had no need of Mathus in arriving at the notion of natural selection: “It seems it was the mathematical

28. Note that these entries suggest that Darwin may already in early 1838 (C, p. 61) have appreciated the fact that only intraspecific competition led to evolution. In the example cited (C, p. 73,) interspecific struggle resulted in local extinction.

29. Recall that Paley in his *Natural Theology*, in chap. 26, sect. 3, discusses superfecundity as follows:

“But to do justice to the question, the system of animal destruction ought always to be considered in strict connexion with another property of animal nature, viz. Superfecundity . . . In almost all cases, nature produces her supplies with profusion. A single cod-fish spawns in one season, a greater number of eggs, than all the inhabitants of England amount to. A thousand other instances of prolific generation might be stated, which, though not equal to this, would carry on the increase of the species with a rapidity with outruns calculations, and to an immeasurable extent . . . But then this superfecundity though of great occasional use and importance, exceeds the ordinary capacity of nature to receive or support its progeny. All superabundance supposes destruction, or must destroy itself. Perhaps there is no species of terrestrial animals whatever, which would not overrun the earth, if it were permitted to multiply in perfect safety..., if any single species were left to their natural increase without disturbance or restraint, the food of other species would be exhausted by their maintainance. It is necessary, therefore, that the effects of such prolific faculties be curtailed.”

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demonstration of the insufficiency of food supplies if number increased too fast, and the consequent inevitableness of the penalties, that Darwin derived from Malthus' work, not the principle of selection itself. In introducing the fourth notebook (E), de Beer added: "What Malthus gave Darwin was evidence of the rigorousness of selection and of the inevitableness of widespread mortality." 30 These conclusions were based de Beer's attribution of the passage in the D notebook, page 175, reading "All this agrees well with my views of those slightly favoured getting the upper hand & forming species" to a date before Darwin had read Malthus. It has, however, been suggested that this passage was probably entered on September 29. 31 De Beer nonetheless remained steadfast in his beliefs. In his 1965 biography of Darwin, he suggested that the insight Darwin obtained from Malthus was the realization that the high rate of mortality exacted by nature resulted in selection pressure, and "while Malthus argued that this pressure was exerted against the poor member of the human race, Darwin applied the principle to plants and animals and argued that the pressure was exerted against the less well adapted." 32 Eisely suggests that perhaps "Darwin really received only an increased growth of confidence in his previously perceived idea through reading the Malthusian essay", 33 Eisely also believes that Darwin was struck by Malthus's mathematical approach. Toulmin and Goodfield expressed the opinion that "Darwin did not learn anything new from Malthus." 34 Gruber's interpretation is that reading Malthus led Darwin to recognize that "although [natural selection] might work against maladaptive variants, it could also work in favor of occasional variants which were better adapted than their ancestors to the prevailing conditions under which they must survive." 35 Limoges believes that

"Ce qu’aurait fourni Malthus à Darwin, ce n’est pas l’idée d’une lutte pour l’existence, alter commune. Mais plutôt l’idée de l’intensité de cette lutte, de son pouvoir contraignant sur les vivants, l’idée de progression à raison géométrique impliquant qu’une « pression»

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constant s'exerce sur les vivants, engendrant nécessairement entre eux une querre incessante, forme ancestrale de la *population pressure* de l'actuelle génétique des populations. Cela et rien rien de plus.\(^{36}\)

The views expressed by Gavin de Beer and Limoges are the ones which most closely approximate my own, and I believe my findings further corroborate them. I do not, however, agree with the second half of Limoges's further statement: "Si le rôle joué par Malthus dans la constitution de la théorie darwinienne est indubitable, il n'en est pas moins probablement fortuit." As I hope to show, there was nothing fortuitous about Darwin's coming to Malthus. In later sections I shall comment on yet other views, particularly those of Herbert and Kohn.

One of the difficulties to be faced by any interpretation is the fact that the entries in the notebooks written after the Malthusian insight, in particular those in the E notebooks, do not differ markedly from entries written before October 1838. Clearly, Darwin was still not satisfied. He continued working on the species problem and related issues for another half year, his efforts culminating sometime in the summer of 1839 with the closing of the various notebooks. The longer "Sketch" of 1842 only came three years later, and the "Essay" was written in 1844.

To explain these facts, it is usually argued that Darwin believed that for a theory of evolution to be truly explanatory, it must include an account of the causes of variations. But his search for causes of variations proved rather unproductive. His inability to advance a satisfactory explanation for the observed variations was one of the reasons for the long delay in publishing his work on evolution and natural selection.

Darwin's final accomplishment is the more remarkable in that he was able to construct a theory of evolution in which heredity and variation appeared as phenomenological facts, that is, unexplained premises, and in which the doctrine of natural selection was open to question.\(^{37}\) Its eventual success is a testament to his supreme powers as an observer and documenter of natural phenomena. Darwin was clearly aware of the vulnerability of his theory as long as the causes of variations and the mechanism of heredity were not accounted for. This lack placed a much

\(^{36}\) Limoges, *La sélection naturelle*, p. 79.

greater responsibility for the acceptability of his evolutionary theory on his ability to marshal the evidence that evolution had in fact occurred. The first edition of the *Origin* undoubtedly convinced his audience as to the fact of evolution. It was Darwin's view of natural selection as the driving force toward adaptation, as the agent of the dynamic change observed in nature, which aroused the opposition of the more perceptive of his scientific critics. For Darwin's mechanism entailed a rejection of final causes and any concepts of inherent progress. It implied a commitment to a materialistic explanation which denied to living organisms an ontological status different from that of inanimate objects. The originality and importance of Darwin's work was perhaps most succinctly stated by Helmholtz: "Darwin's theory contains an essentially new creative thought. It shows how adaptability of structure in organisms can result from a blind rule of a law of nature without any intervention of intelligence." I shall not be concerned with Darwin's vacillations as to the causes of variations nor with his doubts as to the sufficiency of natural selection subsequent to the publication of the *Origin* in 1859. I shall also not be concerned with his unsuccessful attempts to advance a satisfactory hereditary mechanism. I will primarily be concerned with Darwin's synthesis of an evolutionary theory as outlined in the transmutation notebooks and in the thirteen-page "Draft," and more peripherally with the "Sketch" of 1842, the "Essay" of 1844, his *Natural Selection*, and the first edition of the *Origin*. It is my contention that the process was in fact more complex and ever richer than has been indicated up to now. However, I hope to show that the weaving together of the various strands which Darwin investigated from July 1838 to July 1839 results in a presentation which not only clarifies the process, but also sheds further light on the end product: the theory itself.

2. BREWSTER'S REVIEW OF COMTE'S COURS DE PHILOSOPHIE POSITIVE

Between August 7 and August 12, 1838, Darwin read the review of Comte's *Cours de philosophie positive* which had appeared in the July 1838 issue of the *Edinburgh Review*. The review made a deep impression on Darwin. Although some of the M notebook pages (pp. 65 to 68) containing his notes on this review are missing, there are enough subsequent entries to give an account of the impact of the article. Thus in the entry for August 12, on page 81 of his M notebooks, Darwin writes that while at the Athenæum Club he:

was very much struck with intense an headache/after good days work/ which came on from reading (review of) M. Comte Phil which made/ endeavor to/remember & think deeply

In a letter to Lyell on September 13, 1838, Darwin writes:

By the way, have you read the article, in the "Edinburgh Review" on M. Comte "Cours de la Philosophie" (or some such title)? It is capital; there are some fine sentences about the very essence of science being prediction, which reminded me of "its law being progress."41

When one reads the entries in the M, N, and OUN notebooks in which Darwin mentions Comte, it becomes obvious that the Comtian view of the three stages of development of civilization resonates with Darwin's own view of God's place in the operation of nature: "M. le Comte argues against all contrivance - it is what my views tend to" (M notebook, p. 70, written between August 7 and 12, 1838).

Similarly, on page 12 of the N notebook, entered sometime between October 4 and 8, 1838, Darwin notes:

41. *The Life and Letters of Charles Darwin*, ed. F. Darwin (New York: Appleton, 1896), p. 266. Interestingly, the reference to Comte comes after the sentence "but the past is nothing and the future everything to us geologists, as you show in your capital motto to the 'Elements.'" The motto's origin is an article of Macaulay on Bacon which appeared in the *Edinburgh Review* in 1837: "It is a philosophy which never rests. Its law is progress; a point which was invisible yesterday is its goal today, and will be the starting-post tomorrow." Lyell in a letter to his father in November 1837 indicates it occurred to him to have "this passage as a motto for my 'Elements of Geology' at a supper party at the Milmans attended by among others Mr. and Mrs. Senior, Mr. Whewell, Mr. Rogers and Mr. Rich, M.P." See *Life, Letters, and Journal of Sir Charles Lyell*, ed. Mrs. Lyell (London: John Murray, 1881), p. 33.
M. le Comte's idea of theological state of science, grand idea: as before having analogy to guide one to conclusion that any fact was connected with law – as soon as any inquiry commenced, for instance probably such a thing as thunder would be placed to the will of God. – Zoology itself is now purely theological.42

The same view is expressed in previous entries in the M notebook, page 69. In fact, Darwin had for some time already been concerned with freeing natural phenomena from anthropomorphic interpretation. Thus on page 101 of the B notebook, written sometime before January 38, there occurs the famous entry:

Astronomers might formerly have said that God ordered each planet to move in its particular destiny. – In same manner God orders each animal created with certain form in certain country, but how much more simple, & sublime power let attraction act according to certain law such are inevitable consequences let animals be created, then by the fixed laws of generation, such will be their successors.

Let the powers of transportal be such & so will be the forms of one country to another. – let geological changes go at such a rate so will be the number & distribution of the species!!

In the M, N, and OUN notebooks the other association that Darwin has with Comte is the relation between free will and chance – “free will is to mind, what chance is to matter/ M. le Compte” (M, pp. 72-73; see also OUN, p. 25) – a relation I shall analyze in detail in section 4.

The review was written by Sir David Brewster, the distinguished Scottish “natural philosopher” whose research had primarily been concerned with optical phenomena.43 Being an outstanding Scotsman, Brewster was a “man o’ parts,” that is, a man of wide-ranging interests and abilities, as evidenced by his encyclopedia articles, his biography of

42. The way Darwin spells Comte’s name is very revealing. The first reference on p. 69 of the M notebook is to Mr. le Comte (italics mine). His indebtedness to Comte in the entry associating free will and chance, on p. 72 of the M notebook, brings forth the spelling Mr. Le Compte (italics mine). Darwin knew French. See in this connection the dream he later records in the N notebook, p. 33. The aristocratic appellation “M. le Comte” and the spelling “Compte” are noteworthy.

Newton, and his numerous reviews in the North British Review, the Edinburgh Review, and elsewhere on a wide spectrum of subjects. He was also deeply religious. Educated at the University of Edinburgh during the 1790's, Brewster was thoroughly acquainted with the Scottish common sense philosophies of Reid, Beattie, and Stewart and was "sympathetic to many if not all the principal tenets of Common Sense methodology as expressed by Dugald Stewart."

Brewster, together with Herschel and Babbage, was one of the first to warn Britain in 1830 of the consequences of neglecting science and the education of scientists. He played a very influential role in the formation of the British Association for the Advancement of Science (BAAS) in 1831. He became deeply involved in the reform of the Scottish universities and in the controversy over whether they should remain places of general education or be remodeled on the Cambridge pattern. The full import of Brewster's review of Comte and his more famous and biting review of Whewell's History of the Inductive Sciences in an earlier issue of the Edinburgh Review can only be appreciated within the context of these "tensions which in the years 1830-58 vexed the academic scene in Scotland." These battles pitted Brewster and William Hamilton against J. D. Forbes, the Edinburgh professor of physics who (at least until 1838) was a protégé of Whewell.

It is not clear whether Darwin was aware of the specific tensions


50. See Davie, The Democratic Intellect, chap. 8.
which lurked behind the Comte review. It is likely that he had read the earlier Brewster review of Whewell’s *History* and had appreciated the reviewer’s hurt pride at Whewell’s assessment of the Scottish contribution to science. Darwin had, after all, attended Edinburgh University. His letter to Lyell of September 1838 suggests that he did not know or attempt to find out the identity of the reviewer. He was at the time deeply immersed in the problem of Glen Roy and his species work. The impact of the review can only be gauged from a straightforward reading of it.

Since it is my contention that the review played a central role in the evolution of Darwin’s theorizing, I shall now outline its content. After some general remarks and a comparison of Comte’s work with Whewell’s *History* (they “stand strongly opposed to each other”), Brewster feels obliged to warn the reader that Comte “avows himself an atheist.” To remove this stumbling block, and “to deprive it of all its danger,” Brewster presents Comte’s observation that all real science stands in radical and necessary opposition to all theology; and this character is more strongly indicated in astronomy than in any other; precisely because astronomy is so to speak more a science than any other . . . No science has given such terrible blows to the doctrine of final causes . . . the indispensible basis of all religious systems.

To support these arguments (which Brewster calls “feeble and innocuous”), Comte refers to the stability of the solar system. Brewster quotes Comte’s argument that the existing arrangement of the solar system, which is

51. One would have expected a rather critical review from Brewster. It is somewhat ironical that Brewster’s antipathy to Whewell should have produced a review on the whole favorable to Comte. Bain, in his book on J. S. Mill, states: ‘Brewster found with joy a number of observations on Hypothesis and other points, that he could turn against Whewell; and the effect was, I have no doubt, to soften the adverse criticisms.” Alexander Bain, *John Stuart Mill: A Criticism* (London: Longmans, Green & Co., 1882), p. 70. The intense dislike that Brewster and Whewell had for one another lasted their lifetime. In the 1850s their final public confrontation was over the issue of the plurality of worlds.

52. Two of the entries in Darwin’s “Journal” for the summer of 1838 read as follows: “August 1st London. Began paper on Glen Roy and finished it. Sept. 6th Finished paper on Glen Roy, one of the most difficult instructive tasks I was ever employed on.” See also N, p. 90.

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so essential to the continuous existence of animal species, is a simple necessary consequence (from the mechanical laws of the world) of certain characteristic circumstances of our solar system; – the extreme smallness of the planetary masses in comparison to the central mass, the slight eccentricity of their orbits, and the moderate mutual inclinations of their planes – characters which in their turn may, with much probability, as I shall afterward show, according to the indication of Laplace be derived naturally from the mode of formation of the system.

Brewster comments:

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.

Nonetheless, Brewster continues, this speculation

> does not, when properly viewed, afford the smallest aid to those who are desirous of finding any substitute for the agency of an all-directing mind.

For even if one permits Comte to take the cosmogony of Laplace as the basis of his argument and verifies the conclusion that the stability of the solar system is the *necessary* consequence of this mode of formation,

> the argument for design remains unshaken, and the mind still turns itself to the great first cause . . . The Cosmology of Laplace, even if admitted as a physical truth, would only carry us back to an earlier epoch in the history of creation and exhibit to us the wonders of Divine power.

After congratulating England on possessing “institutions which prevent opinions like his [Comte's] from poisoning the springs of moral and religious instructions,” Brewster proceeds to give an outline of the two volumes of Comte's *Philosophie positive*. Quoting at length Comte's law of the three stages of the development of knowledge,
Brewster has “no hesitation in admitting its general accuracy.” He quotes Comte on the nature of positive philosophy:

The fundamental character of *Positive Philosophy* is to regard all phenomena as subjected to invariable natural laws, the precise discovery of which, and their reduction to the least possible number, are the object of all our researches, regarding as senseless and absolutely inaccessible the inquiry into what are called *causes*.

Brewster then gives Comte’s justification for this view, based on the Newtonian law of gravitation and Fourier’s laws of “thermological phenomena”: one does not inquire into “the intimate nature” of gravitation or of heat in the formulation of these most important and precise laws.

Having indicated the character of positive philosophy, Brewster outlines Comte’s assessment of “the degree of progress which it has made” and “the steps which are yet necessary for its establishment.”

Astronomy, terrestrial physics, chemistry, and physiology have been, according to Comte, reduced to positive theories. Social physics, however, has not yet acquired any positive character. Brewster notes that the intent of the *Cours* is to give a course in positive philosophy, not a course in positive Science, and he proceeds to present Comte’s view of the hierarchy of the positive sciences, an arrangement. Brewster explains, made “in reference to their mutual dependence.” Brewster then outlines the Comtian arrangement of the six fundamental sciences: mathematics, astronomy, physics, chemistry, physiology and social physics.

The Comtian notions regarding *theoretical* and *practical* knowledge are briefly presented, and Brewster concurs with Comte’s statement: “The whole history of science has established the incontrovertible fact that speculations the most abstract often lead, in the course of time, to practical results of high value.”

Brewster then proceeds to give a “brief and imperfect notice” of Comte’s views of mathematics, and in particular the applicability of mathematics to the phenomena subsumed under the sciences.53 To explain the reason that mathematical analysis has not been applicable to

53. The nature of mathematics and its relation to the various sciences was one of the central concerns of the Scottish Common Sense philosophers. On these matters Brewster and the traditional Scottish educational philosophy differed sharply from Whewell and the newer Cambridge mathematics curriculum. See Davie, *The Democratic Intellect*, and Olson, *Scottish Philosophy*.
complex phenomena, such as those encountered in meteorology and physiology, Brewster quotes Comte:

It cannot be doubted that each of the numerous agents which concur in the production of these phenomena, follow separately mathematical laws, though we are still ignorant of the greater number of them: but their multiplicity renders the observed effects as irregular in their variations, as if each cause had not been subject to any precise condition.

Brewster continues:

But not only are we often unable to obtain fixed numerical results, even in the most special cases – the phenomena are often so complicated that even when we shall have discovered the mathematical law, which each agent separately obeys, the corresponding problem may become absolutely insoluble, when a great number of conditions require to be combined.

An outline of Comte's view of astronomy is then presented, and an explanation of why Comte believes that astronomy ought to be placed at the head of the sciences follows. In this discussion Brewster quotes Comte:

Our art of observing consists, in general, of three different methods. 1. Observation, properly so-called; that is the direct examination of a phenomenon such as it naturally appears to us; 2. Experiment, or the contemplation of a phenomenon more or less modified by artificial circumstances, which we express purposely of examination; and 3. Comparison, or the gradual comparison of a series of analogous cases, in which the phenomenon is more and more simplified. The science of organized bodies which studies phenomena of the most difficult access, is also the one which really permits us to employ all these three methods of research.

