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CHARLES DARWIN AND ARTIFICIAL SELECTION

By Michael Ruse

In a letter to A.R. Wallace written in April 1859, Charles Darwin, presumably in reply to a question about how he discovered the theory of evolution through natural selection, wrote: "I came to the conclusion that selection was the principle of change from the study of domesticated productions; and then, reading Malthus, I saw at once how to apply this principle."[1] In his private *Autobiography,* written towards the end of his life (ca. 1880), Darwin repeated this account of his discovery.

> After my return to England it appeared to me that by following the example of Lyell in Geology, and by collecting all facts which bore in any way on the variation of animals and plants under domestication and nature, some light might perhaps be thrown on the whole subject. My first note-book was opened in July 1837. I worked on true Baconian principles, and without any theory collected facts on a wholesale scale, more especially with respect to domesticated productions, by printed enquiries, by conversation with skilful breeders and gardeners, and by extensive reading. When I see the list of books of all kinds which I read and abstracted, including whole series of Journals and Transactions, I am surprised at my industry. 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.
>
> In October 1838, that is, fifteen months after I had begun my systematic enquiry, 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. . . .[2]

However, despite these apparently clear accounts by Darwin of his discovery of the theory, scholars have continued to find the exact details of the discovery somewhat difficult to discern and evaluate. In the past, one of the chief stumbling blocks was the question of the precise importance of Malthus' work. "Why," it was asked, "if Darwin had actually grasped the principle of selection in nature, and if, as we know, he was fully aware of the struggle for existence because he had read Charles Lyell's *Principles of Geology,* in which work the struggle is described quite explicitly, did Darwin feel it necessary to

[1]F. Darwin and A. C. Seward, eds., *More Letters of Charles Darwin* (London, 1903), I, 118.

[2]N. Barlow, ed., *The Autobiography of Charles Darwin 1809–1882* (New York, 1969), 119–20.

acknowledge so great a debt to Malthus?"[3] Fortunately, several writers recently have addressed themselves specifically to the answering of this question, and so there is no need to try to explicate and assess again every nuance of Darwin's indebtedness to Malthus.[4] But another challenge to Darwin's account has arisen, and it is with this challenge that I am primarily concerned in this paper. It is argued, mainly on the evidence of the private notebooks which Darwin kept just at the time when he discovered his mechanism of natural selection,[5] that where Darwin erred in his later accounts of his discovery was in attributing a crucial role to artificial selection and to the analogy which can be drawn between it and natural selection. It is argued that it was only after he had grasped a clear notion of natural selection through the struggle for existence (a step which owed a vital debt to Malthus) did he then see the analogy which could be drawn between the two kinds of selection—an analogy which came to play so big a role in the completed theory of the *Origin*. In the words of one of the advocates of this view:

Surveying all the comments in the notebooks made before Malthus, it does not seem that Darwin held a sufficiently unambiguous notion of artificial selection to have enabled him to anticipate finding, as a mechanism for evolution, a similar process at work in untended nature. Rather, it would seem, the discovery of natural selection made the domestic analogy much more clear to Darwin than it had been before.[6]

In this paper, I suggest that although those who have made this most recent challenge to Darwin's account have brought us significantly closer to the true story of Darwin's path of discovery, they have still ignored one vital piece of evidence—evidence which, when revealed and evaluated, enables one to weave a fabric which makes better sense of what Darwin himself said about his path of discovery, while not denying the actual things Darwin wrote in his notebooks at the time of his discovery.

In order to lead up to this evidence let us recall the salient facts already known about Darwin's discovery. First, Darwin wrote his (species) notebooks

[3]Among others who ask this question are G. Himmelfarb, *Darwin and the Darwinian Revolution* (New York, 1959); L. Eiseley, *Darwin's Century* (New York, 1959); and G. de Beer, *Charles Darwin* (London, 1963).

[4]See particularly F. N. Egerton, "Studies of Animal Populations from Lamarck to Darwin," *J. Hist. Biology*, **1** (1968), 225–59; P. Vorzimmer, "Darwin, Malthus, and the Theory of Natural Selection," *JHI*, **30** (1969), 527–42; and R. M. Young, "Malthus and the Evolutionists: the Common Context of Biological and Social Theory," *Past and Present*, **43** (1969), 109–45. I discuss the Darwin-Malthus relationship, but from a more formal viewpoint, in "The Nature of Scientific Models: Formal v. Material Analogy," *Phil. Social Sciences*, **3** (1973), 63–80.