In astronomy direct observation is "the least significative" and "the reasoning part is incomparably the greatest." Astronomical phenomena are "for the most part essentially constructed by our understanding." Hence, because of the perfection of its scientific character and the "prepondering importance of the laws which it unveils," astronomy is justly entitled to be placed at the head of the sciences. Brewster
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emphasizes Comte's "fundamental axiom that all science has for its object prediction - by which it is distinguished from simple erudition." After a summary of Comte's "impressive exposition of gravitational phenomena and astronomy," Brewster proceeds to Comte's exposition of what is known about double stars. Comte's summary is then contrasted to Whewell's presentation in the History of the Inductive Sciences. Whewell's account is labeled "vague in its conception as well as incorrect in its statement." Thereafter, Brewster outlines Comte's account of the cosmogony of Laplace and his explanation by the agency of heat and gravity, the general circumstances which characterise the constitution of our solar system; namely the identity in the direction of all the annual and diurnal motions of the planets and their satellites from west to east; the small eccentricity of their orbit, and the slight deviation of their planes compared with that of the solar equator.

Brewster comments that this ingenious hypothesis affords a rational explanation of all the general phenomena exhibited in the solar system... and as our author [Comte] has for the first time remarked, it follows from the hypothesis, that the creation of the different parts of the solar system has been necessarily successive; those planets being the most ancient which are furthest from the sun.

Brewster then summarizes Comte's "bold attempt to give real mathematical consistency to the comogony" of Laplace. "In order to do this," Brewster notes that Comte "tried to discover an aspect in which it would admit some numerical verification - an indispensable criterion... of every hypothesis relative to astronomical phenomena." Brewster then outlines Comte's deductions and their verification, together with Comte's arguments regarding the present stability of the solar system and Comte's cyclic view of the evolution of the solar system. He concludes that

These views of the origin and destiny of the various systems of the world... break upon the mind with all the interest of novelty and the brightness of truth. Appealing to our imagination by their grandeur, and to our reason by the severe principle of science on which they rest, the mind feels as if a revelation had been vouchsafed to it of the past and future history of the universe.

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The review continues with Comte's views on the physical sciences, again emphasizing "the ultimate object of physical theories is to *predict, as exactly as possible all the phenomena which a body will present when placed in any given circumstances.*" Brewster also emphasizes Comte's philosophical law: "*that in proportion as phenomena become more complicated, they are capable of being examined under a great number of relations.*" He continues:

In astronomy, our art of observing is limited to the use of the single sense of sight; but in physics all our senses may be employed to discover and compare the properties of bodies. Even with these power auxiliaries, however, we should make but little progress in physical research, if we did not possess another powerful instrument of investigation. This instrument is *experiment*, by means of which we observe bodies out of their natural state; by placing them in artificial aspects and conditions contrived for the purpose of exhibiting to us, under the most favourable circumstances, their phenomena and their properties.

Brewster thereafter lets Comte speak for himself:

After the rational use of experimental methods, the principal basis for the improvement of physics arises from the more or less complete application of mathematical analysis . . . The fixity and simplicity of physical phenomena, ought naturally to permit an extensive application of the mathematical instrument . . . This application may be direct or indirect. The first takes place when the immediate consideration of phenomena allows us to recognize in them a fundamental numerical law which becomes the basis of a series . . . of analytical conclusions.

In the direct application mathematics is introduced "*after the phenomena have been first brought by experimental inquiry to some geometrical or mechanical law.*"

Brewster then states Comte's views on the place of physics in the hierarchy of the sciences, and outlines Comte's views on the rational formation and true use of hypotheses. He notes with approval Comte's view that both induction and deduction would prove insufficient even in the simplest of phenomena were one not often to anticipate the results by making "*some provisional supposition*, at first essentially conjectural, with respect to some of the notions which constitute the final object
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of research. Hence, [says Comte], the introduction of hypotheses into natural philosophy is strictly indispensible... and he pronounces, those hypotheses only to be scientific which bear exclusively on the laws of phenomena, and never on their modes of production."

Brewster, however, takes exception to this last statement, which he "cannot admit without great modification."

3. THE IMPACT OF THE BREWSTER REVIEW ON DARWIN

I have already noted the psychological impact that reading the Comte review had on Darwin. The crucial pages 65 to 68 in the M notebook dating from the time of his reading the review are unfortunately no longer extant. It is well known that usually Darwin used the missing pages for other manuscripts.54 Nonetheless, I believe Darwin expressed the highest compliment that one thinker can extend to another by suppressing his indebtedness to Comte. In Darwin's defense, it should be noted that expressing an intellectual debt to Comte after 1845 would only have been one more cross for Darwin to bear.55

54. I conjecture that they were used when he drafted his Variation of Animals and Plants under Domestication in 1867 (see the end of the present section). He very probably referred to these pages when he wrote to Lyell in 1861 (see end of section 9 and n. 191).

55. In section 9, I note Herschel's sharp attack on Comte in his BAAS presidential speech at Cambridge in June 1845. Whewell in the introduction to the first edition of his Philosophy of the Inductive Sciences, published in 1840, refers specifically on page xi to Brewster's review of Comte's Philosophie positive and notes "the reviewer's extreme laxity and obscurity of view with regard to the nature of science... defects which make his judgment on such subjects nearly worthless." In book XI, chapter VIII, and book XIII, chapt. IV, Whewell "discusses and confutes" some of Comte's leading doctrines. In his preface to the second edition, published in 1847, Whewell notes that "more than one of my critics had expressed an opinion that... I had not given due attention to the Cours de Philosophie Positive of M. Comte." In order to show that at the time of the publication of the first edition he had not "lightly passed over those of M. Comte's work which had then appeared," Whewell includes in the second edition "an additional portion of the work which, though I had written, I excluded from the former edition." This constitutes book XII, chap. XVI, of the second edition and is an extended "confutation" of Comte's view on "causes," his law of the three stages, and Comte's claim of priority to the insight that the introduction of hypothesis into natural philosophy is strictly indispensable. For some reaction to the later Comte by influential members of the scientific community, see Whewell's article "Comte and Positivism," in MacMillan's Magazine of March 1866, and particularly Huxley's scathing 1869 Fortnightly Review article entitled "The Scientific Aspects of Positivism." Darwin's reaction to the Huxley review is worth noting. On July 24, 1868, Darwin wrote Hooker: "You must read Huxley v. Comte; he never wrote anything so clever before, and has smashed everybody right and left in grand style. I had a vague wish to read Comte, - and so had George, but he has entirely cured us of any such vain wish." More Letters of Charles Darwin, ed. F. Darwin and A.C. Seward ed. (New...
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The impact of the review on Darwin's scientific work can be gauged from entries in the transmutation notebooks dating from after August 12 and from his subsequent writing on natural selection. Here I will first adduce some general evidence, then evidence with respect to Darwin's thinking on natural and "artificial" selection. I then turn to more general methodological questions.

The review, with its emphasis on the cosmogony of Laplace and Comte's calculations of the periods of the planets, presented Darwin with a model of a predictive evolutionary theory in the natural sciences. The facts which Comte was attempting to explain - the identity in the direction of all annual and diurnal motions of the planets and their satellites, the small eccentricities of the orbits, and the near coincidence of the plane of their orbits with the equatorial plane of the sun - were precisely the ones which Whewell had advanced in his *Bridgewater Treatises* as evidence of design. Darwin was well acquainted with them.57

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57. Some of these facts are also discussed in chap. 12 of Paley's *Natural Theology*, entitled *Astronomy*. The material is, however, not stressed because in Paley's opinion: "Astronomy. . . is not the best medium through which to prove the agency of an intelligent Creator." The presentation is also dated: Buffon's nebular hypothesis is referred to, but no mention is made of Laplace's work on this subject. Incidentally, Darwin was also acquainted with the work of Fourier, which is mentioned by Brewster. Fourier's research on thermal phenomena is reviewed by Herschel in sect. 149 of the *Discourse*. John F.W. Herschel, *A Preliminary Discourse on the Study of Natural Philosophy* (London, 1831). Lyell in his *Principles of Geology* discusses Fourier's work on the variation of the mean temperature over the surface of the globe and its relation to continental drift. C. Lyell, *Principles of Geology, Being an Inquiry How Far the Former Changes of the Earth's Surface Are Referable to Causes Now in Operation*, 5th ed., 4 vols. (London, Murray, 1837).

Darwin was, of course totally at home with all the "applications" of the physics of heat to geophysics. At this stage in his life, he identified himself professionally as a geologist. For his work on volcanoes (see in particular, *Proc. Geol. Soc. London*, 2 [1838], 654-660), Darwin had mastered all the literature on theoretical geophysics and geological dynamics (as outlined, for example, in vol. III, chap. VII of Whewell's *History of the Inductive Sciences*, London, 1837; Darwin had read the *History* by mid-1838). Undoubtedly, he thoroughly appreciated the relationship of the doctrine of central heat (see Whewell, *History*, p. 559) to the nebular hypothesis of Laplace (*Laplace, Exposition du système du
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Darwin, in his undergraduate Cambridge days, had been introduced to Laplace's work on the stability of the solar system in sections 304 and 305 of Herschel's *Discourse*. However, no mention is made there of Laplace's evolutionary theory of the formation of the solar system. The nebular hypothesis is also not mentioned in Herschel's *Treatise on...*
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*Astronomy*,58 which Darwin read sometime in early 1837.59 Neither Laplace's nor Kant's nebular hypothesis is mentioned in Lyell's *Geology*. Probably the places where Darwin first saw Laplace's nebular hypothesis being discussed in an *astronomical* context were in J.P. Nichols's *Views of the Architecture of the Heavens*, which he read in 1837, and in Whewell's Bridgewater treatise, which he first read in early 1838.60

The argument in Chapter II of Book II in Whewell runs as follows. The *accidental* features of the solar system (such as the distance from the planets to the sun, the inclination of their orbit, their periods of rotation) are not accounted for by Newton's laws. Yet these features are precisely the ones "which...answer the purpose of the earth, perhaps of the other planets, as the seat of animal and vegetable life." Since Laplace had already shown that the probability of all these features coinciding was extremely small, God was responsible.

Chapter III of Book II deals specifically with the stability of the solar system, and Whewell notes that "it appears that the arrangement which at present obtains is precisely that which is necessary to secure the *stability* of the system." That arrangement (that all planets move in the same direction in orbits of small eccentricities), Whewell notes, was a key element in the proof Lagrange and Laplace had given for the stability of the solar system. Laplace had shown:

that in the long run, the orbits and motions remain unchanged; and that the changes in the orbits, which take place in shorter periods, never transgress certain *very* moderate limits. Each orbit undergoes deviations on this side and that side of its average state; but these deviations are never very great and it finally recovers from them, so that the average is preserved. The planets produce perpetual perturbations in each other's motions but these perturbations are not indefinitely progressive, they are periodical: they reach a maximum value and then diminish.

Chapter VII of Book II of the treatise, entitled "The Nebular Hypothesis," opens by referring to the fact that Laplace himself said that the arrangement by which the stability of the solar system is secured is not the result of chance but that "a *primitive cause* has directed the

59. As indicated by annotations in Darwin's copy in the Darwin Collection.
60. See C, p. 72. Darwin refers to the Bridgewater treatise again in 1840, but with respect to a different problem, the evolution of conscience.

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planetary motions." But whereas Whewell, quoting Newton, draws the conclusion "that the admirable arrangement of the system cannot be but the work of an intelligent and most powerful being," Laplace, it is pointed out, proposed his nebular hypothesis as the primitive cause. Whewell very summarily presents this nebular hypothesis, emphasizing its conjectural nature. He also notes "that it carries us back to the beginning of the present system of things; but that it is impossible for our reason to stop at the point presented to it." And Whewell asks: "Do we not, far more than ever, require an origin of this origin? . . . can it [the nebular hypothesis] prevent our looking beyond the hypothesis to a first cause, an Intelligent Author . . .?"

The Brewster review, by contrast, emphasized that the nebular hypothesis could be cast into a theory which could make both qualitative and quantitative verifiable predictions. An example of a qualitative prediction was the notion "that the different parts of the solar system have been necessarily successive," which surely must have resonated with Darwin's geological views. Similarly, the review indicated that quantitative predictions could be made and that the validity of the hypothesis could be verified on the basis of their confirmation or refutation.

The review also must have reinforced a viewpoint Darwin subscribed to, namely, that one need not go back to an "origin of origin":

In my speculations, must not go back to first stock of all animals, but merely to classes where type exist, for if so, it will be necessary to show how the first eye is formed - how one nerve becomes sensitive to light . . . which is impossible.61

To explain the origin of the solar system one could, as Laplace did, start with a "nebulae" without having to account for its origin. The same is true with the origin of life.

Comte's account did for the solar system precisely what Darwin was attempting to do for the species problem; namely, to show that the characteristic circumstances of the biosphere, including the stability of the system, are necessary consequences, through the operation of natural laws, of the mode of formation of the system. Stated differently, once life had started, "we can perceive that events are brought about not by insulated interpositions of Divine power, exerted in each particular

61. This entry in D, p. 21, dates from the first half of August (the next date, on p. 35, is August 16, 1838). Peter Gautrey accepts an August 12 attribution "give or take a day or two," which would date the entry to a period after Darwin read the Comte review.

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case, but by the establishment of general laws.” This last quotation is of course taken from Whewell’s Bridgewater treatise and is one of the two quotations which prefaces the Origin.62

On August 16, four days after Darwin finished reading the Comte review and thinking deeply about it (the headache at the Atheneum is on August 12), he made following entry in the D notebook, page 36:

What a magnificent view one can take of the world. Astronomical causes modified by unknown ones, cause changes in geography & these changing affect each other & their bodies by certain laws of harmony kept perfect in these themselves – instincts alter, reason is formed & world peopled with myriads of distinct forms from a period short of eternity to the present time, to the future. –

How far grander [italic mine] than idea from cramped imagination that God created (warring against those very laws he established in all organic nature) the Rhinoceros of Java & Sumatra, that since the time of the Silurian he has made a long succession of vile molluscous animals. How beneath the dignity of him, who is supposed to have said let there be light & there was light . . . - bad taste.63

Recall that Brewster had commented on the Comtian views of Laplacian cosmogony as follows:

These views . . . break upon the mind with all the interest of novelty and the brightness of truth. Appealing to our imagination by their grandeur [italics mine] the mind feels as if a revelation has been vouchsafed to it of the past and future history of the universe.64

The above entry of the D notebook gets transformed into the last paragraph of the “Sketch” of 1842:

There is a simple grandeur in the view of life with its powers of growth, assimilation and reproduction, being originally bequeathed into matter under one or a few forms, and that whilst this our planet has gone circling according to fixed laws, and land and water, in a

63. The comment “bad taste” was added by Darwin at a subsequent reading of the entry.
64. It is also interesting to note that several of the entries in the D notebook immediately following August 12, 1838, deal with the past and future history of the universe. Thus p. 38: “with respect to future destinies of mankind” and p. 39: “with respect to the Deluge.”
cycle of change, have gone on replacing each other, that from so simple an origin, through the process of gradual selection of infinitesimal changes, endless forms most beautiful and most wonderful have been evolved.

This passage, with some slight changes, also constitutes the last paragraph of the conclusion of the “Essay” of 1844. It is, of course, the origin of the concluding paragraph in the first edition of the *Origin of Species*. Its indebtedness to the Comte review is unmistakable.

Let me turn next to the impact of the review on Darwin’s thinking about natural and artificial selection. It will be recalled that Brewster in his review had quoted Comte to the effect that in analyzing complex phenomena we possess a powerful instrument of investigation, experiment.

This instrument is *experiment*, by means of which we observe bodies out of their *natural* [italics mine] state; by placing them in *artificial* aspects and *conditions* [italics mine] contrived for the purpose of exhibiting to us, *under the most favourable circumstances* [italics mine], their phenomena and their properties.

The “Outline and Draft” on the subject of “the principles of variation in animal and vegetable organism under the effect of domesticity” opens with:

Section 1. An organism placed under conditions, different from those to which it had been adapted by nature, sometimes varies during its individual life in an extremely small degree & in trifling respect;

Section 4 opens with

The most favourable <conditions> circumstances for variation seems to be propagation for many generations in domesticity . . . the influence of domestication seems to resolve itself into conditions different from those under which nature placed the organism.

Chapter I of the “Essay” of 1844 opens with the statement

The most favourable conditions for variation seem to be when organic beings are bred for many generations under domestication.

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It is well known that Darwin's interest in genetical questions had made him investigate the literature of plant and animal breeding. Entries on pages 133-134 of the C notebooks written in late spring 1838 refer to Wilkinson's and Sebright's work on improving domesticated animals.66 Other entries corroborate that view. But entries on artificial selection become much more frequent after his reading of the Comte review.67 Darwin was clearly groping for the analogy between natural and artificial selection by late August 1838. Thus on page 20 of the D notebook Darwin writes:

The varieties of the domesticated animals must be most complicated, because they are partly local & then the local ones are taken to fresh country & breed confined to certain best individuals – scarcely any breed but what some individuals are picked out – in a really natural breed not one is picked out.

The entry on pages 32-34 of the D notebook concerns artificial breeds:

Dr. Bachman regularly breeds in Carolina for his table Muscovy & common ducks – . . . The hybrids do not vary . . . more than parent species.

I observe Bachman call these *Hybrids new* species.

The entries from pages 41-44 refer primarily to artificial breeds. There is a long entry in D pages 52-54 in which Darwin initially speculates that "the infertility of cross & cross is method of nature to prevent the picking of monstrosities as man does," and ends with a quote from Sir T. Browne's works: "There are no grotesques in nature...'for Nature is the act of God' – after Decandolle's idea."68 Decandolle's idea is, of course, that "all the plants of a given country are at war with one another... the more profilic made themselves masters of the ground."69

On September 7 (p. 65 of the D notebook), Darwin notes:


67. Limoges in *La sélection naturelle* has also noted the greater number of entries on artificial selection after August 1838. But care must be exercised, because the search for causes of variations in sexual reproduction is certainly another reason that Darwin was studying the breeders so intensely at this time. Similarly, it should again be stressed that the role of selection as perceived by Sebright is to act as nature's broom by removing inferior organisms and monstrosities.

68. "After Decandolle's idea" was not written at the same time as the rest of the entry, but inserted at some later date.

69. Decandolle's views are quoted in Lyell's *Principles of Geology*, II, 131 (1st ed.), and this is where Darwin first read them while on the *Beagle*. 257
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I was struck looking at the Indian cattle with Bump, together with Bison of some resemblance as if the “variation in one was analogous to specific character of other species in genus” – is there any law of this. Do any varieties of sheep evidently artificial approach in character to goats, or dogs to foxes . . . or donkeys to zebras.

This entry of September 7 is in fact one of the few places where Darwin speaks of the artificial approach. Page 88 of the D notebook, dating from the same time, is another instance:

Saw cross between Penguin Duck from Bombay and Canada Goose. Former strange misshaped bird & looks very artificial bred.

On September 13, 1838, Darwin speculates on the possibility of adaptation in nature of crosses between wild and domesticated birds:

Is English red Grouse a cross between Black game & the subalpina of Sweden . . . it may be so – but very improbably, for it can hardly be thought the cross would have adapted it to changing circumstances. (D, p. 105)

On D p. 106 Darwin further notes:

The fact of Egyptian animals not having changed is good – I scarcely hesitate to say that if there had been considerable change, it would have been greater puzzle than none.

Earlier Darwin had entered that

It certainly appears in domesticated animals that the amount of variation is soon reached – as in pigeon no new races –

On a previous page (D, p. 100) Darwin noted that all the varieties of domestic pigeons “now known” existed in 1765. The entries on pages 107, 108, 118, and 128 of the D notebook all deal with artificial breeds. I suggest that after reading the Comte review, Darwin conceived of artificial selection as the method of exhibiting under the most favorable conditions the properties of “variations” and of studying the dynamics of adaptation resulting from such selection.

The “Outline and Draft” is very clear on this point. Thus, section 8 of the “Draft” states: “will select & therefore in one sense make a race of
sheep which cannot climb over walls." Unfortunately: "Man's power in making breeds is limited." And "the whole amount of variation produced under domestication is quite unknown" – that is, man has not yet produced a new species; man only makes "breeds or races" (in fact "infinitely numerous races").

Similarly, in section 6, Darwin states:

The varieties produced by the direct effects of external conditions & habits & the accidents of the reproductive system are almost endless in kind and number.

Already in late January 1838 Darwin was writing:

As man has not had time to form good species, so cannot the domesticated animals with him! – (B, p. 244)

However, Darwin noted, given enough time, man would be able to produce a new species of animals under domestication. But since he

70. See also sect. 7, 11, 10 and "To Sum Up" of the "Draft."
71. "Outline and Draft", sect. 11.
72. If my understanding of Darwin's thinking is right, the analogy he would have drawn from the Laplacian and Comtian models of the formation of the planetary system would further have reinforced his view that the rate of variations is slow and gradual. There is a slow secular transformation of species stemming from small variations, the system being stable under small perturbations. Such a view would also conform to his geological outlook.
73. "Outline," sect. 10, "To Sum Up."
74. Recall that Lyell had, in vol. II of his Geology, argued convincingly that variation under domestication could not be used to prove transmutation of species. In fact, Lyell on p. 26 of the first edition of vol. II of the Principles of Geology – which Darwin read while aboard the Beagle – states: "We may consider, therefore, that in perfecting the arts of domesticating animals and cultivating plants, mankind have first selected those species which have the most flexible frames and constitutions, and have then been engaged for ages in conducting a series of experiments, with much patience and at great cost, to ascertain what may be the greatest possible deviation from a common type which can be elicited in these extreme cases" (italics mine).
has not done so yet, "artificial" selection can only be used as an analogy; one cannot use it as the "experiment" to prove speciation under natural "selection." In the Origin the analogy between "artificial" and "natural" selection is used didactically, undoubtedly because Darwin was aware that variations had not been proven to be infinite under artificial conditions.

Nonetheless, that Darwin thought of artificial selection of plants and animals under domestication as playing the role of the experiment in the analysis of the complex phenomena subsumed under "transmutation of species" is attested to by the fact that in his introduction to The Variation of Animals and Plants Under Domestication 75 — which incidentally contains one of the most concise statements of Darwin’s view of natural selection — he states:

But the initial variation on which man works, and without which he can do nothing, is caused by slight changes in the conditions of life, which must have often occurred under nature. Man, therefore, may be said to have been trying an experiment on a gigantic scale; and it is an experiment which nature during the long lapse of time has incessantly tried. Hence it follows that the principles of domestication are important for us. The main result is that organic beings thus treated have varied largely, and the variations have been inherited.

Let me next take up briefly the more general methodological questions. Darwin was clearly "well prepared to appreciate" these aspects of the Brewster review. The classification of the sciences and the role of experiments, deduction and induction, and hypotheses were subjects which Herschel dealt with in his Preliminary Discourse. This book was one of the two works (the other being Humboldt’s Personal Narrative) which Darwin said 76 had crucially influenced him while he was at Cambridge and inspired him to pursue a scientific career.

Darwin was aware that methodological questions would play a central role in convincing Lyell, Herschel, Whewell, and others of the correctness of any transmutation theory he put forward. England was in the midst of a methodological debate which reverberated in the articles Darwin read. Even a cursory reading of the BAAS presidential addresses and the popular writings of Herschel, Whewell, and their Scottish

colleagues Brewster, Brougham, Forbes, Waterston, during this period will attest to the centrality of these issues.77 These matters were clearly also discussed at the luncheons and dinners that Darwin attended during this crucial period of his life.

The problem of analyzing the "phenomena," that is, of resolving complex phenomena into simpler phenomena, was exactly what Part II of Herschel's Preliminary Discourse had dealt with. The title of that section is "Of the principles on which physical science relies for its successful prosecution, and the rules by which a systematic examination of nature should be conducted, with illustrations of their influence as exemplified in the history of its progress." The search for "verae causae," that is, the rule of referring phenomena to independently known rather than unknown causes, was the central feature of this process.78 Cause and force play a large role in Herschel's philosophy of the natural sciences, and explanations in terms of "forces" give Herschel particular satisfaction. The emphasis that Darwin places on finding causes undoubtedly stems from the influence of Herschel's Discourse. For the same reason, Darwin could not accept the Comtian limitation that scientific laws be merely descriptive.

Darwin, however, clearly appreciated the emphasis that Brewster had placed on the role of speculation and prediction in formulating theories. Brewster in the review had put great stress on Comte's views on the true use of hypothesis: "the introduction of hypothesis into natural philosophy is strictly indispensable." I have already referred to Darwin's excited letter to Lyell written on September 13, 1838, where he referred to Comte's view that the very essence of science is prediction. On Septem-


ber 7, 1838, after having been struck by the fact that “variation in one [Indian cattle with bump] was analogous to specific character of other species in genus [bison]” and that “it is well worthy of examination whether variations are produced only in those characters which are seen to be different in species of same genus,” Darwin made the following entry in the third transmutation notebook:

Although no new fact be elicited by these speculations even if partly true they are of the greatest service towards the end of science, namely prediction, till facts are grouped & called there can be no prediction. The only advantage of discovering laws is to foretell what will happen & to see bearing of scattered facts.” (D, p. 67)

In fact, a few days earlier he had had to warn himself about the dangers of pure speculation. Thus on September 2, the following entry appears:

Is there some law in nature an animal may acquire organs, but lose them with more difficulty . . . hence become extinct, & hence the improvements of every type of organization. Such a law would explain everything – Pure hypothesis be careful. – (D, p. 58)

Recall also his entry on page 51 of the D notebook dating from the period after he read the Comte review.

That Darwin had in fact already been using for some time the method of hypothesis, deductions, and refutations is attested by such entries as pages 224 and 226 of the B notebook.79 The entry on page 228 of the B notebook (December 1837) terminates with

My theory would give zest to recent fossil Comparative Anatomy; it would lead to study of instincts, heredity and mind heredity, whole [of] metaphysics. It would lead to closest examination of hybridity, . . . and generation, cause of change in order to know what we have come from and to what we tend, this and direct examination of direct passages of structure in species might lead to laws of change, which would then be [the] main object of study, to guide our speculations with respect to past and future [italics mine].

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Reading the Comte review must have given Darwin the feeling that his procedures were methodologically justified. Yet, it will be recalled that in his *Autobiography* Darwin characterized his methodological approach in the transmutation notebooks as follows: “I worked on true Baconian principles, and without any theory collected facts on a wholesale scale”!

Again in the introduction to *The Variation of Animals and Plants Under Domestication* 80 Darwin summarizes his views on the role of hypothesis in a statement which clearly reveals Comte’s influence:

In scientific investigations it is permitted to invent any hypothesis, and if it explains various large and independent classes of facts it uses to the rank of a well grounded theory. The undulations of the ether and even its existence are hypothetical, yet every one now admits the undulatory theory of light. The principle of natural selection may be looked upon as a mere hypothesis, but rendered in some degree probable by what we positively know of the variability of organic beings in a state of nature – by what we positively know of the struggle for existence and the consequent almost inevitable preservation of favourable variations – and from the analogical formation of domestic races. Now this hypothesis may be tested – and this seems to me the only fair and legitimate manner of considering the whole question – 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. If the principle of natural selection does explain these and other large bodies of facts, it ought to be received.

Interestingly, the passage concludes with an attack on theological explanations:

On the ordinary view of each species having been independently created, we gain no scientific explanation of any one of these facts. We can only say that it has so pleased the Creator to command that the past and present inhabitants of the world should appear in a certain order and in certain areas; that He has impressed on them the most extraordinary resemblances . . . But by such statements we gain no new knowledge; we do not connect together facts and laws; we explain nothing.

80. *Variation of Animals*, p. 20.

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Finally, there is one other aspect of the methodological issue which I believe struck Darwin. Brewster stressed the fact that Comte "tried to discover an aspect in which it [Laplace's cosmogony] would admit some numerical verification - an indispensible criterion . . . of every hypothesis relative to astronomical phenomena." Now astronomy had reached the positive stage; clearly, any science claiming to have left the metaphysical stage behind must similarly strive for quantitative verification. Moreover, as Comte emphasized, "the ultimate object of physical theories is to predict, as exactly as possible all the phenomena which a body will present when placed in any given circumstances." These views parallel those of Herschel: the best kind of fundamental laws were quantitative.81 Darwin adopted this criterion and tried to meet the requirement that his theory contain quantitative statements and be able to make quantitative predictions.

Summarizing, I believe Darwin obtained the following from reading the review: (1) greater confidence in the notion that a dynamical theory accounting for the evolutionary process (which assumed the origin of life) could be formulated; (2) the conviction that an acceptable dynamical theory must be able to make predictions and must contain quantitative statements; and (3) a clarification of the role of experiment in analyzing complex phenomena, and thereby crystallizing in his mind the role that artificial selection was to play in his theory.

Certainly one element on which the theory was to be built was the fact of variations. As previously noted, by August 1838 Darwin had accepted the ubiquity of variations and the phenomenological fact that they were indefinite, accidental, chance phenomena. Before proceeding further, we must analyze more thoroughly what chance and chance variations meant to Darwin.

4. DARWIN ON CHANCE

The Transmutation notebooks, the "Outline and Draft," the "Sketch" of 1842, the "Essay" of 1844, and the Origin all begin with reference to variations (see the opening entries of the B notebook, particularly pp. 3-5). Thus the "Sketch" of 1842 opens with a statement of the ubiquity of variation:

A certain degree of variation (Müller's twins) seems inevitable effect of process of reproduction. But more important is that simple

81. Herschel, Preliminary Discourse, p. 123.
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generation, especially under new conditions [when no crossings] causes infinite variation and not direct effect of external conditions, but only in as much as it affects reproductive functions. There seems to be no part (beau ideal of liver) of body, internal or external, or mind or habits, or instincts which do not vary in some small degree and [often] some to a great amount.

The evolution of the notion of variation and its centrality within Darwin's thought will not be repeated here. Suffice it to say that his theory of natural selection rests on the fact of variability. Although Lyell and others had noted the occurrence of variations, no one before Darwin had taken a broad survey of the whole range of variations in the animal and vegetable kingdom. Moreover, Lyell's public commitment to the fixity of species required "indefinite divergences, either in the way of improvement or deterioration being prevented, and the least excess beyond defined limits being fatal to the existence of the individual." In fact, it was this statement in the fifth edition of Lyell's *Principles*, published in March 1837, which drew Darwin's notation in the margin: "if this were true adios theory."83

By December 1, 1837, Darwin had accepted variations as a phenomenological fact. Although Darwin would thereafter, constantly and unsuccessfully, search for the causes of variations, and at times vacillate as to the amount of variation that selection works on, and sometimes be ambiguous as to the "effects on the reproductive system" of the environment, nonetheless, "the tendency to small change" would always be one of the principal tenets of his theory.

From September 1838 until the first edition of the *Origin*, Darwin believed that "individual variations" produced by the "indefinite effects" of external conditions acting on the "reproductive system" were not directed nor *directively* induced by the environmental conditions surrounding the individual.84 In the beginning of the fifth chapter of the *Origin*, Darwin states:


83. See also Whewell's *History of the Inductive Sciences*, 3 vols. (London, 1837), in particular 11, 565, and the recapitulation at end of the fourth chapter of vol. II.

84. Thus for example in the "Sketch," p. 44, Darwin states: "But can varieties be produced adapted to end, which cannot possibly influence their structure and which it is absurd to look at as effect of chance."

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I have hitherto sometimes spoken as if the variations... had been due to chance. This, of course, is a wholly incorrect expression, but it serves to acknowledge plainly our ignorance of the cause of each particular variation.85

This Laplacian view of chance is the one which Darwin consistently held. It is certainly the concept of chance expressed in the M and N notebooks. To Laplace, the notion of probability and chance relates to our knowledge of things and not to things in themselves. In dealing with complex phenomena, it is our ignorance of the different causes that produce the phenomena and the imperfection of our mathematical tools which prevent us from drawing conclusions with the same certainty as when dealing with astronomical phenomena.

We regard a thing as the effect of chance when it offers to our eyes nothing regular or indicative of design and when we are moreover ignorant of the causes which have produced it. Thus chance has no reality in itself; it is only a term fit to designate our ignorance concerning the manner in which the different parts of a phenomenon are arranged among themselves and in relation to the rest of Nature.86

One of the places where Darwin first encountered a discussion of the notion of chance was in Paley's Natural Theology.87 The edition of this book issued in 1836 contained illustrative notes by Lord Brougham and Sir Charles Bell together with “Supplementary Dissertations” by Bell.88 It is very likely that Darwin saw this particular edition with Bell’s notes. This book, together with Henry Lord Brougham’s A Discourse on Natural Theology, Showing the Nature of the Evidence, and the Advantages of the Study was lengthily reviewed by Sir David Brewster in the January 1837 issue of the Edinburgh Review, a magazine Darwin

87. Recall Darwin's recollection in the Autobiography of his reading Paley: “The logic of this book [Evidences of Christianity] and, I may add, all his Natural Theology gave me as much delight as did Euclid. The careful study of these works... was the only part of the academic course which as I felt then, and as I still believe, was of the least use to me in the education of my mind.”
88. Paley's Natural Theology, with illustrative notes by Henry Lord Brougham and Sir Charles Bell, and “Supplementary Dissertations” by Sir Charles Bell and Charles Knight (London 1836).
read consistently upon his return to England.89 Lord Brougham was an influential patron of science, one of the organizers of the BAAS, and an eminent scholar in his own right.90 Bell was a distinguished anatomist and physiologist and a well-known surgeon. Darwin must have used Bell's *Anatomy and Physiology of the Human Body*91 as a text while a medical student at Edinburgh in 1825-1827.92 He certainly read Bell's *Bridgewater Treatise on the Hand*, which appeared in 1833.93

Paley's view on chance, as expressed in *Natural Theology*, was that he desired

no greater certainty in reasoning than [that] by which chance is excluded from the present disposition of the natural world. Universal experience is against it. What does chance ever do for us? In the human body, for instance, chance, i.e., the operation of causes without design, may produce a wen, a wart, a mole, a pimple but never an eye. Amongst inanimate substances, a clod, a pebble, a liquid drop might be; but never a watch, a telescope, an organized body of any kind answering a valuable purpose by a complicated mechanism, the effect of chance. In no assignable instance hath such a thing existence without intention somewhere.94

89. There is a strong correlation between the articles which appeared in the *Edinburgh Review* between 1836 and 1840 and Darwin's reading at that time, as indicated by his M and N notebooks and the list "Books To Read" in the B notebook. It is likely ("Pure speculation, be careful."!) that Darwin saw William Empson's lengthy review entitled "Life, Writings and Character of Mr. Malthus" in the January 1837 issue of the Review. It is also possible that Darwin first noticed Ehrenberg's work in David Brewster's review of Buckland's *Bridgewater Treatise on Geology and Mineralogy*, which appeared in the *Edinburgh Review* of April 1837.

90. See the *Dictionary of Scientific Biography*, *Dictionary of National Biography*. See also Olson, *Scottish Philosophy*, and Orange, "The Origins of the British Association for the Advancement of Science."


92. Gruber in *Darwin on Man*, p. 39, relates that at the meeting of March 27, 1827, of the Plinian Society where Darwin presented his first scientific discoveries, Darwin was exposed to a materialist criticism of Sir Charles Bell's *Anatomy of Expression*. The discussion which ensued was evidently very heated, for it was subsequently decided to strike from the record both the presentation and the subsequent discussions. According to Gruber, the meeting made a deep impression on the young Darwin.