[5]"Darwin's Notebooks on Transmutation of Species," Parts I–IV, ed. G. de Beer; Addenda and Corrigenda, ed. G. de Beer and M. J. Rowlands; Part VI (Excised pages), ed. G. de Beer, M. J. Rowlands, and B. M. Skramovsky, *Bulletin of the British Museum (Natural History) Historical Series*, **2**, nos. 2–6, and **3**, no. 5. There are four notebooks, corresponding to de Beer's Parts I, II, III, and IV. Darwin labelled them "B," "C," "D," and "E." I shall use Darwin's pagination throughout.

[6]S. Herbert, "Darwin, Malthus, and Selection," *J. Hist. Biology*, **4** (1971), 209–17; 212–13. Another advocate of this viewpoint is C. Limoges, *La sélection naturelle* (Paris, 1970).

between July 1837 and July 1839. Second, when he began his notebooks Darwin was a convinced evolutionist and (obviously) was the same when he finished them. We can say this with some confidence both from the direct evidence (thus, even on p. 8 of the first book we find "As we thus believe species vary, in changing climate we ought to find representative species; this we do in South America closely approaching.") and more importantly, from the third fact about Darwin's discovery, namely, that Darwin seems to have held some *theory* of evolution before he started his notebooks. As Sydney Smith has pointed out,[7] in Darwin's copy of Volume 2 of the 5th edition of Lyell's *Principles*[8] which Darwin seems to have read earlier in 1837 (before he began the notebooks), against a denial by Lyell of the possibility of the indefinite variation of species, Darwin wrote in the margin: "if this were true, adios theory." Moreover, right through the early notebooks, long before he read Malthus, Darwin repeatedly and confidently spoke of "my theory" (e.g., "My theory very distinct from Lamarck's."[9]).

Now, before we go on to recount other facts known about Darwin's discovery of his theory of evolution through natural selection, let us pause for a moment and ask ourselves what precisely was this earlier theory of Darwin's, if it was not his theory of evolution through natural selection? Although it appears to have varied somewhat through the notebooks, it seems clear that it was one which had two main ingredients. These ingredients were, first, variation in direct response to the environment and, secondly, isolation. Thus it was supposed that when a group of animals is isolated from their parent body in new conditions they evolve away from their parents in some way in response to and by virtue of these new conditions. What distinguishes this kind of evolutionary mechanism from a selective mechanism is that it is the individual which is the crucial unit in change, rather than, as in the case of selection, the group—in the former case, the crux is that the individual is responding to the environment; in the latter, the crux is that only a percentage of a group survive and reproduce. Although Darwin never wrote down this first theory of his in a formal manner in the notebooks, it is easy to find passages which support what I am suggesting:

> We *know* world subject to cycle of change, temperature and all circumstances, which influence living beings.
>
> We see the young of living beings become permanently changed or subject to variety, according to circumstance,—seeds of plants sown in rich soil, many kinds are produced, though new individuals produced by buds are constant; hence we see generation here seems a means to vary or adaptation.—Again we know, in course of generation even mind and instinct becomes influenced. Child of savage not civilized man.—Birds rendered wild generations acquire ideas ditto. V. Zoonomia.—
>
> There may be unknown difficulty with *full grown* individual with fixed organisation thus being modified,—therefore generation to adapt and alter the race to *changing* world.—[10]

[7] "The Origin of 'The Origin'," *Advancement of Science*, **64** (1960), 391–401.

[8] This volume is in the University Library, Cambridge, as are Darwin's Notebooks.

[9] B, 214.

[10] B, 2–4.

Let a pair be introduced and increase slowly, from many enemies, so as often to intermarry—who will dare say what result.