In one of the additional notes, Bell made the following comment on Paley's notion of chance:

There is great inaccuracy, and indeed a very unphilosophical and superficial view of the subject in these observations upon "chance". Chance is merely an abridged form of expressing our ignorance of the cause or preceding event to which a given event may be traced; and nothing can be more inaccurate, or indeed more productive of serious errors in this very branch of science, than to speak of chance as a substantive thing or power. To take the most obvious instance: we say, in common parlance, that the dice being shaken together, it is a matter of chance what faces they will turn up; but if we could accurately observe their position in the box before the shaking, the direction of the force applied, its quantity, the number of turns of the box, and the curve in which the motion was made, the manner of stopping the motion and the line in which the dice were thrown out, the faces turned up would be a matter of certain prediction, after a sufficient number of experiments had been made to correct the theory. It is only because we take no heed of all these things that we are ignorant what will be the event; and the darkness in which we are respecting the circumstances which regulate it, is called by the name of chance. Nor is it correct to say, that this or anything else is done without design. All we can mean by the expression is, that our design stops short at a certain point, and leaves the laws of nature to guide the rest of the operation. But such a position is manifestly inapplicable to the operation of nature. Equally inaccurate is it, if not more so to speak of a wen or a pimple, & as the result of any cause in least degree different from that which produced the eye.

This Laplacian view of chance, as outlined by Bell, was the one universally held by the scientific community. In fact, later in his book (Chapter XXVI, "Goodness of the Deity"), Paley gives a similar definition of chance in the course of trying to answer the question: Why should there be, in a world governed by a Supreme and benevolent will "so much as there is of the appearance of chance?"

The appearance of chance will always bear a proportion to the ignorance of the observer. The cast of a die as regularly follows the laws of motion . . . yet because we cannot trace [the operations of those laws] in the shaking or throwing of the die . . . we call the turning up of the number of the die chance . . . It is the same in those
events which depend upon the will of a free and rational agent. The verdict of a jury, the sentence of a judge . . . will have more or less the appearance of chance . . . according as we were more or less acquainted with the reasons which influenced the deliberation. The difference resides in the information of the observer and not in the thing itself; which in all cases proposed proceeds from intelligence, from mind, from counsel, from design.

Interestingly, Paley also argues that there must be chance in the midst of design, "by which we mean that events which are not designed, necessarily arise from the pursuit of events which are designed."95 Earlier in the book Paley had also noted:

IV. There is another answer which has the same effect as the resolving of things into chance; which answer would persuade us to believe, that the eye, the animal to which it belongs, every other animal, every plant, indeed every organized body which we see, are only so many out of the possible varieties and combinations of being which the lapse of infinite ages has brought into existence; that the present world is the relic of that variety; millions of other bodily forms and other species having perished, being, by the defect of their constitution incapable of preservation, or of continuance by generation. Now there is no foundation whatever for this conjecture in any thing which we observe in the works of nature; no such experiments are going on at present . . . which should be constantly pushing into existence new varieties of being.

Bell, in an additional note on these points, says:

As to the second position, that the animals which exist are the happy result of chance when thousands have perished by imperfection, the supposition is contradicted by the perfect and harmonious chain of beings forming the animal kingdom, in which there is no link interrupted, no interval implying the loss of any species.96

95. This statement is to be compared with the views expressed by Cournot. See in this connection the important and seminal article by C. C. Gillispie, "Intellectual Factors in the Background of Analysis by Probabilities" in Scientific Change, ed. A. C. Crombie (New York: Basic Books, 1963).

96. The question relating to "the loss of species" raised by Bell had, of course, been on Darwin's mind for a long time and was central to his concerns by mid-June 1838 (see, e.g., D, pp. 21 and 37). Although these questions form an important part of the "long argument," I will not consider them further here.
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It is worth noting that Darwin was to answer Bell’s argument “that this or anything else is done without design” precisely by having “the laws of nature” guide “all the operations of nature.” Bell’s argument echoes Whewell’s 1833 Bridgewater treatise in having the rule of general law apply only to the material world. (Recall that for Whewell chance was eliminated from physical phenomena indirectly by God’s instituting divine laws and directly by God’s determining “initial conditions.”) Similarly, Darwin adopts Paley’s argument that all organized bodies “are only so many out of the possible varieties and combinations of beings which the lapse of infinite ages has brought into existence.”

Already in the fall of 1837 Darwin in his first transmutation notebook asks: “Whether every animal produces in course of ages ten thousand varieties (influenced itself perhaps by circumstances) and those alone preserved which are well adapted?” (B, p. 90). In the “Outline and Draft” section 6, Darwin states:

The varieties produced by the direct effect of external conditions & habits & the accident of the reproductive system are almost endless in kind and number.

In the “Essay” of 1844, Darwin is even more explicit:

If there were any selective agency at work it seems impossible to assign any limit to the complexity and beauty of the adaptive structure which might thus be produced: for certainly the limit of possible variation of organic beings, either in a wild or domestic state is not known.97

And in the conclusion to the “Essay,” Darwin reiterates:

Doubtless, our first impression is to disbelieve that any secondary law could produce infinitely numerous organic beings each characterized by the most exquisite workmanship and widely extended adaptations.98

98. “Essay,” p. 253. In the Big Book, p. 245, the statement is as follows: “I believe there is no limit / 26u / to the number of species tending to be formed from the most favored forms in any country (or those which have any [sic] the greatest advantages over cohabitants except the number of species which the country is capable of supporting, but such modified descendants, or new species, after a long period will have to be ranked not in the same genera, but in distinct genera, families or orders.” See also p. 246 of the Big Book, where the statement is repeated.

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The above quotations and remarks are intended to demonstrate the centrality of the notion of chance in Darwin’s theoretical structure. It is, however, a Laplacian conception of chance: Darwin was a determinist. Phenomena being infinitely complex,99 we cannot know all the causes; hence we must be content with a partial description. This partial description may turn out to be probabilistic (though of course a more fundamental explanation would reveal the deterministic causes).

Thus even though we speak of a puppy or a man having free will, there is no free will. Were we to know all causes, all “the direct effect of organization,” we would know what puppy or man would do under any given circumstances.100 Darwin repeatedly equates free will and chance. Consider, for example, the entry on page 31 of the M notebook, written between July 15 and 22, 1838:

I verily believe free will & chance are synonymous – shake ten thousand grains of sand together & one will be uppermost.

The analogy with a die (with ten thousand faces) makes Darwin’s meaning clear. And just as in the case of dice we can accept a description in terms of chance at the phenomenological level, so our lack of knowledge of motives (“the effects of organization”) allows us to speak of free will when describing human behavior at the phenomenological level.

After reading the Brewster review, Darwin strongly associated Comte with the notion of free will. Thus on page 72 of the M notebook, written right after having read the review, Darwin notes: “free will is to mind, what chance is to matter/ M. Le Compte.” The addenda to the entry of September 6, 1838, on page 25 of the OUN notebook gives a partial explanation:

99. “Infinitely complex” is a description which occurs often in Darwin’s writing, particularly in the Big Book and in the Origin. For example, on p. 80 of the Origin: “Let it be borne in mind how infinitely complex and close-fitting are the mutual relations of all organic beings to each other and to their physical conditions of life.” This point is repeated on p. 127. See also Darwin’s discussion of variability on p. 43 of the Origin.

100. See, for example, M, pp. 27, 73. M, p. 72, reads: “With respect to free will, seeing a puppy playing cannot doubt that they have free will, if so all animals, then an oyster has & a polype (& a plant in some senses, perhaps, though from not having pain or pleasure, actions unavoidable & only to be changed by habits). Now free will of oyster, one can fancy to be direct effect or organization, by the capacities its senses give it of pain or pleasure. If so free will is to mind, what chance is to matter.” See also M, p. 74: “It may be doubted whether a man intentionally can wag his finger from real caprice. It is chance which way it will be, but yet it is settled by reason.”

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one well feels how many actions are not determined by what is called free will, but by strong invariable passions – when these passions weak, opposed & complicated one calls them free will – the chance of mechanical phenomena – (mem.: Mr. le Comte one of philosophy, & savage calling laws of nature chance).

In other words, savages in the metaphysical stage will speak of chance as a “substantive thing or power” and equate it with a law of nature. Further down on page 25 in the OUN notebook is an entry written between September 6 and October 2, 1838, in which Darwin speculates on how the concept of free will evolved:

The general delusion about free will obvious – because man has power of action & seldom analyse his motives (originally mostly INSTINCTIVE) & therefore now great effort in reason to discover them: this is important explanation) he thinks they have none.

Sometime after November 29, 1838, Darwin writes in the N notebook, page 49,

hence there is great probability against free action – on my view of free will, no one could discover he had it not."

Darwin once again read about chance and free will in a long review of Quetelet's Sur l'homme which appeared in the Athenaeum in 1835 and which he read in mid-September 1838. The views Darwin expressed about free will in the addendum to page 25 of the OUN notebook, quoted above, correlate with the views expressed in that review. The review opens with a discussion of chance:

Amongst the infinite variety of circumstances by which man is surrounded in nature and in society, there are but few whose cause is sufficiently simple and direct to become matter of intuitive perception. By dint of long and painful study, a certain portion of these phenomena has been traced to causes operating by universal laws; which laws, being accurately ascertained, present a key, enabling the

101. In section 9, I clarify the other association of "Mr. le Comte one of philosophy" in the present context.
102. The addendum was probably added after Sept. 6, 1838, the date OUN, p. 25, bears. OUN, p. 27, written between Sept. 6 and Oct. 2, concerns itself with the punishment of criminals and the necessity of disease, matters discussed in the Quetelet review.
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observer to calculate with utmost precision the possible results of their agency. In far [the] greater number of cases, the phenomena arise out of causes, either so obscure or so complicated, as to elude the perseverance of the inquirer: the law of their activity remains unascertained; and no safe inference can be drawn as to its consequences in any given contingency. Man, however, by interest and by curiosity impelled to account to himself for whatever strikes upon his senses, invented an explanation of these last train of appearances, by referring them to an unknown and mystical principle which he christened Chance. To say a thing has happened by chance, is indeed merely to say it has happened because it has happened! The word, not withstanding, has acquired, from use, a real and a philosophical meaning – either as a confession of ignorance, or an abridged expression for an unknown formula. In this last sense, the value of chance may become a fit subject for inquiry.

The review continues:

In every complicated case, then, there are certain agencies which universally tend to produce, identical effect; there are others, accidental and variable in different instances, which tend to produce in each case a different consequence. In throwing the dice, there is every throw the same (presumed) equality of the faces of the die, the same equal solidity of all parts of its substance, the same number of possible events. These all tend to produce the six separate faces of the die in every six throws. On the other hand, there are endless varieties of force employed by the gambler in shaking and projecting the die, unknown inequalities in the die itself, in the table that receives it, etc. all tending to determine the throws in a series altogether irregular. In any one fair throw, the actions of the last set of causes so far overmasters that of the first, that it is impossible to determine what will be the event, scientifically [italics mine], and not as a mere accidental guess. It is found, however, by observation that in the long run, the reverse is the fact; that the constant causes predominate over the accidental; and that by embracing a long series of events, an average result may be attained, which will very nearly approximate to what from theory should happen were the constant causes alone in operation: for the unknown and varying forces are not the less under the influence of laws, because we cannot comprehend them; and the effects which they can produce are consequently placed within some limits, so that some undefined series of events, their eccentricities must be exhausted, and must balance and neutralize each other.
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After discussing "the application of this mode of thinking, of seeking after certainty, and reducing hazard to a determinate law," the review continues:

Of the many circumstances hitherto attributed to human nature, a considerable portion are assigned upon a coarse and rude observation; and others are assumed from refined speculations a priori upon the supposed constitution of the animal. The latter have been the subjects of endless dispute, and the causes of some of the most acrimonious contentions that have disturbed the peace of society. Of these, the discussions on free will and necessity are a prominent instance. It is, perhaps, too much to expect that any extent of observation will suffice to silence such disputes . . . however . . . it is abundantly clear that the old methods of seeking to establish the true nature of the abstract man . . . have proved insufficient to their purpose; and that, therefore, the method of investigation embraced by the term Statistics, would be worthy of all attention, although its applications had been attended by discoveries far less striking than those with which works of the description of M. Quetelet's has made us acquainted.

As we shall see later, there was nothing fortuitous about Darwin's turning to Quetelet. That an article dealing with statistics should deal with free will and necessity should also not be surprising. The problem of chance, free will and determinism deeply troubled all the leading scientists of the nineteenth century. Darwin and Maxwell—who in their private letters were quite open about their grappling with this most difficult problem—are merely two outstanding representatives.103

5. DARWIN AND ADAM SMITH

The M and N notebooks contain several different strands of inquiries which often intertwine. One strand details Darwin's attempt to under-

103. See the letter Darwin wrote to Lyell in 1861, which is quoted in the last paragraph of section 9. In 1866, Darwin wrote "Your last question seems to resolve itself into the problem of free will and necessity, which has been found by most persons insoluble"(Life and Letters, 1, 247). In 1873 Maxwell discussed the problem before an informal group at Cambridge in a lecture entitled: "Does the Progress of Physical Science Tend to Give Any Advantage to the Opinion of Necessity (or Determinism) over That of the Contingency of Events and the Freedom of the Will?" See Lewis Campbell and William Garnett, The Life of James Clerk Maxwell (London, 1882; reprinted with additions New York, 1969), p. 434, 434.
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stand how one can explain the evolution of instinct, pleasure, pain, fear, and so on. Another strand consists of his speculations on how one can explain the evolution and stability of the social and moral order. These inquiries and speculations on the origins of instincts, habits, and feelings are strongly coupled with his investigations of the properties of the social environment, how it evolved, and how it reacted back on the individual.

By the summer of 1838, Darwin had convinced himself of man's position on the evolutionary ladder.104 By November 30, 1838, as attested by the entry on page 49 of the E notebook, Darwin believed that morals are the result of evolution from "social instincts, which as I hope to show is probably the foundation of all that is most beautiful in moral sentiments of the animated beings." On December 4, 1838, Darwin wrote on page 63 of the E notebook:

> When two races of men meet, they act precisely like two species of animals – they fight, eat each other, bring diseases to each other &c, but then comes the most struggle, namely which have the best fitted organization, or instincts (i.e., intellect in man) to gain the day.

That Darwin concerned himself not only with the static stability of the social and moral order, but also with its dynamic evolving character is clearly shown by various entries in the M notebook. Thus page 51 (late July 1838) and page 88 (mid-August 1838) indicate that Darwin had been reading Edmund Burke's *A Philosophical Inquiry into the Origin of Our Ideas of the Sublime and Beautiful*.105 Pages 117-118 then record how to apply the calculus of maximum pleasure:

> Definition of happiness the number of pleasant ideas passing through mind at given time – intensity to degree of <happy> pleasure of such thoughts.

> To make greatest number of pleasant thoughts he must have a contingency, no pain...

And on September 8, on page 132e Darwin notes:

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104. C, p. 223, dated July 1838, has the entry "I will never allow that because there is a chasm between man . . . and animals that man has different origin."

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I am tempted to say that those actions which have been found necessary for long generation (as friendship to fellow animals in social animals) are those which are good & consequently give pleasure & not as Paley rule is then that on long run will do good – alter will is such cases to have & origin as well as rule will be given.

M, page 108, written between August 24 and 26, 1838, indicates that Darwin had been reading Dugald Stewart's On the Life and Writing of Adam Smith:

Adam Smith (D. Stewart life of p 27) says <sympathy> we can only know what others think by putting ourselves in their situation & then we feel like them - hence sympathy very unsatisfactory because does not like Burke explain pleasure.

This constitutes a rejection of Adam Smith's explanation of the stability of the moral order. On September 23 or very soon thereafter, there is an entry on M page 155:

D. Stewart <Smith> lives of Adam Smith Reid, etc worth reading as giving abstract of Smith's view.

Further proof that questions relating to the evolution and stability of the social order were very much in Darwin's mind at the time of the Malthusian insight appears in an entry dated October 2, 1838, in the OUN notebook, page 29:

- No checks were necessary to the vice of intemperence, circumstances made the check. – the licentiousness jealousy & every one being [named?] to keep up population. with the existence of so many checks – (this is encroaching on views in second volume of Malthus) Adam Smith also talks of the necessity of these passions, but refers (I believe) to present day & not to wider state of Society. – Civilization is now altering these instinctive passions which being unnecessary we call vicious. – (jealousy in a dog no one calls vice) on same principle that Malthus has shown incontinence to be a vice & especially in the female.

On the same day, he writes on page 30 of the OUN notebook:

Two classes of moralists: one says our rule of life is what will produce the greatest happiness. The other says we have a moral sense. – But
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my views unites* both / & shows them to be almost identical / & what has produced the greatest good /or rather what was necessary for good of all /is the /instinctive /moral sense . . . In judging of the rule of happiness we must look far forward /& to the general action /certainly because it is the result of what has generally been best for our good far back – (much further than we can look forward: hence our rule may sometimes be hard to tell) . . . 106

The difference between civilized man & savage, is that the former is endeavouring to change that part of the moral sense which experience (education is the experience of others) shows does not tend to greatest good. – Therefore rule of happiness is to certain degree right. – The change of our moral sense is strictly analogous to change of instincts amongst animals.

**Society could not go on except for the moral sense, any more than a hive of Bees without their instincts.**

I believe that it was by reading the writings of Adam Smith and the other Scottish Common Sense philosophers that Darwin initially got his emphasis on individuals as the units for his theory of natural selection. In the “Outline and Draft” this emphasis is particularly noticeable. Section 1 begins:

*An organism* placed under conditions, different from those to which it has been adapted by nature, sometimes varies during its individual life in an extremely small degree & trifling respects... These changes ... in individual lives . . . In individual animals, however . . .

Section 2 begins

When a <individual organism> . . . the variation is <sometimes> greater than happens in the life of an <animal> individual plant . . .

The variations occur in individuals, *all* of which have been placed in a similar environment (see sections 3 and 4).