According to this view animals on separate islands, ought to become different if kept long enough apart, with slightly differ[ent] circumstances.—Now Galapagos tortoises, mocking birds, Falkland fox, Chiloe fox.—English and Irish Hare.—[11]

Countries longest separated—greatest differences,—if separated from immense ages possibly two distinct type[s], but each having its representatives—as in Australia

This presupposes time when no mammalia existed; Australia; Mamm[alia] were produced from propagation from different set as the rest of the world.—

This view supposes that in course of ages, and therefore changes, every animal has tendency to change.—

This difficult to prove cats etc. from Egypt no answer, because time short and no great change has happened.—

I look at two Ostriches as strong argument of possibility of such change; as we see them in space, so might they in time.—

As I have before said, *isolate* species, especially with some change, probably vary quicker.—

Unknown causes of change. Volcanic island.—Electricity. Each species changes. Does it progress.[12]

With respect to extinction we can easy see that variety of ostrich Petise may not be well adapted, and thus perish out, or on other hand like Orpheus being favourable, many might be produced. This requires principle that the permanent varieties, produced by confined breeding and changing circumstances are continued and produce according to the adaptation of such circumstances, and therefore that death of species is a consequence (contrary to what would appear from America) of non-adaptation of circumstances.—[13]

All structures either direct effect of habit, or hereditary and combined effect of habit,[14]

According to my views, habits give structure, . . . habits precede structure, ∴habitual instincts precede structure.[15]

One important point usually overlooked by those who are prepared only to take note of what they take to be of value in Darwin, is that this theory was *never* relinquished by Darwin. Right through the various editions of the *Origin*, although Darwin made selection to be the chief cause of evolutionary change, he still believed and argued that one could and would get evolutionary change through the direct response of the organism to its environment. Consider the following passage which remained virtually unchanged from the first to the sixth edition of the *Origin*.

From the facts alluded to in the first chapter, I think there can be little doubt that use in our domestic animals strengthens and enlarges certain parts, and disuse diminishes them; and that such modifications are inherited. Under free nature, we can have no standard of comparison, by which to judge of the

[11]B, 7.
[12]B, 15–18. Darwin's italics.
[13]B, 37–38.
[14]C, 63.
[15]C, 199.

effects of long-continued use or disuse, for we know not the parent-forms; but many animals have structures which can be explained by the effects of disuse. . . . As the larger ground-feeding birds seldom take flight except to escape danger, I believe that the nearly wingless condition of several birds, which now inhabit or have lately inhabited several oceanic islands, tenanted by no beast of prey, has been caused by disuse.[16]

As the value of natural selection as a cause of evolutionary change waxed and waned in Darwin's eyes, this other mechanism of evolutionary change played a correspondingly lesser or greater role for Darwin. Thus, its fortunes were probably at its lowest ebb in about 1859 at the time of the writing of the first edition of the *Origin,* but it came back into more favor in the 1860's as natural selection came under increasing attack.[17] In the notebooks, while it is the only theory at the beginning, it is being pushed over by natural selection towards the end, although it should be added that, as T.H. Huxley remarked, in Darwin's 250-page *Essay* on evolution written in 1844, it still has a much bigger part than in the *Origin.*[18]

Returning now to the list of salient facts which should be noted about Darwin's discovery of natural selection as a mechanism of evolutionary change, two final facts must be noted. First, Darwin read Malthus at the end of September 1838, and it is only then in the notebooks that we start to get a clear intimation that Darwin was prepared to look upon natural selection as a cause of interspecific evolutionary change. There are certainly all sorts of anticipations of natural selection before this—for instance, in one of the quotations already given Darwin writes of the failure of species to survive because they are not adapted—but we have to wait until the Malthusian era to get such clear statements as this: "All this agrees well with my view of those forms slightly favoured getting the upper hand and forming species."[19] Second, as the recent commentators (i.e., those I am presently opposing) have pointed out, it is only after this (specifically in the fourth notebook) that Darwin started confidently to stress the analogy between change in domestic organisms and change in wild organisms (through selection). Before reading Malthus, Darwin, if anything, stressed reasons why one who believed in evolution should not draw an analogy with domestic organisms. For example, in his copy of Lyell's *Principles* (vol. 2, 5th ed.), opposite the page on which he wrote "if this were true, adios theory" Darwin wrote: "The great difficult[y] appears, that though some animals long domesticated change not indefinite (Do we know this), but most domesticated animals are hereditary monsters." Here, he was trying to disavow himself from the domestic world. And even in the third notebook, not long before he read Malthus, Darwin wrote "It certainly appears in domesticated animals that the amount of variation is soon reached—as in pidgeons [sic] no new races."[20]

[16]*The Origin of Species* (1st. ed., London, 1859), 134.

[17]P. Vorzimmer, *Charles Darwin: The Years of Controversy* (London, 1972) documents these vacillations by Darwin in some detail.

[18]Darwin wrote a short *Sketch* on evolutionary theory in 1842 and a much longer *Essay* in 1844. These are reprinted with an introduction by F. Darwin as *Foundations of the Origin of Species* (Cambridge, 1909). Huxley's comment is reported on xxviii.

[19]D, 175. [20]D, 104.

There are other comments like these, and what is perhaps more important is the negative fact that Darwin gave no repeated references to artificial selection or to a hypothetical natural counterpart, which is what one would expect were his own later accounts literally true. It would seem then that Darwin's recent commentators are essentially correct. The artificial selection analogy did not have a crucial role in Darwin's discovery of natural selection as a cause of evolutionary change. It was only after he had grasped this latter concept that he came to stress the analogy.

The trouble with this conclusion is, as I have said, that it ignores one vital piece (or set of pieces) of evidence. This is the writings by the breeders, which Darwin tells us he studied carefully on his path to the idea of natural selection. When these, or at least some of them, are examined, it seems to me that artificial selection and the analogy between it and natural selection must, once again, be brought into the account of Darwin's discovery of natural selection (or, more precisely, his discovery of the importance of natural selection).

What breeders, and in particular, what writings by these breeders should we consider? Darwin mentioned many breeders and their writings in the notebooks, but I shall pick out two for special consideration: Sir John Sebright and John Wilkinson. Darwin read pamphlets on breeding by these men around the time when he was in the middle of writing his second notebook. Since this notebook was written between February and July of 1838, it would seem that he read the pamphlets some six months (or a little less) before he read Malthus. The pertinent entry in his notebook is as follows:

Sir J. Sebright pamphlet most important showing effects of peculiarities being long in blood.**—thinks difficulty in crossing race.—bad effects of incestuous intercourse.—excellent observations of sickly offspring being cut off so that not propagated by nature.—whole art of making varieties may be inferred from facts stated.—

**Fully supported by Mr. Wilkinson = milking hereditary, development of important organ (see marks on pages)—crosses of diff. breeds succeed. yet seems to grant, that difficult and other go back to either parent.[21]

From this entry we can identify the pamphlets as "Remarks on the Improvement of Cattle" by John Wilkinson and "The Art of Improving the Breeds of Domestic Animals" by John Sebright.[22] Both of these pamphlets are in the

[21]C, 133. De Beer's transcription of this page is rather misleading because he (de Beer) puts Darwin's footnote right into the text without acknowledgment. From de Beer's text, therefore, it is far from obvious that, when Darwin talks of inferring the art of making varieties from the facts stated, it is Sebright's pamphlet he is referring to directly, not Wilkinson's.

[22]The full titles of these pamphlets are: J. Wilkinson, "Remarks on the Improvement of Cattle, etc. in a letter to Sir John Saunders Sebright, Bart. M.P." (Nottingham, 1820); J. Sebright, "The Art of Improving the Breeds of Domestic Animals in a letter addressed to the Right Hon. Sir. Joseph Banks, K.B." (London, 1809). These are Darwin Offprints Nos. 62 and 63 respectively. De Beer incorrectly identifies the Sebright pamphlet as one which was written by Sebright much later, namely "Observations upon the Instinct of Animals" (London, 1836). Although Darwin also owned and read this pamphlet (Darwin Offprint Collection No. 64), it cannot possibly be the one referred to in the above passage from Darwin's second (species) notebook. As soon as

Darwin Offprint Collection in the University Library Cambridge (that is, Darwin owned both pamphlets) and both have been annotated by Darwin. By 1838 Darwin was in the habit of making marks in all the books and pamphlets he was reading, and since in the passage from the notebook quoted above Darwin refers to marks he has made in the Wilkinson pamphlet, and there are such marks in the pamphlet he owned, it seems reasonable to assume that these and other marks in the pamphlets were made by Darwin at the time when he made notes about them in his notebooks.[23]

Upon looking at the pamphlets three points stand out. First, the pamphlets are very explicit about the nature and power of artificial selection. Secondly, the Sebright pamphlet, again quite explicitly, talks about natural selection, but not by this name, and draws the analogy between artificial and natural selections. Thirdly, Darwin marked the pamphlets in such a way as makes clear that he was taking special note of these facts. These three points taken together call, I suggest, for a reevaluation of the importance of artificial selection (and the analogy based on it) for Darwin.[24] But before I attempt such a reevaluation, let me first present the pertinent information from the pamphlets in more detail.