In an insightful article in 1971, Sandra Herbert has stressed the importance in Darwin’s thinking of the transition from using species as

106. Note the stress on looking “far forward” and “far back,” a point made in the Comte review.
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the unit of analysis (which she attributes to Lyell) to using individuals as the unit.107 I believe her point that an appreciation of the struggle between the individuals of the same species was essential before Darwin could formulate his theory is very important and correct. She attaches great importance to Darwin's reading of Malthus for this change of focus to individuals and for his realization of how interspecific struggle gives rise to intraspecific struggle. I think, however, that Dugald Stewart and Adam Smith were the initial influences,108 and were responsible for Darwin's adoption of the Scottish view of trying to understand the whole in terms of the individual parts and their interactions. It should also not be forgotten that certainly by August 1838 Darwin had focused the site of random variations on individuals. Moreover, entries such as those on pages 148 and 211 of the B notebook and, particularly the one on page 61 of the C notebook indicate that Darwin understood that only intraspecific struggle could lead to evolution.

Dugald Stewart's Biographical Memoir of Adam Smith includes an account of the lectures that Smith gave while he was a professor of moral philosophy at Glasgow University from 1751 to 1753. The account is by Mr. Millar, who later became professor of law at the University of Glasgow. Millar points out that Smith's lectures on moral philosophy were based on the plan that seems to be suggested by Montesquieu:

107. Herbert, "Darwin, Malthus and Selection." Darwin's shift from species to individuals was first pointed out and stressed by Ghiselin in 1969 in his Triumph of the Darwinian Method.

108. H. Höffding, in his perceptive essay "The Influence of the Conception of Evolution on Modern Philosophy," written in commemoration of the centenary of the birth of Charles Darwin and the fiftieth anniversary of the publication of the Origin of Species and published in Darwin and Modern Science, ed. A. C. Seward (Cambridge: Cambridge University Press, 1909), places Darwin "in the school that was founded by Shaftesbury and afterwards represented by Hutcheson, Hume and Adam Smith." This attribution is, however, based primarily on Darwin's moral philosophy as expressed in the Descent. Marx and Engels's statement that classical economics influenced Darwin, based on the resemblance of the theory of evolution to the laissez-faire economics of the capitalist marketplace, is the starting point of a large literature (see for example, Bertrand Russell, Religion and Science [London: Oxford University Press, 1935], pp. 72-73). An extensive bibliography on these matters may be found in Ashley Montagu, Darwin, Competition, and Cooperation (Westport, Conn.: Greenwood Press, 1973). All these matters are discussed in the important and stimulating books by Ghiselin: The Triumph of the Darwinian Method and The Economy of Nature and the Evolution of Sex (Berkeley: University of California Press, 1974). I find that many of the statements that Ghiselin makes in The Triumph are borne out by the evidence of Darwin's original documents. There is one other strand which relates Adam Smith to Darwin. Gruber in the introduction of Darwin on Man, p. 13, points to the importance of the development of "self-regulating machinery" and "the concept of society as a self-regulating system," which

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endeavouring to trace the gradual process of jurisprudence both public and private from the rudest to the most refined ages, and to point out the effect of those acts which contribute to subsistence and to the accumulation of property, in producing correspondent improvements or alterations in law and government . . .

In the last part of his lectures, he examined those political regulations which are founded not upon the principle of justice, but of expediency, and which are calculated to increase the riches, the power and the prosperity of the State.

In section II of his life of Adam Smith, Dugald Stewart turns his attention to concisely defining what Smith was attempting to accomplish in his *Theory of Moral Sentiment*:

The science of ethics has been divided by modern writers into two parts; the one comprehending the theory of morals and the other its practical doctrines. The questions about which the former is employed, are chiefly the two following: First by what principles of our constitution are we led to form the notion of moral distinctions (whether by that faculty which in the other branches of human knowledge perceives the distinction between truth and falsehood or by a peculiar power of perception (called by some Moral Sense) which is pleased by one set of qualities and displeased with another. Secondly what is the proper object of moral approbation? or in other words: what is the common quality or qualities belonging to all the different modes of virtue? Is it benevolence or a rational self love; or a disposition (resulting from the ascendant of reason over passion) to act suitably to the different relations in which we are placed?

These two questions seem to exhaust the whole theory of morals. The scope of one is to ascertain the origin of our moral ideas; that of the other to refer the phenomena of moral perception to their most simple and general laws [italics mine].

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became "prominent in the work of Adam Smith and others"; see Otto Mayr, *The Origins of Feedback Control* (Cambridge, Mass.: MIT Press, 1970). Charles Lyell in the eleventh edition of his *Principles of Geology* which appeared in 1872, commented that "when first the doctrine of the origin of species by transmutation was proposed, it was objected that such a theory substituted a material self-adjusting machinery for a Supreme Creative Intelligence." This view probably reflected his reading of A. R. Wallace's article "On the Tendency of Varieies To Depart Indefinitely from the Original Type," *J. Proc. Linn. Soc.*, August 1858, which states that "the action of this principle is exactly like that of the centrifugal governor of the steam engine." Recall that in the 1830's Lyell had regarded the earth as a self-regulating geological machine.
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Noting that Smith’s views are well known, Stewart limits himself to the following abstract of A Wealth of Nations:

I shall content myself, therefore, with remarking in general terms, that the great and leading object of his speculations is, to illustrate the provision made by nature in the principles of the human mind, and in the circumstances of man’s external situation, for a gradual and progressive augmentation in the means of natural wealth; and to demonstrate, that the most effectual plan for advancing a people to greatness, is to maintain that order of things which nature has pointed out; by allowing every man, as long as he observes the rules of justice, to pursue his own interest in his own way, and to bring both his industry and his capital into the freest competition with those of his fellow citizens. Every system of policy which endeavours, either by extraordinary encouragements to draw towards a particular species of industry a greater share of the capital of the society than would naturally go to it, or, by extraordinary restraints, to force from a particular species of industry some share of the capital which would otherwise be employed in it, is, in reality, subversive of the great purpose which it means to promote [italics mine].

I want to make a parallel between Adam Smith’s individuals (who have free will) and social phenomena, on the one hand, and Darwin’s variations (which are random and stochastic and are so only when considered at the level of individuals) and biological phenomena, on the other hand. Smith’s theory of society starts from individuals who are free agents, but whose nature and character is determined by their existence in society. Its basic assumption is that social phenomena can only be understood by an analysis of individual actions directed toward other people and guided by their expected behavior. The Scottish analysis of society contends that the combined effect of individual actions results in the institutions upon which society is based, and that such a society is a stable and evolving one and functions without a designing and directing mind.109 This Scottish viewpoint should be compared with the “continental” viewpoint. A concise statement of the

109. Thus Adam Ferguson writes in An Essay on the History of Civil Society (1767), “the forms of society are derived form an obscure and distant origin; they arise . . . from the instincts, not from the speculations of man . . . Nations stumble upon establishments which are indeed the result of human action but not the result of human design.” See Adam Ferguson, LL.D., An Essay on the History of Civil Society, ed. Duncan Forbes (Edinburgh: Edinburgh University Press, 1966); on p. xiii of the introduction Forbes says, “all Scottish ‘philosophical’ historians shared certain characteristic views . . . Thus it

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contrast between the viewpoint of the British classical economists (influenced by Locke and Hume) and the continental physiocrats (influenced by Descartes) has been given by Benn:

With Quesnay, following nature meant ascertaining by a study of the world about us and of its laws what conduct is most conducive to health and happiness; and the natural rights meant liberty to pursue the course so ascertained. Such liberty only belongs to the wise and the good, and can only be granted to those whom the tutelary authority in the state is pleased to regard as such. With Adam Smith and his disciples, on the other hand, nature meant the totality of impulses and instincts by which the individual members of society are animated; and their contention is that the best arrangements result from giving free play to those forces in the confidence that partial failure will be more than compensated by success elsewhere, and that the pursuit of his own interest by each will work out in the greatest happiness of all.110

In a remarkable entry on page 95 of the E notebook (written sometime after January 6, 1839, but before March 9, 1839), Darwin gives proof of his commitment to the Scottish viewpoint of trying to understand the whole in terms of its parts:

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was generally agreed that the progress of society is a spontaneous process... that it is largely the unlooked-for by-product of men willing and planning other things." Josiah Tucker in his *Elements of Commerce* (1756), reprinted in Josiah Tucker: A Selection from his Economic and Political Writings, ed. R.L. Schuyler (New York; 1931), p. 92, writes, "The proper design of this chapter is to show that the universal mover in human nature, self love, may receive such a direction in this case (as in all others) as to promote the public interest by those efforts it shall make towards pursuing its own." Adam Smith's well-known statement in the *Wealth of Nations*, ed. Cannan, 1, 421, is the following: "By directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention. Nor is it always the worse for the society that it was no part of it. By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it." See Albert Schatz, *L'individualisme economique et social* (Paris, 1907); Gladys Bryson, *Man and Society: The Scottish Inquiry of the Eighteenth Century* (Princeton: Princeton University Press, 1949); Davie, *The Democratic Intellect*; and Olson, *Scottish Philosophy.*


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The enormous number of animals in the world depends on their varied structure & complexity – hence as the forms became complicated, they opened fresh means of adding to their complexity – but yet there is no necessary tendency in the simple animals to become complicated although all perhaps will have done so from the new relations caused by the advancing complexity of others. – It may be said, why should there not be at any time as many species tending to dis-development (some probably always have done so, as the simplest fish) my answer is because, if we begin with the simplest forms & suppose them to have changed, their very changes tend to give rise to others.

I have stressed that certainly by August 1838, Darwin had situated the site of random variations at the level of individuals. His study of breeding – even though the initial focus was on ascertaining the causes of variation – surely must have impressed him with the fact that every individual is different from every other and with the critical importance of selecting the individuals used in breeding. In an entry dated September 11 Darwin in fact tells us so:

Generation Mr. Yarrell says it is well known that in breeding very pure South Down that the [italics mine] ewe must never be put to any other breed else lambs will deteriorate. (D, p. 152)

There could no doubt in Darwin’s mind that any mechanism which operates in nature must act selectively on individuals. The fact that variations are chance elements (stochastic, to use an anachronistic term) made Darwin look at Adam Smith and other Scottish economists and moral philosophers to see how a theory (that is, an explanation) with random elements can account for the stability of the social and economic order. In the moral and economic sphere the chance element is introduced by the assumption that the individual actors have free will. Yet there is an ensuing order (as if each individual were “led by an invisible hand”). We shall see in the next section that the review of Quetelet’s Sur l’homme which Darwin read in mid-September 1838 further emphasized this “population” approach.

111. Ruse and Mayr have both emphasized this point: Ruse, “Charles Darwin and Artificial Selection”; Mayr, “Evolution through Natural Selection.”

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I believe that the philosophy of individualism which Darwin reflects (in particular, the analogy of free agents and chance variations) is more characteristic of Smith's writings than of Malthus's. Individualism in Malthus is primarily expressed in man's exercise of moral restraint (in order to avert catastrophe) and does not animate his system. My emphasis on Smith's influence on Darwin also accounts for the somewhat guarded optimistic naturalism that Darwin expresses. It reflects Smith's view. The Malthusian mood is more somber and pessimistic. *The Essay on Population* was after all originally written to disprove the perfectibility of man.

6. DARWIN, QUETELET, AND MALTHUS

We have seen that by the end of August 1838 Darwin had read and thought deeply about the Brewster review of Comte's work. Any theory to explain the process of transmutation he would develop thereafter would have to have quantitative elements in it and should be able to make definite predictions, preferably quantitative numerical predictions. Finally, the theory would have to be deterministic.

It is at this stage that Darwin turned to Quetelet's work, probably to look for a quantitative statement relating to variations. On page 268 of the B notebook, written around this period, there is an entry:

Find out from Statistical Society where M. Quetelet has published his laws about sexes relative to age of marriage.

On page 152 in the back section of the D notebook, to which Darwin had skipped, is a bibliographic note dated September 11, 1838, stating that he had found the answer to his query about Quetelet. The entry reads:


114. See, e.g., the concluding paragraph in chap. III of the *Origin*; see also the *Autobiography*, p. 88.

115. That Darwin was looking at Quetelet is quoted in *Darwin on Man*, p. 170.
In the Athenaeum numbers 406, 407, 409 Quetelet papers are given & I think facts there mentioned about proportion of sexes, at birth & causes

The three articles referred to are the three parts of a lengthy review of Quetelet's *On Man and the Development of His Faculties (Sur l'homme et le développement de ses facultés)* which appeared in August 1835 in the *Athenaeum*, a very influential and widely read journal. The catalogue of the *Library of Charles Darwin Now in the Botany School, Cambridge*, indicates that Darwin possessed Quetelet's *Sur l'homme* (Paris 1835).

Quetelet's work was well known in England in 1838. Quetelet had visited England in 1827 and met Herschel at that time. Whewell had invited him to attend the 1833 BAAS meeting at Cambridge. Quetelet played a crucial role in establishing the statistical section of the BAAS at that meeting and was influential in the formation of the Statistical

116. The *Athenaeum* chronicled the meeting of all the scientific societies in England: the Astronomical, Botanical, Geological, Geographical Statistical Society, Meteorological Society, the BAAS, the Royal Society, etc. The often very extensive reports of these meetings were made by influential members of the societies concerned: Airy, Herschel, Lyell, Sedwick, Playfair, Russell, Lindley, de Morgan, Bucher, among others. See Leslie A. Marchand, *The Athenaeum: A Mirror of Victorian Culture* (Chapel Hill: University of North Carolina Press, 1941).

117. The books are now in the library at Down House. They contain no annotations. I thank Mr. Titheradge, the curator at Down House, for communicating this fact to me.

118. There is no modern biography of Quetelet. As with most matters dealing with the history of science in the nineteenth century, an enlightening discussion is to be found in J. T. Merz, *A History of European Scientific Thought in the Nineteenth Century* (New York: Dover Publications, 1965), 11, 563 ff. J. Lottin, *Quetelet, statisticien et sociologue* (Paris, 1912), is the most complete biography to date. Biographical material may be found in the article by David Landau and Paul F. Lazarfeld on Quetelet in the *Encyclopedia of the Social Sciences*. This article also contains a useful supplementary bibliography which is a good starting point for further studies of Quetelet. The most complete bibliography on Quetelet to 1966 is in Liliane Wellens-de Donder, “*Inventaire de la correspondance d'Adolphe Quetelet déposée à l'Académie Royale de Belgique,*” *Mémoires de l'Académie Royale de Belgique, Classe des Sciences*, 37, no. 2 (1966). See also P. Lazarfeld, *Quantification in Sociology in Quantification: A History of the Meaning of Measurement in the Natural and Social Sciences*, ed. Harry Woolf (Indianapolis: Bobbs Merrill, 1961; Victor Lowell Hills, “*Statist and Statistician: Three Studies in the History of Nineteenth Century Statistical Thought.*” Ph.D. diss., Harvard University, 1967; and Hilts, “Statistics and Social Science,” in Giere and Westfall, eds., *Foundations of Scientific Method*. See also the informative contribution of Marion Patricia Johnson, “The Origins of Adolphe Quetelet's Social Physics,” unpub. senior thesis in the Department of the History of Science, Harvard University, 1976.
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Society of London in 1834.\(^1\)\(^1\)\(^9\) He was a close friend and correspondent of Babbage and others in that small circle of influential persons that dominated the British scientific scene in the 1830's. Quetelet's correspondence is one of the many impressive things about this very influential (but underrated) Belgian.\(^1\)\(^2\) By 1838 his correspondents in England included, among others, Airy, Babbage, Brewster, Herschel, Faraday, Lyell, Porter, Sabine, Nassau Senior, and Whewell.\(^1\)\(^2\) Quetelet assiduously kept them informed of his scientific research, which by 1835 centered almost exclusively on the vital statistics of populations and the statistical description of social phenomena.

The *Athenaeum* review of Quetelet's *Sur l'homme* concluded with the following remarks:

We have bestowed more space upon M. Quetelet's highly-important "Essay" than comports perhaps with the general interests of our journal; yet at every step of our very imperfect analysis, we have been cribbed and confined by the quantity of matter, and compelled to leave untouched much that is valuable and curious. To the zeal and perseverance of the author, the science is deeply indebted for much of the progress it has made, and for much of the importance it has recently acquired in the eyes of philosophical Europe.

We consider the appearance of these volumes as forming an epoch in the literary history of civilization.

It is certainly the case that in 1837-38 Babbage, Lyell, and Whewell knew intimately the activities of the London Statistical Society and appreciated Quetelet's influential work. Whewell, for example, prepared the questionnaire on education and literature for the Statistical Society. It was one of the numerous interrogatories that the Society planned to issue in 1837.\(^1\)\(^2\) Whewell and Darwin met often from 1837 to 1839 at the executive meetings of the Geological Society.


\(^1\)\(^2\) The inventory by Wellen-de Donder lists over 2700 letters from scientific correspondents.

\(^1\)\(^2\) The inventory of Wellens-de Donder lists 7 letters from Babbage dating from 1826 to 1838. From 1832 to 1838 there are 4 letters listed from Airy, 6 from Whewell, and 7 from Nassau Senior.
Similarly, Darwin knew Babbage well. Babbage was instrumental in establishing the statistical section of the BAAS and was one of the founders of the London Statistical Society.\(^{123}\) Darwin notes in his Autobiography that after his marriage in 1839 he “used to call pretty often on Babbage and regularly attended his famous evening parties,”\(^{124}\) and he undoubtedly was acquainted with Babbage before his marriage. In 1838 Darwin had refused invitations to Babbage’s parties at Dorset Street because “I would be sure to meet people to whom I had sworn that I never went out.”\(^{125}\)

I believe that the idea of the printed list of “Questions about the Breeding of Animals,” the interrogatory which Darwin sent to animal breeders in early 1839,\(^{126}\) stems from his interactions with Babbage and Whewell. Gruber and Barrett have discovered an earlier handwritten list addressed to a Mr. Wynne, which very probably became the basis of the later printed version of the questionnaire.\(^{127}\) They attribute a mid-1838 date to the handwritten list. That Darwin should turn to Quetelet’s work to try to obtain quantitative statements regarding variations and populations is thus not surprising.

122. See the Prospectus of April 23, 1834, of the Statistical Society, published in The Annals of the Royal Statistical Society, 1834-1934. The ideas of interrogatories was adopted at the July 1836 meeting of the Society.