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we take Darwin's footnote out of the text (see note 21 above), we see that the Sebright pamphlet mentioned in the text must be the one which talks of "sickly offspring being cut off so that not propagated by nature." The instinct-pamphlet is not about this at all, whereas the improving-the-breeds-pamphlet is all about this. Darwin talks about the instinct-pamphlet on his next page (C, 134), where he starts "Shows instinct (Sir J. Sebright admirable essay) hereditary journey wild ducks.—" This new praise makes sense only if he is praising another Sebright essay (other than the one praised on the previous page—the improving-the-breeds-pamphlet). Moreover, in his reading list at the end of the second notebook, Darwin refers, in the plural, to Sebright pamphlet*s* which he has read, and there is no mention in the notebooks of any pamphlet by Sebright other than those I have given.

[23]More evidence for this conclusion is perhaps the fact that, in his reading list, next to the entries for the Sebright and Wilkinson pamphlets, Darwin wrote: "not abstracted" (C, 275). Perhaps we can conclude that there was no need to do this because he already owned and had marked relevant passages of the pamphlets. It should, in fairness, be added that although the underlining and marks by passages are in ink, some of the comments written by Darwin on the edges of pages of the Sebright pamphlet are in pencil. Possibly these pencilled comments were added later, although even if they were, it would not appreciably affect my thesis. Moreover, it is worth noting that in the second notebook, just at about the time of the entries on these pamphlets, Darwin was (very uncommonly for this notebook) using both pen and pencil, and since a word in pencil was crossed out in ink (C, 137), Darwin was presumably using both pen and pencil almost interchangeably.

[24]In fairness, I must concede that Limoges does acknowledge Darwin's reading of these pamphlets and he notes also the fact that the pamphlets contain the term "selection." But Limoges does *not* mention the vital pieces of information about which passages interested Darwin enough for him to mark them, about how some of these marked passages are quite explicitly discussions of artificial selection, about the way in which Sebright argued analogically to a form of natural selection and about how Darwin marked this passage also. I shall argue that when these latter pieces of information are taken into account, one cannot dismiss the pamphlets in the casual manner of Limoges. (Limoges does not even feel it necessary to raise the contents of the

As far as the nature and power of artificial selection are concerned, consider the following quotations from the pamphlets:

> Were I to define what is called the art of breeding, I should say, that consisted in the selection of males and females, intended to breed together, in reference to each other's merits and defects.[25]

> The fineness of the fleece, like every other property in animals of all kinds, may be improved by selection in breeding. . . . Climate, food, and soil, have certainly some effect upon the quality of wool, but not so much as is generally supposed.[26]

> The alteration which may be made in any breed of animals by selection, can hardly be conceived by those who have not paid some attention to this subject; they attribute every improvement to a cross, when it is merely the effect of judicious selection.[27]

> It may as well be contended, that the white pheasant . . . was produced from a cross with a Dorking fowl, whereas it was one of those accidental varieties which sometimes occur, and which has been perpetuated by selection. The same may be said of the endless variety in the colour, shape, and size, of rabbits, ducks, and pigeons, in a domesticated state, a variety produced by the art of man, and which did not exist in these creatures in their natural state.
>
> A greater proof, I conceive, of what may be affected by selection and perseverance, cannot be adduced.[28]

> Whether the different breeds with which we are now acquainted, descended originally from one common stock, the wild Bison, is a question, I think, hard to be determined. Of this, however, we may be assured, from the very nature of the case, that the distinct breeds at first, if more than one, could have been by no means numerous; so that the great variety which we behold at present, is owing to food, to climate, or to other collateral and accidental circumstances. And perhaps of all the causes contributing to this multiplicity none would be more effectual, than the hidden springs of nature itself. For though we perceive that there is a *strong* tendency, for *like to produce like,* as it is usually termed; yet he that is at all conversant with nature, must perceive also, that there is a *certain* tendency to change. And this law of nature would soon be assisted by man, who is ever fond of novelty; and delights in diversity, even for its own sake.
>
> Thus then, we have seen, that distinct breeds might readily be formed by the joint efforts of nature and of art; nor will it be more difficult to perceive how they might afterwards be improved. That all would be capable of improvement is too obvious to need discussion. For no one can behold any breed whatever in its more natural and less improved state, without perceiving a great variety in the shapes of individuals, their different degrees of tendency to feeding, or certain other remarkable properties, which might give to some a decided superiority over the rest. These, therefore, must be selected from the whole herd; and as you yourself, Sir, have remarked, the male and female be