124. Autobiography, p. 108. Darwin was reading Babbage’s Ninth Bridgewater Treatise on December 2 or 3, 1838, and it is there that he came across Herschel’s statement calling the appearance of new species “the mystery of mysteries”; E, p. 59. He probably had seen the statement earlier in Herschel’s letter to Lyell, which was printed in Proc. Geo. Soc. London, 2 (1834-37).

125. Undated letter of C. Darwin to C. Babbage, quoted in Moseley, Irascible Genius, p. 235. Also, in the already quoted letter of September, 13, 1838, that Darwin wrote to Lyell, he speaks of Babbage in a way indicating that he knows him: “I have been much amused with an account I have received of the wars of Don Roderick (Murchinson) and Babbage. What a grievous pity it is that the latter should be so implacable.” The account Darwin refers to is of the 1838 meeting of the BAAS. In a letter to his sister Caroline dated February 27, 1837, Darwin wrote that Lyell wanted him to be present “for a party at Mr. Babbage, who sent me a card for his parties this season. Lyell says Babbage’s parties are the best in the way of literary people in London – and there is a good mixture of pretty women.”


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At the meeting in Cambridge in 1833 of the British Association for the Advancement of Science and in all his subsequent correspondence and lectures, Quetelet propagated intensely for the use of the methods of the quantitative sciences, particularly statistics, in the social sciences. For Quetelet, statistical regularity mirrored the order and regularity to be found in social and moral phenomena, and statistical laws were to form the basis of the science of social phenomena. The statistical regularity of birth rates, death rates, and crime rates were interpreted by Quetelet as indications of the stability of the social system.

Quetelet, if not in fact certainly in spirit, was a student of Laplace. While in Paris from 1823 to 1824, he had thoroughly studied Laplace’s and Fourier’s work on probability and statistics. He had also mastered Laplace’s astronomical work. Laplace’s demonstration that the regularity of birth and death rates could be explained in terms of Bernouilli’s theorem (rather than by appeal to divine wisdom) had impressed Quetelet deeply, as did Laplace’s demonstration of the stability of the solar system. Concern with stability is an essential feature of Quetelet’s work.

It should be emphasized that Laplace’s researches in celestial mechanics and in probability were intimately connected. His major reason for clarifying and developing probability notions was to fashion and perfect tools to assist in the search for causes in a deterministic universe. Quetelet was aware of this, and his justification for the search for statistical laws governing social phenomena reflects his mentor’s views.

In *Sur l’homme* Quetelet dealt with many of the questions that were uppermost in Darwin’s mind. The purpose of *Sur l’homme*, Quetelet states,

is to study in their effects the causes, whether natural or disturbing, which influence human development; to endeavour to measure the

128. Quetelet had been sent to Paris by Falck, the Dutch minister of education, to study astronomical instrumentation because he had become very much involved in plans to build an astronomical observatory near Brussels. The École Polytechnique became his intellectual center of gravity, and his Paris stay of 1823-24 is the starting point of his subsequent intellectual career. See Johnson, “The Origins of Adolphe Quetelet’s Social Physics.” See also Lottin, *Quetelet*, p. 153, for the possible influence of Saint-Simon and Comte on Quetelet.

129. Roughly speaking, Bernouilli’s theorem states that an event which occurs with a probability $p$ will appear $pN$ times in $N$ trials; i.e., it will appear with a frequency $pN/N = p$, as the number of trials in increased indefinitely. Bernouilli’s theorem could thus be construed as giving a mathematical reason for the existence of statistical regularity whenever there seemed a “constant cause” in operation.


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influence of these causes, and the mode according to which they mutually modify each other.

It is not at all my intention to propose a Theory of Man, but merely to ascertain by proof the facts and the phenomena which affect him, and to endeavour by observation to discover the laws forming the connecting links of these phenomena . . .

The object of scientific research should be to inquire:
1. What are the laws of human reproduction, growth and physical force - growth of his intellectual powers . . . the laws regulating his passions and tastes . . . the laws of human mortality . . .
2. What influence has nature over man; what is the measure of its influence . . .
3. Finally, can human forces compromise the stability of the social system?131

In the first part of Sur l’homme Quetelet discusses his concept of the “average man” and the influence of disturbing causes.132 Quetelet there also states his mathematical version of the Malthusian law of limits to population growth; namely, that the obstacles to population increase “as the square of the rapidity with which it [the population] tends to increase.”

In the second book of Sur l’homme, Quetelet concentrates on questions (and laws) relating to human growth (each age has its typical height, intellectual achievement, propensity toward criminal activities, and so on). In the third and fourth books, Quetelet discusses average moral and intellectual faculties and their possible measurements. Throughout Quetelet retains his emphasis on the average man:

The greater number of individuals observed the more do individual peculiarities, whether physical or moral, become effaced, and leave in a prominent point of view the general facts, by virtue of which society exists and its importance is preserved.133

131. My quotations are from the English translation of Sur l’homme, which was published with a new introduction by Quetelet in 1842 by the Chambers brothers of Edinburgh: A Treatise on Man and the Development of His Faculties. This edition is available as a reissue from Burt Franklin Publisher, New York, 1968. R. Chambers is, of course, the author of Vestiges of Creation. The influence of Quetelet on that work has been noted by Milton Millhauser, Just before Darwin: Robert Chambers and “Vestiges”. (Middletown: Wesleyan University Press, 1959).

132. In chap. I of book I, which discusses “of births in general, and of fecundity,” Quetelet quotes Malthus’s observations regarding the ratio of births to marriage taken as a measure of fecundity.

133. Quetelet, A Treatise on Man, p. 2.
Chapter VII of *Sur l'homme* contains a clear outline of Malthus's essay on population:

It appears incontestible, that population would increase in a geometrical ratio, if no obstacle were presented to its development. The means of subsistence are not developed so rapidly; and according to Malthus, in the most favourable circumstances for industry, they can never increase quicker than in an arithmetical ratio.¹³⁴

The obstacle to population, then, is the want of food, proceeding from the difference of ratio which these two quantities follow in their respective increases. When a population, in its development, has arrived at the level of its means of subsistence, it ought to stop at this limit . . . or if it has the misfortune to overleap this limit, it must forcibly be brought back by an excess of mortality.

Quetelet, however, is not satisfied with Malthus's treatment of the "modus operandi of the obstacles" to population growth and proceeds to state his own version of the population laws:

Population tends to increase in geometrical ratio. The resistance, or sum of the obstacles to its development, is, all things being equal, as the square of the rapidity with which it tends to increase.

It is not clear how carefully Darwin looked at his copy of Quetelet's *Sur l'homme* in view of his difficulties with French.¹³⁵ However, the entry of September 11, 1838, on pages 152-153 of the D Notebook indicates that he read the *Athenaeum* review of Quetelet's book.¹³⁶ The reviewer, after indicating what "causal" factors allow "chance" to enter in the description of complex phenomena, notes:

¹³⁴. The footnote on p. 48 in Quetelet's original text gives the reference to Malthus's French edition. It also calls attention to Nassau Senior's *Two Lectures on Population* and McCulloch's notes on Smith's *Wealth of Nations*.

¹³⁵. On October 30, 1838, Darwin records the following dream on p. 33 of the N notebook: "Dreamt somebody gave me a book in French. I read the first page & pronounced each word distinctly. Woke instantly but could not gather general sense of this page. . . Now when awake I could not picture to myself reading French book quickly, & running over imaginary words: it appears | as if the mind had dwelt on each word separately, neglecting time, & general sense, any more than connected with general tendency of the dream".

¹³⁶. I conjecture that the review was written by George Richardson Porter (1792-1852), who at that time was the head of the statistical department of the Board of Trade. He was also one of the promoters of the Royal Statistical Society and of Section F of the BAAS.
The application of this mode of seeking after certainty and reducing hazard to a determinate law, has long been applied by gamblers to the events of game of chance; and by insurance companies, to determining the probable duration of human life, and the still more apparently incalculable chances of fire and shipwreck. In the latter instance, it seems at first sight absolutely impossible that the action of elements, so proverbially inconstant, should be reducible to any rule: yet so much otherwise is the fact, that though particular underwriters may in any given year be ruined by some great storm wrecking particular fleets of large value, the general business of an underwriter is as certainly prosperous as any other brand of industry; while competition keeps down the rate of insurance very closely to the real extent of the risk.

This degree of certainty having been reached where accident seems to reign exclusively, it is not surprising that philosophers should have been tempted to apply so available a method to the appreciation of physiological and social facts and to the assignment of the laws which regulate the “development of the faculties of man.”

This then introduces the subject of Sur l'homme. Certain particulars in man may be regarded as fixed (“every perfect man has a heart, lungs, ...”), and certain others as not – those which admit of considerable variations in different individuals (“every man has not the same complexion, stature, weight”). Since these variations are confined to fairly narrow limits, one can form the “abstract conception of an imaginary being called ‘man,’” to whom a long series of propositions are applicable “though not strictly and rigourously predictable of any one man.” The reviewer continues:

But while no particular human being is found precisely identical with this imaginary “man” yet if any number of men [be] taken at hazard there will be observed a manifest tendency to approach to it: and the larger the number, the more close will be their average

Several comments in the review, particularly the footnote deploring the fact that in England “so many institutions tend powerfully to promote the concentration of promotion of property into a few hands,” indicate that the reviewer held liberal views. Porter would fit that bill. Porter also had extensive correspondence with Quetelet during this period. He was at that time writing his very influential Progress of The Nation in Its Various Social and Economical Relations from the Beginning of the Nineteenth Century to the Present Time, the first volume of which appeared in London in 1836. He was therefore in total command of all the materials found in Quetelet’s book.

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approximation to that standard . . . a perfect and complete determination of the attributes of this abstract being is an essential preliminary to an efficient discharge of the task of legislation; and it is a matter of experience, that false and superficial notions of human nature have introduced some of the most fatal errors in social institutions of nations. If therefore, the application of a scientific method shall succeed in giving a greater precision to the received ideas on this point, a vast and important advantage will be obtained.

A much more detailed outline of the book than I have given earlier in this section constitutes the bulk of the review. Many facts regarding births, deaths, and mortality (with an emphasis on the differences between the two sexes) and some discussion of possible causes for the observed statistics are given. 137 “On the general question of population,” the reviewer notes:

Mons. Quetelet agrees very closely with the views of Malthus, which he reduces to the following formulae: — “Population tends to increase in a geometrical ratio. The sum of the obstacles, which are opposed to this tendency is, caeteris paribus, as the square of the rapidity of actual increase” — another instance of the analogy often found to subsist between mechanical laws and those which govern human action. “Never, therefore, can population advance so rapidly as to strike with violence upon its utmost possible limit. In approaching that limit the obstacles must multiply too rapidly to admit of a shock. Nature will, it is true, levy her tribute of dead in proportion to the nearness of approach; but, that debt being paid in detail, it will be less sensible than if levied at once.”

The review ends with a summary of the fourth part of Sur l’homme, in which the reviewer notes:

Mons. Quetelet enters upon his résumé of the average man – that is, on the philosophy of the facts contained in the preceding books. The

137. The review is particularly valuable in giving some fine insights into the “atmospherics” of the statistical movement during the 1830’s in Great Britain. The concerns which animate the statisticians (the relations between social conditions and health, mortality, crime, education, etc., and the prerequisites for the amelioration of the society) are clearly apparent in capsule form. The reviewer has not yet recovered from the shock created within the British statistical community by Gerry’s heresy in 1833. See Cullen, The Statistical Movement in Early Victorian Britain.
subject is not, he observes, a matter of mere idle speculation, since this ideal abstraction is the centre of gravity, on which the movement of society turns.

He continues:

The value of statistical tables for determining the average man in relation to the natural and medical sciences, is self-evident. All medical theories repose upon the supposition of such an abstraction; as all medical practice turns on the observation and calculation of the several divergences from it, peculiar to each individual patient. Hitherto the determination of the several attributes, in health and in disease, of this ideal being has been too vague and general, and medical theory consequently has been, and is, subject to endless and vexatious uncertainty and variation.

The reviewer then notes that the chapter in which Quetelet considers the average man in relation to the moral and intellectual attributes "is full of curious and ingenious remark, and it will repay" perusal. From the section where Quetelet examines points relative "to the differences between average man of a peculiar time and country, and the average type of humanity, with a view to determining in what particulars man is a stationary, and in what a perfectible, being," the reviewer quotes Quetelet's statement: "If an individual at any given epoch of society possessed all the qualities of the average man, he would represent all that is great, good, or beautiful." But the reviewer questions whether, in such a being, the springs of action would not be so accurately balanced as to neutralize each other. Our conception of the great, good and beautiful, we rather think contains, in a certain degree, the idea of excess; so that it is no play upon words to say, that the "homme moyen" would be a mediocre personage... is not a certain degree of physical insensibility necessary to the beau ideal of courage! a certain indifference to externals necessary to the power of profound generalization? a certain defect in the power of considering things in their unity necessary to the power of noting and imitating individuals in the arts, etc? The idea of perfection, then, is not, we think to be sought in uniformity of individuals, but in their endless variety, and in the balancing of their several attributes in social co-operation.

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It would be difficult to give a more concise statement of "population" thinking.

Quetelet's emphasis on the average man would clearly efface the advantage toward adaptation of any individual variation. Darwin therefore could not accept any argument which makes the "average" the "center-of-gravity" of a quantitative approach. Nor could Darwin accept the seemingly time-independent viewpoint Quetelet presented. He was, after all, searching for an evolutionary - time-dependent - dynamic theory. As the reviewer emphasized, a dynamic theory (which would account for perfectibility) "is not, to be sought in uniformity of individuals, but in their endless variety, and in the balancing of their several attributes in social co-operation." Reading the Quetelet review had, however, given Darwin the insight he needed: the Malthusian statement of population growth. And he proceeded for "his amusement" to read Malthus in the original version.

7. THE SYNTHESIS

We are now ready to weave the strands together. By August 1838 Darwin had accepted the facts that (1) small variations were copious, undirected, and random when located on individuals and were to be accepted as empirical (phenomenological) facts; and (2) small variations were hereditary.

Reading Brewster's review of Comte in early August 1838 refocused Darwin's attention on "picking" by breeders and suggested to him that artificial selection might play the role of the "experiment" in the complex phenomena encompassed by "transmutation of species." It also helped confirm the previously discerned role of selection in adaption. Indeed, in 1859 Darwin himself corroborated this view. In a letter to Wallace he wrote, "I came to the conclusion that selection was the principle of change from the study of domesticated productions." As Gavin de Beer has claimed, Darwin thereafter was undoubtedly looking for a corollary to artificial selection in the "state of nature." His reading of Dugald Stewart, Adam Smith, and the other Scottish philosophers, helped make individuals and their variations the focus of his theory. (Individuals had already been the focus of his thesis of variability.)

His search for a quantitative statement led to Quetelet and Malthus. In connection with the Malthusian episode and its import, it should be


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pointed out that Darwin had in fact already seen the Malthusian statement of population growth while an undergraduate at Cambridge. Chapter XXVI of Paley's *Natural Theology* contains a discussion of physical evils and states:

Mankind will in every country *breed up* to a certain point of distress. That point may be different in different countries or ages, according to the established usages of life in each. It will also shift upon the scale, so as to admit of a greater or less number of inhabitants, according as the quantity of provision, which is either produced in the country, or supplied to it from other countries, may happen to vary. But there must always be such a point, and the species will always breed up to it.

The order of generation proceeds by something like a geometrical progression. The increase of provision, under circumstances even the most advantageous, can only assume the form of an arithmetic series. Whence it follows, that the population will always overtake the provision, will pass beyond the line of plenty, and will continue to increase, till checked by the difficulty of procuring subsistence.* Such difficulty therefore, along with its attendant circumstances, *must* be found in every old country.

*See a statement of this subject, in a late treatise upon population.

Clearly at that time Darwin was not ready to apprehend the importance of these statements and must have forgotten them. It was only in 1838, after the *Beagle* voyage and his communion with Nature, after his readings and speculations, and after his confrontations with the biological facts and problems, that the quantitative Malthusian statements could be accommodated. "The mind has to be not only prepared but cocked ahead of time." 140

Reading about the Malthusian principles of population growth sometime in the middle of September 1838 now helped fit the separate pieces into a coherent whole. 141 In the Malthusian formulation Darwin

140. C. C. Gillespie, private communication. Incidentally, Darwin had also come across the Malthusian statement in 1833 in A. von Humboldt's *Political Essay on the Kingdom of New Spain* (New York: 1. Riley, 1811) which he got in Buenos Aires when the *Beagle* anchored there.

141. On September 21, Darwin records the following dream in his M notebook, pp. 143-144: "Was witty in a dream in a confused manner. Thought that a person was hung & come to life, & then made many jokes about not having run away & having faced death like a hero." Gruber, in *Darwin on Man*, p.43, interprets this dream of execution of a witty man "as Darwin dreaming of himself being punished for his ideas." I would suggest that it also indicates that his ideas, although still somewhat "confused," clearly reflected an apprehension of a coherent whole. In other words, by September 21 Darwin had appreciated the Malthusian principle and its eventual place in his theory.

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had found a *quantitative, deterministic* formulation of the superfecundity principle. The Malthusian formulation allowed superfecundity to be the force behind natural selection. As Limoges puts it: "the idea of a geometric progression implies that a constant pressure is exerted on the living, engendering an incessant war, the ancestral form of population pressure of present day population genetics."\(^{142}\)

Furthermore, the Malthusian principle accounted for the *dynamical* stability of the process: "if a population have the misfortune to overlap this limit [its means of subsistence] it will forcibly be brought back by an excess of mortality."\(^{143}\) Darwin had read Herschel, Whewell, and Brewster on Comte. All had stressed the importance of accounting for the dynamical stability of systems. Darwin could not have found acceptable a theory which did not account for the stability of the evolutionary process. Here then was not only the mechanism which allowed any small perturbation to be damped out, and the population of any one species to oscillate about a stable mean,\(^{144}\) but also the mechanism by which the better-adapted forms could establish themselves and the less favored be weeded out – "to sort out proper structure & adapt it to change."

The pieces which Darwin had previously apprehended *separately* were now molded together into an evolutionary theory. I am suggesting that after reading the Malthusian statement of population in the Quetelet review Darwin had discerned most of the argument as it appeared in the *Origin*. This argument can be summed up in a few principles:

1. Small variations are hereditary.

142. Limoges, *La sélection naturelle*, p. 79.
143. Quetelet, *A Treatise on Man*, p. 49. The statement in the Quetelet review, quoted above, also emphasized the role of mortality in stabilizing the population. Interestingly, Wallace in 1858, in his paper "On the Tendency of Varieties To Depart Indefinitely from the Original Type", likewise indicates that "The action of this principle is exactly like that of a centrifugal governor of the steam engine, which checks and corrects any irregularities almost before they become evident; and in like manner no unbalanced deficiency in the animal kingdom can ever reach any conspicuous magnitude, because it would make itself felt at the very first step, by rendering existence difficult and extinction almost sure to follow." In other words, the principle guarantees the stability of the process. This Wallace article is reprinted in A. R. Wallace, *Contributions to the Theory of Natural Selection: A Series of Essays* (New York: Macmillan, 1870).
144. In the "Essay" of 1844, in Darwin's discussion of natural selection, there occurs the following pregnant phrase on p. 46: "Malthus on man – in animals no moral [check] restraint – they breed in time of year when provision most abundant, or season most favourable every country has its season – calculate robins – oscillating from years of destruction."
2. Organisms tend to produce many more offspring than can be supported.
3. A struggle for existence inevitably follows from the high rate at which organisms tend to increase.
4. In the ensuing struggle for existence, favorable variants are preserved, less favorable ones weeded out. (This, of course, is the principle of natural selection.)
5. The effect of natural selection is to adapt species to changing circumstances.

I agree with de Beer and Limoges that "internal" factors were sufficient for Darwin to arrive at the notion of "selection owing to struggle." It seems to me that the notebooks support the view that Darwin was struck with the numerical and deterministic aspect of the Malthusian statement. The D notebook of September 28 contains the following record:

(I do not doubt every one till he thinks deeply has assumed that increase of animal exactly proportionate to the number that can live.
- ) Even the energetic language of <Malthus> De Candolle . . .

And further on:

yet until the one sentence of Malthus no one clearly perceived the great check amongst men . . . (The final cause of all this wedging, must be to sort out proper structure & adapt it to change – to do that for form, which Malthus shows is the final effect (by means however of volition) of this populosity or the energy of man) one may say there is a force like a hundred thousand wedges trying force every kind of adapted structure into the gaps in the economy of nature, or rather forming gaps by thrusting out weaker ones.

145. Recall that inside the front cover of the D notebook, Darwin entered the statement: "Towards close I first thought of selection owing to struggle.
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The juxtapositions of the quantitative numerical Malthusian relation with that of a “force like a hundred thousand wedges” is to be noted. This juxtaposition implies that two criteria are simultaneously satisfied: on the one hand, Comte’s and Herschel’s criterion that the best laws are *quantitative* and, on the other, Herschel’s criterion of force as a “*vera causa*.”

The wedge analogy is used by Darwin in the “Essay” and in the *Origin*. But it is most forcefully expressed in *Natural Selection*:

Nature may be compared to a surface covered with ten-thousand sharp wedges, many of the same shape and many of different shapes representing different species, all packed closely together and all driven by incessant blows: the blows being far severer at one time than at another; sometimes a wedge of one form and sometimes another being struck; the one driven deeply in forcing out others; with the jar and shock often transmitted very far to other wedges in many lines of direction: beneath the surface we may suppose that there lies a hard layer, fluctuating in its level, & which may represent the minimum amount of food required by each living being, & which layer will be impenetrable by the sharpest wedge.”

The insight the Malthusian statement in the Quetelet review gave to Darwin was the intensity and pervasiveness of the struggle. I believe that Darwin immediately apprehended how this struggle would lead to selection acting on individuals – whether the struggle was interspecific or already intraspecific, as in the case of sexual selection. There was never any question after August 1838 that selection in nature (whatever its origin) would act on individuals of a given population.

I will show in section 8 that by the end of August 1838 Darwin was an agnostic. He certainly no longer believed in “contrivance.” Moreover, at

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147. Cf. Vorzimmer, “Darwin, Malthus,” and Ghiselin, *The Triumph of the Darwinian Method*. A similar conclusion based on Herschel’s influence was reached by Ruse, “Darwin’s Debt to Philosophy.” *Studies in Hist. Phil. Science*, 6 (1975), 159-181. I came across this article after completing this paper. Interestingly, Ruse comments in his note 51 “that in August 38 Darwin read with avid interest a review by Sir David Brewster of Comte’s *Cours de Philosophie Positive*. What he would have got from this is that the aim of a science is the positive stage, that the fundamental character of *Positive Philosophy* is to regard all phenomena as subjected to invariable natural laws” (p. 281) and that “the best of all laws is the Newtonian law of gravitational attraction” (p. 282).


the end of August 1838 Darwin certainly accepted at least the Lyellian and de Candolliam view of the struggle in nature. To my mind, these facts mute and weaken the thesis advanced by Kohn that “the key to Malthus' [Essay] influence was that he destroyed the harmonious interpretation of the balance of nature which Darwin had absorbed as much from Lyell as from Paley.” 151 Perhaps. But my point is that by mid-September, there were no blocks to allowing any intermediate cause or mechanism to take its course. The Malthusian statement of population growth was all Darwin needed. Thus I am arguing that after reading the Quetelet review, but before September 28, the theory had essentially crystallized. As further corroboration of this assertion, I suggest that once Darwin had read the Malthusian statement of population growth, it was not fortuitous that he should again turn to Ehrenberg's work on the quantitative aspect of the phenomenal growth of infusoria (which he had earlier noted in the C notebook, p. 143) and record on September 25, 1838:

One invisible animalcule in four days could form 2 cubic stone, like that of Billin. (D, p. 167) 152

This statement says “could”. The Malthusian statement says that population, if unrestrained, grows in a geometrical ratio.

What then did Darwin get from reading Malthus's Essay on the Principles of Population on September 28, 1838? I believe that the further important insight which Darwin obtained from reading Malthus's Essay is the relation of the process of transmutation and, particularly, of extinction to the struggle for existence. David Kohn 153 has convincingly shown there was in Darwin's mind a parallel between process determining the life and death of individuals and those affecting the origin and extinction of species. In the early stages of the B notebook, on page 63, Darwin wrote

They die, without they change like Golden Pippins, it is a generation of species like generation of individuals 154

Kohn has interpreted this passage to mean that Darwin thought extinction would occur unless there was a change in the physical

151. Kohn, “Charles Darwin's Path to Natural Selection.”
152. “Billin” should probably have been transcribed as “Billion.”
154. The Golden Pippin was a variety of apple tree introduced in England from France in the seventeenth century; it was maintained by grafting rather than sexual crossing until the beginning of the nineteenth century, when it became extinct.

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environment or a change of the individual as a result of sexual mating with slightly different individuals. That this view was still held by Darwin in the summer of 1838 is indicated by this notebook entry:

The constitution being hereditary & fixed certain physical changes at last become unfit the animal cannot change quick enough & perishes. (C, p. 153)

Similarly, Darwin persistently regarded the transmutation of species as comparable to reproduction in individuals. I believe that Kohn is therefore right in asserting that Malthus gave Darwin the insight that:

the extinction and origin are inextricably linked with the struggle for existence. From July 1837 on he had sought to explain the final cause of death, i.e. to answer the question “Why is life Short?” Now however he understood the creative power of death.

Indeed, while reading the Essay, Darwin quotes Malthus (E, p. 3):

. . . since the world began the causes of population & depopulation have been probably as constant as any of the laws of nature with which we are acquainted

And Darwin continues

This applies to one species. – | would apply not only to population & depopulation, but extermination & production of new forms – this number & correlations |

Darwin had tasted the fruit of the tree of knowledge. No wonder the Malthusian episode had deep meaning for him for the rest of his life!

I believe there is another insight, not hitherto alluded to by anyone, which Darwin obtained from Malthus’s Essay. The Essay suggested to Darwin that there are difficulties in correlating the time scales of extinction and transmutation of species with the time scale of geological phenomena.

It should be recalled that the statement of Malthus’s law in Quetelet and in the Quetelet review did not include the time scale for the geometrical progression. It is certainly possible to arrive at the concept of struggle from this time-independent statement and to obtain the connection between natural selection and “adaptation of forms.” The

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process of extinction can likewise be understood, provided that one believes, as Darwin did until that time, that the extinction of species is a slow process correlated with lack of adaptation to a slowly changing environment.

At the beginning of September 1838, Darwin stated his views on these matters as follows:

When we multiply the effects of earthquakes, elevating forces in raising continents, sea on beaches we really measure the rapidity of change of forms & instincts in the animal kingdom. — It is the unit of our calendar — epochs & creations reduce themselves to revolutions of one system in the Heavens. — (D, p. 140)

In other words, Darwin then believed that the geological time scale determined "the rapidity of change of forms," that is, that the rate of transmutation and extinction of species is determined by the rate of geological change.

In his Essay Malthus stressed the time scale for the geometrical growth in the famous "one sentence" which so impressed Darwin: "population, when unchecked, goes on doubling itself every twenty-five years, or increases in a geometrical ratio." I believe it was the time scale which struck Darwin in his second reading of the population law. This would account for the "FAR SHORTER" and the underscoring of the "few" years in the famous September 28 entry:

population in increase at geometrical ratio in FAR SHORTER time than 25 years — yet until the one sentence of Malthus no one clearly perceived the great check amongst men . . . Even a few years plenty, makes population in men increase & an ordinary crop cause a dearth.

I believe that on reading the Essay Darwin realized that the time scale for the extinction of species might, at times, be much shorter than he had believed at the beginning of September. This interpretation is corroborated by the fact that on October 4 Darwin enters the following in his E notebook (p. 5):

Those who have studied history of the world most closely & know the amount of change now in progress, will be the last to object to the theory on the score of small change — on the contrary islands separated with same animals etc. — if the change could be shown to be
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*more rapid* [italics mine] I should say then some link in our train of geological reasoning extremely faulty... it is curious that geology by giving proper ideas on these subjects should be *absolutely necessary* to arrive at right conclusion about species. Changes of level etc. are easily recorded, but change of species not as—without every animal preserved. My theory requires each form to have lasted for its time: but we ought in same bed if very thick to find some change in upper and lower level... Study introduction to Cuviers Règne Animal

I interpret this to mean that the rapidity of the process suggested by Malthus conflicts with Darwin's geological views. Darwin must have been pondering this matter, for he returns to the subject a few days later on page 16 of the E notebook:

Species not being observed to change is very great difficulty in thick strata can only be explained by several strata being merely leaf...

Still pondering the question, Darwin observes on November 1:

If species change, we see external conditions have great effect on them & therefore extermination becomes part of same law. – When a species becomes rarer, as it progresses toward extermination, some of the species must increase in number. Where then is the gap, for the new one to enter? – (E, p. 43)

And a few days later, Darwin records the following:

When discussing extinction of animals in Europe; the forms themselves have been basis or argument of change. – now take greater area of water & snow line descent. I do not wish to say only cause, *but one great final cause* [italics mine], nothing probably exists for one cause. My theory gives great final cause of sexes in separate animals: for otherwise there would be as many species, as individuals, & though we may not trace out all the ill effects, – we see it not the other in this perfect world, either | at the present, or many anterior epochs. – but we can see if all species, there would not be social animals. hence not social instincts, which as I hope to show is probably the foundation of all that is most beautiful in the moral sentiments of the animated beings – etc this is stated too strongly. for there would be innumerable species & hence few only social there could not be one body of animals. life with certainly another (E, pp. 48-49)

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It is clear that in Darwin's mind the problem of the extinction of species is associated with Malthus. Malthus in the opening page of his Essay had stated:

The principal object of the present essay is to examine the effects of one great cause [italics mine] intimately united with the very nature of man; which though it has been constantly and powerfully operating since the commencement of society, has been little noticed by the writers who have treated this subject... The cause to which I allude is the constant tendency in all animated life to increase beyond the nourishment prepared for it.

The realization that the extinction of species can come about from different causes, and that the time scale may differ according to cause, implies that geological dating based on the fossil record of extinct animals must be handled with care.155 Darwin sees this clearly by December 25, 1838:

Lyell says the elevated shells in Bayfields district are much more like those of Scandinavia than the N. American species — Dr. Bech says the shells in Scandinavia from height of 200 & 300 ft are identically same as those of present seas — now in this country we have better means of judging the slowness of physical changes than in any other & yet 200-300 ft no elevation & no change & even no loss of species

It must never be overlooked that the chronology of geology rests upon amount of physical change & only secondarily, by assumption well grounded, on time; — therefore the mere loss of species, which may be the works of a few years as with the Lamantin of Steller tells us much less though it also the effect of change, than a slow gradation in form which must be effect of slow changes & therefore precludes effects of catastrophes, which must serve to confound our chronology. CONSIDER ALL THIS.
- Extinction & transmutation, two foundations, hitherto confounded, of geology (E, p. 87e)

155. The use of the fossil record to set up a quantitative geological chronometer is discussed at length in vol. III of Lyell's Principles of Geology. For Lyell the working of this chronometer depended crucially on his belief that over the past there was an essentially uniform rate of change in the organic world. Based on this, Lyell suggested that quantitative estimates of the relative ages of any two deposits could be obtained by comparing the proportion of extinct to extant species in each. See M. J. S. Rudnick, "The Strategy of Lyell's Principles of Geology," Isis, 61 (1970), 5-33.

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The resolution of the problem is at hand.156 The connection of transmutation and extinction to the struggle for existence has, however, stood the test unshaken.

How much we attribute to the Malthusian insight is to a certain extent a reflection of our proclivities. My own reading is that the Malthusian statement gave Darwin the quantitative element he needed to make the theory meet the standards of theories in the natural sciences. It was also the important antichance deterministic element. For the Malthusian principle and the struggle for existence it entails, as Darwin emphasized, "will determine that those variations, however slight which are favourable shall be preserved or selected, and those which are unfavourable shall be destroyed."157

The Malthusian element "by the inevitability of widespread mortality and the rigourness of selection" accounted for the "stability of the system" and also made the overall description a deterministic one. That the overall theory had to be deterministic was never questioned by Darwin. As I have stressed in section 5, Darwin fully subscribed to the deterministic tenets of his scientific generation.158 In his Natural Selection (p. 198) Darwin notes:

The chemist may throw a dozen salts into solution and may hope to predict the result; the naturalist cannot do this with the living beings dispersed by ten thousand ingenious contrivances all round him; but when we see the virgin forest reassuming its beautiful variety apparently in the same exact proportions, over the ancient Indian ruins, we must see how little of what we call chance has to do with the final result.

In the Origin, this and the previous paragraph in the Natural Selection are amplified:

When we look at the plants and bushes clothing an entangled bank, we are tempted to attribute their proportional numbers and kinds to what we call chance. But how false a view is this! Everyone has heard

156. See part II of the "Sketch" of 1842, particularly sect. V on extermination; chap. V of the "Essay" of 1844; and chaps. IX and X of the Origin.
that when an American forest is cut down, a very different vegetation springs up; but it has been observed that the trees now growing on the ancient Indian mounds, in the Southern United States, display the same beautiful diversity and proportion of kinds as in the surrounding virgin forests. What a struggle between the several kinds of trees must here have gone on during long centuries, each annually scattering its seeds by the thousands; what war between insect and insect – between insects, snails and other animals with birds and beasts of prey – all striving to increase, and all feeding on each other or on the trees or their seeds and seedlings, or on the other plants which first clothed the ground and thus checked the growth of trees! Throw up a handful of feathers, and all must fall to the ground according to definite laws; but how simple is this problem compared to the action and reaction of the innumerable plants and animals which have determined in the course of centuries, the proportional numbers and kinds of trees now growing on the old Indian ruins!159

The requirements that the theory be quantitative, predictive, and deterministic have been fulfilled.160

8. DARWIN ON HIS RELIGIOUS BELIEF

There is another dimension to the M, N, and OUN notebooks. They record Darwin's growing agnosticism. These notebooks detail the search for a manifestation of God by a convinced evolutionist who has a unitary vision of the past and future history of the solar system. This vision includes the evolution of the planetary system, the evolution of the geological features of the earth, the evolution of the myriad forms of life on earth, of higher organisms, of mind, of human society and its institutions. And after December 1838, Darwin believes he can account for the evolution of the entire system by the operation of natural laws

159. Origin, p. 74.
160. There are of course many other quantitative, predictive, deterministic statements in both the "Essay" and the Origin, for example, the discussion of the relation of variation to the number of species and the size of genus they belong to. This question was already on Darwin's mind on December 2, 1838. E. p. 59 records the following: "Lyell letter Mr. Beck considers the characteristics of the Tropical Forms in shells are numerous species, numerous individuals & species of large size – consider this (cetacea) with reference to my theory." The quoted passage is, to the best of my knowledge, the one which most succinctly and beautifully expresses the relationship between the deterministic, the quantitative, and the predictive aspects of the theory.
without any divine intervention. The "fixed laws" of physics, chemistry, and natural selection (or its manifestation at higher levels in such principles as maximum pleasure or self-interest) can account for everything!

In the *Autobiography*, which Darwin started on May 31, 1876, in the discussion of his religious belief he notes that "during these two years I was led to think much about religion." Darwin also stresses the fact that he was very unwilling to give up his religious beliefs:

I feel sure of this for I can well remember often and often inventing day dreams of old letters between distinguished Romans and manuscripts being discovered at Pompeii or elsewhere which confirmed in the most striking manner all that was written in the Gospels. But I found it more and more difficult to invent evidence which would suffice to convince me. Thus disbelief crept over me at a very slow rate, but was at last complete.

There is a striking parallel between the discussion in his *Autobiography* and the material in the M, N, and OUN notebooks. Darwin had looked over his notebooks in May of 1873. Doing so must have recalled for him his struggles with his religious beliefs during the 1837-1839 period. He must also have used his M, N, and OUN notes while preparing the autobiographical passage on Religious Belief.

Compare, for example, the discussion in the *Autobiography* of pain and suffering and of pleasure and the relation of these feelings to natural selection with the entries in the M and N notebooks. In his *Autobiography* he adduces "the pleasure from exertion, – even occasionally from great exertion of the body or mind – the pleasure of our daily meals; and

161. E., p. 58, has the famous entry: "Three principles will account for all 1) Grandchildren like grandfathers 2) Tendency to small change especially with physical change 3) Great fertility in proportion to support of parent!” The entry on p. 59 is dated December 2.
163. Nora Barlow delineates the period from October 1836 to January 1839. I would characterize the time span as ranging from July 1837 to July 1839. Some of the OUN notebooks dealing with Mackintosh's *Ethical Philosophy*, "On the Moral Sense" [OUN, pp. 42-48], and with Whewell's discussion of conscience in his preface to the *History of the Inductive Sciences* are dated May 1839. The months of September and October 1838 seemed to have been crucial. Thus, Darwin's "Journal" for September 1838 records that: "All September read a good deal on many subjects, thought much upon religion. Beginning of October ditto."
especially in the pleasure derived from sociability and from loving our families” as supporting the thesis that “it has come to pass that most or all sentient beings have been developed in such a manner through natural selection, that pleasurable sensations serve as their natural guides.”

In the M notebook, pages 118 to 126 have a parallel discussion. Page 132e has the entry previously quoted:

I am tempted to say that those actions which have been found necessary for long generations (as friendship to fellow animals in social animals) are those which are good & consequently give pleasure & not as Paley’s rule.

In the *Autobiography*, after disposing of various arguments for proofs of the existence of God, Darwin writes:

At the present day the most usual argument for the existence of an intelligent God is drawn from the deep inward conviction and feelings which are experienced by most persons . . . But now the grandest scenes would not cause any such convictions and feelings to use in my mind. It may truly be said that I am like a man who has become colour-blind, and the universal belief by men of the existence of redness makes my present loss of perception of not the least value as evidence . . . Therefore I cannot see that such inward convictions and feelings are of any weight as evidence of what really exists. The state of mind which grand scenes formerly excited in me, and which was intimately connected with a belief in God, did not essentially differ from that which is often called the sense of sublimity; and however difficult it may be to explain the genesis of this sense, it can hardly be advanced as an argument for the existence of God, any more than the powerful though vague and similar feelings excited by music.

In the M notebook pages 36 to 39 give Darwin’s “Analysis of pleasures of scenery” and “4th pleasure of imagination, which correspond to those awakened during music.” These he jotted down in the week of July 15, 1838.

In March 1839, in the N notebook, page 107, Darwin asks:

165. Ibid., p. 89.
166. Ibid., p. 90.
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Does music bear any relation to the period when men communicated before language was invented – were musical notes the language of passion & hence does music now excite our feelings.

How does Social animal recognize / & take pleasure in / other animals ... – ideas of beauty of music are great distinguishing character between man & animals. –

Pages 18–20 in the OUN and page 57 in the N notebook record his struggle to apprehend the "genesis of the sense of the sublime." He was at the time reading D. Stewart’s essays\(^{167}\) on the sublime as well as Burke’s.\(^ {168}\)

What was left then was the argument that Brewster had used against Comte, in his discussion of Laplacian cosmogony: the argument of a First Cause. This is, of course, also Whewell’s argument in his Bridgewater treatise. Recall Brewster:

But even if science could go infinitely farther, and trace all the forms of being to their germ in a single atom, and all the varieties of nature to its development the human mind would still turn to its resting-point, and worship with deeper admiration before this miracle of consolidated power.

The *Autobiography* records that for a time Darwin considered himself atheist because of

the impossibility of conceiving this immense and wonderful universe including man with his capacity of looking far backwards and far into the futurity, as the result of blind chance or necessity. When thus reflecting I feel compelled to look to a First Cause having an intelligent mind in some degree analogous to that of man; and I deserved to be called a Theist.

This conclusion was strong in mind about the time, as far as I can remember, when I wrote the *Origin of Species*; and it is since that time that it has very gradually with many fluctuations become weaker. But then arises the doubt – can the mind of man, which has as I fully believe, been developed from a mind as low as that possessed by the

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lowest animal, be twisted when it draws such grand conclusions? May not these be the result of the connection between cause and effect which strikes us as a necessary one, but probably depends only on inherited experience?\footnote{169}

I suggest that Darwin was not remembering well.\footnote{170} Pages 13-14 of the N notebook record his thoughts “on cause and effect being a necessary notion” and how this notion evolved. He there also notes:

All science is reason acting / systematizing / on principles, which even animals practically know ((art precedes science – art is experience & observation)) in balancing a body & an ass knows one side of triangle shorter than than. V. Whewell – Induct. Scienc. Vol. 1, p. 334

On January 21, 1839 (N, p. 60), he notes

Herschel’s Discourse p. 35. On origin of idea of causation (succession of night and day does not give notion of cause): d[itt]o p. 135. on the importance of name with reference to origin of language.

Page 162 of the N notebook indicates Darwin is reading

Lrd Broughhams / Dissertation / on subject of science connected with Nat Theology – says animals have abstraction because they understand signs – very profound – concludes that difference of intellect between animals & man only in kind probably very important work.

In the first week of October 1838 (M, pp. 135, 151, 154e), he had been concerned about how evolution could account for the three Comtian stages. Page 151 of the M notebook summarizes his findings:

May not the idea of God arise from our confused idea of “ought” joined with necessary notion of “causation” in reference to this “ought” as well as the works of the whole world. Read Mackintosh on Moral Sense & Emotions. –

\footnote{169. \textit{Autobiography}, p. 92.}
\footnote{170. Nora Barlow indicates that the sentence “This conclusion was strong in my mind about the time, \textit{as far as I can remember} [italics mine], when I wrote the Origin of Species” was added later. It does not exist in the original Charles Darwin manuscripts. It was evidently entered by Charles Darwin into Francis’s copy.}
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In October 1838, Darwin is also reading Hume on the origin of religion and sceptical philosophy in general.\(^{171}\)

I would suggest that "This conclusion" had already become much weaker in 1839. The letter his wife wrote him shortly after their marriage in the spring of 1839 dealing with her religious views clearly indicates that Darwin was discussing his loss of faith with her.\(^ {172}\) There were indeed fluctuations. I interpret the entry of September 6, 1838, in the OUN notebook, page 25—"M. Le Comte one of philosophy, & savage calling laws of nature chance" as indicating that Darwin was not ready to accept Comte's atheism (recall Brewster's emphasis on this point). In the *Essay on Theology and Natural Selection*, written in the late fall of 1838 (certainly after October 1838), Darwin notes on page 9 that "all Bridgewater Treatises are reduced simply statements of productiveness & laws of adaptation"; and the *Essay* concludes with:

I look at every adaptation, as the surviving one of ten thousand trials—each step being perfect (or nearly so (except in 1st) although having hereditary organization . . .) to the then existing conditions.

On page 10 of the OUN notebook Darwin notes that

The final cause of innumerable eggs is explained by Malthus—[is it anomaly in me to talk of Final causes: consider this?]

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172. The letter is reproduced on p. 235 of the *Autobiography*. It is interesting to note that the final two arguments for the evidence of God which occur in the "Religious Belief" section of the *Autobiography*, namely, the arguments based on suffering in the world and, immortality, cannot be "matched" to the M, N, and OUN notebooks. They are, however, the ones that Emma used in her letter to Charles in the spring of 1839. Emma had written to him: "I should be most unhappy if I thought we did not belong to each other for ever." Nora Barlow indicated that Darwin's discussion "with respect to immortality" was "added later to the end of the paragraph." Reluctantly, Darwin would state the truth "conscientiously and sincerely" as he saw it, mindful of the pain it might cause. Frederick Burkhardt has informed me that there are unpublished letters extant that Emma wrote to Charles Darwin before they were married and that refer to Darwin's religious views in a way which indicated that they were troubling her. See also the insightful article by Donald Fleming, "Charles Darwin: The Anaesthetic Man," *Vict. Stud.*, 4 (1961), 219-236; reprinted in *Darwin: A Norton Critical Edition*, ed. P. Appleman (New York: W. W. Norton, 1970).
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The silence of the universe had struck Darwin full force, and he reeled from the blow. He was an utter materialist! Although he could regulate the moral order of his own life by recognizing that "if he acts for the good of others, he will receive the approbation of his fellow men and gain the love of those with whom he lives; and this latter gain undoubtedly is the highest pleasure on this earth," conduct based on such a rationale was nog acceptable to his Victorian society and, most important, was not acceptable to his wife. Emma Darwin is very explicit on this. In her letter of 1839 to him she writes: "I do not quite agree with you in what you once said that luckily there were not doubts as to how one ought to act."

Darwin surely recognized that England in 1839 was not ready for the materialistic doctrines he had espoused; nor was he sure that he had sufficient evidence to prove their validity. His investigations regarding the origin of intelligence, feeling, and instinct clearly had convinced him that he did not have enough facts to lay the "stable foundations" for the science of genetic epistemology. Moreover, he undoubtedly felt that he would spread himself too thin (intellectually and physically) were he to attack on all fronts. He would therefore concentrate his effort on the origin of species. The "Outline and Draft" clearly states his position: he will, for the time being, limit himself to the species problem. The "Outline" concludes with a section whose title is "Omissions." The final paragraph under "Omissions" states:

Extent of my theory – having nothing to do with first origin of life, grow (th), multiplication, mind & (or with any attempt to find out whether descended from one form & what that form was.

9. THE DELAY

The analysis presented here gives some further insight into possible reasons why Darwin delayed his Big Book after he had finished the "Essay" of 1844.

174. Ibid., p. 236.
175. The entry in Darwin’s “Journal” for May 1, 1838, begins recording his “being unwell” (the bouts of the disease that were to plague Darwin throughout the rest of his life). For example, in June: "& lost very much time being unwell”; the same in November and for the rest of the year. See also the entries for 1839, particularly from May to July. See Ralph Colp, To Be an Invalid: The Illness of Charles Darwin (Chicago: University of Chicago Press, 1977).

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I shall deal only with external factors. Darwin's amassing of further facts to prove the case for evolution and to exhibit the explanatory powers of natural selection has been well chronicled. I will only briefly comment on some of the psychological dimensions of the problems. Gruber in Darwin on Man has presented the case for Darwin's anxiety regarding the materialistic aspect of his theory. I have established that he was fully aware of the materialistic position his theory entailed by 1839 and had become an agnostic by that time. The case Gruber makes is the more convincing in view of the earlier date of Darwin's "agnosticism." I would add another and perhaps as important a dimension: Darwin's concern for his wife. The poignancy of the three lines Darwin appended to the letter his wife had written him concerning her religious views in the spring of 1839, shortly after they were married, is piercing:

"When I am dead, know that many times, I have kissed and cryed over this. C.D." 178

The depth of his feeling for his deeply religious wife and his concern over the impact that his materialist and agnostic views would have on her are surely some of the hidden anxieties which animate the "Essay," the Big Book, and the Origin. I would, in fact, go so far as to suggest that the introduction of the imaginary "being with penetration sufficient to perceive differences in the outer and innermost organization quite imperceptible to man" in the discussion of variation and selection in the "Essay" of 1844 was motivated by Darwin's concern for his wife's religious views. He had made her responsible for the publication of the "Essay" in case of his sudden death, and she would have been the first to read the manuscript. 180

Darwin clearly also appreciated the likely reaction the publication of his materialistic views would elicit. The reception of Chambers's Vestiges of Creation in 1845 gave him ample evidence of what was likely to happen. 181 The fact that his "theory" could withstand all the arguments

176. See, for example, de Beer, Charles Darwin, chaps. 6 and 7.
177. Darwin on Man, chaps. 1 and 2, pp. 19 ff.
181. See Millhauser, Just before Darwin.
Sedgwick had adduced against the *Vestiges* in his review of the book in the *Edinburgh Review* of 1845 could only make the impact more explosive. Sir David Brewster reviewed the *Vestiges* in the *North British Review*. His attack was sharp and to the point:

We are unwilling to charge our author with a systematic attempt to undermine the foundations of natural and revealed religion – but we should ill discharge the duties of our calling, were we to conceal the opinion that every individual speculation which his work contains and the entire hypothesis which it is written to support have a direct tendency to expel the Almighty from the universe he has made . . . Although the author’s name is concealed, it is not difficult to delineate his character . . . He is an ill-disguised materialist . . . Trained in less severe schools than those of geometry and physics, his reasonings are in general loose and inconclusive . . . his facts are often conjectures and sometimes fancies; and the grand phenomena of the material world . . . have become in his hand the basis of dangerous and degrading speculations.

The review surely could not have encouraged Darwin in hastening publication of his theory. Moreover, in view of my findings, Chambers’s *Vestiges* and its reception must have played an even more important role in Darwin’s life than has been inferred thus far. For Chambers had traveled the same route as Darwin had. He had read Comte’s account of Laplacian cosmogony, and he had made it the initial phase of a cosmic evolutionary account. Each subsequent edition of Chambers’s *Vestiges* chronicles the scientific attacks on Comte’s calculations concerning the nebular hypothesis. The latter had in fact fallen into disrepute among astronomers by the mid-1840’s. Although Darwin had been careful to delimit the extent of his evolutionary hypothesis, he nonetheless must have been keenly sensitive to the discrediting of the Comtian calculations.

Herschel’s presidential address before the British Association for the Advancement of Science in June 1845 must likewise have been a very

185. John F. W. Herschel, “The Logic of Scientific Endeavor,” presidential address to
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strong restraining influence. Coming on the heels of the publication of *Vestiges*, Herschel used the address to attack evolutionist ("transmutationist") theorizing. After paying his respects to the methodological advances that have been made by Whewell and J. S. Mill in the philosophy of science ("they... leave the philosophy of science, and indeed the principles of all general reasoning, in a very different state from which they found them"), he turned his attention to the role to be played by

those ultimate principles of religious faith which we regard, and rightly regard, as sacred from question... It is only by working our way *upwards towards* those principles as well as *downwards from them*, that we can ever hope to penetrate such intricacies and thread their maze; and it would be worse than folly - it would be treason against all our highest feelings - to transgress these lines.

Herschel then proceeded to attack Comte's rejection of the idea of cause and the adoption of the idea

that science has no concern but with the discoveries of laws... The evil I complain of becomes yet more grievous when the idea of *law* is brought so prominently forward as not merely to throw into the background that of cause, but altogether to thrust it out of view altogether.

A diatribe against evolutionist theorizing follows:

Surely, when we hear such a theory, the natural human craving after *causes*... *causes why* the development at different parts of its progress should divaricate into different lines... becomes importunate. And when nothing is offered to satisfy this craving but loose and vague references to *favourable circumstances* of climate, God, and general situation... who does not perceive that such a theory is in no respect... *explanatory.*

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The reference to "favourable circumstances" could not have gone unnoticed by Darwin. Herschel's admonition that "whatever innovations... may arise, they can only be introduced slowly and on a full sense of their necessity; for the limited faculties of our nature will bear but little of this sort at a time without a kind of intoxication which precludes all rectilinear progress" would be taken seriously. Surely Darwin must have recalled that "intoxicating" period from 1837 to 1839. Darwin valued Herschel's esteem highly. In the Autobiography, Darwin comments: I felt a high reverence for Sir J. Herschel. It will be recalled that after the Origin appeared Darwin was particularly eager to receive Herschel's reaction to it. He was deeply distressed when he heard that Herschel said the Origin "is the law of higgledy-piggledy." Darwin wrote to Lyell on December 12, 1859, that he did not know what higgledy-piggledy meant, but it is evidently very contemptuous. If this were true, Herschel's evaluation was a "great blow and discouragement."

In 1861, when Darwin read the criticism of the Origin that Herschel had appended to his Physical Geography of the Globe to the effect that "that higher law of Providential Arrangement should always be stated," Darwin was more composed. In a letter to Lyell he notes, "But astronomers do not state that God directs the course of each comet and planet." Darwin continues:

It seems to me that variations in the domestic and wild conditions are due to unknown causes, and are without purpose, and in so far accidental; and that they become purposeful only when they are selected by man for his pleasure or by what we call Natural Selection in the struggle for life... I do not wish to say that God did not foresee everything would ensue; but here comes very nearly of the same some sort of wretched imbroglio as between freewill and preordained necessity. I doubt whether I have made what I think clear; but certain A. Gray's notion of the causes of variations... reminds me of a Spaniard whom I told I was trying to make out how the Cordillera was formed; and he answered me that it was useless, for "God made

186. Autobiography, p. 107. Darwin must have been pleased to have been asked by Sir John Herschel to contribute chap. VI, on geology, to the Manual of Scientific Enquiry; prepared for the Use of H. M. Navy; and Adapted for Travellers in General, ed. John Herschel (London, 1849).


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them.” It may be said that God foresaw how they would be made. I wonder whether Herschel would say you ought always to give the higher providential law, and declare God had ordered all certain changes of level, that certain mountains should arise. I must think that such views of Asa Gray and Herschel merely show that the subject in their minds is in Comte’s theological stage of science.

**EPILOGUE**

John Theodore Merz, that perceptive and insightful historian of the intellectual and scientific thought of the nineteenth century, stressed the great importance of the development of the statistical view of nature: “The study of blind chance in theory and practice is one of the great performances of the nineteenth century.” He cited Darwin’s and Maxwell’s work as examples of the statistical view of nature. This paper is a testament to that insight and an indication of how strongly coupled these developments were.

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My indebtedness to Howard Gruber’s and Paul Barrett’s *Darwin on Man* must be specially acknowledged. This book is a most valuable source on that remarkable period of creativity in Darwin’s life from 1837 to 1840.

190. Compare this with M, p. 69, and the note that it comes after the excised pp. 65-68 on Comte’s review.


My greatest debt is to Professor E. Mayr. He carefully went over the initial version of this paper and gave me the constructive benefit of his vast knowledge of Darwin and evolution. He also made available to me E. David Kohn's important dissertation "Charles Darwin's Path to Natural Selection." I learned much from reading it. My subsequent discussions with David Kohn and his helpful comments on my manuscript gave me the benefit of his keen insight into the Darwin notebooks and how natural selection was put together. Mr. Peter Gautrey's prompt replies to my inquiries were always valuable and useful. I thank him.


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