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pamphlets as possible counter-evidence when he proposes his thesis about the unimportance of artificial selection in Darwin's discovery. He refers to them only when later he is discussing claims by L. Eiseley about Darwin's possible indebtedness to Patrick Matthew.) See Limoges, 104.

[25]Sebright, "Improving," 5.

[26]*Ibid.*, 24, 25. Second sentence has line (drawn by Darwin) beside it.

[27]*Ibid.*, 26.

[28]*Ibid.*, 27. First paragraph has line beside it.

properly matched. When we come to their progeny, some will probably be worse, some equal to, and some even better, than the parents themselves. The worst must unquestionably be rejected, while the rest, and especially the best of these, are carefully to be preserved for future stock. And thus by a judicious selection of male and female, and discarding every thing that is refuse, we must continue to proceed. And by such procedure, animals have at length been produced, so different from the generality of the stock from whence they were originally taken, that none but such as are well acquainted with these matters, could have any idea, that there existed between them the least affinity. The distinction indeed between some, and their own particular variety, has scarcely been less, than the distinction between that variety and the whole species. The longer also these perfections have been continued, the more stability will they have acquired, and the more will they partake of nature itself.[29]

Then in the Sebright pamphlet there is the statement of natural selection and the analogy drawn between it and artificial selection.

Many causes combine to prevent animals, in a state of nature, from degenerating; they are perpetually intermixing, and therefore do not feel the bad effects of breeding *in-and-in:* the perfections of some correct the imperfections of others, and they go on without any material alteration, except what arises from the effects of food and climate.

The greatest number of females will, of course, fall to the share of the most vigorous males; and the strongest individuals of both sexes, by driving away the weakest, will enjoy the best food, and the most favourable situations, for themselves and for their offspring.

A severe winter, or a scarcity of food, by destroying the weak and the unhealthy, has all the good effects of the most skilful selection. In cold and barren countries no animals can live to the age of maturity, but those who have strong constitutions; the weak and the unhealthy do not live to propagate their infirmities, as is too often the case with our domestic animals. To this I attribute the peculiar hardiness of the horses, cattle, and sheep, bred in mountainous countries, more than to their having been inured to the severity of the climate; for our domestic animals do not become more hardy by being exposed, when young, to cold and hunger: animals so treated will not, when arrived at the age of maturity, endure so much hardship as those who have been better kept in their infant state.[30]

Finally, apart from the various lines Darwin drew besides these passages, there is the following sentence written by Darwin beneath the passage just given (and on the facing page also).

In plants man presents mixtures, varies conditions and destroys, the unfavourable kind—could he do this last effectively and keep on the same exact conditions for many generations he would make species, which would be infertile with other species.—[31]

Now, how do we evaluate the worth of these passages in the pamphlets and Darwin's reaction to them? It is, I am sure, important not to overestimate

[29]Wilkinson, "Remarks," 2–5. Last sentence in quotes and with two lines beside it.

[30]Sebright, "Improving," 15–16. Line drawn by Darwin beside the whole passage (last half of last paragraph, i.e., that on 16, is in pencil).

[31]This is in pencil.

their importance. For a start, there seems no suggestion in the text that Sebright's "natural selection" can lead all the way to speciation, even though Darwin's comment shows that he (*i.e.*, Darwin) in fact was thinking in terms of some kind of selection leading to speciation. Sebright's "natural selection" leads to intra-specific differences, although it should be noted that its effect does seem to be "positive" in that it can help the development of new characteristics (*e.g.*, resistance to cold) rather than just preventing degeneration and ensuring specific stability through the weeding-out of inferiors.[32] Secondly, there is no suggestion that artificial selection and natural selection will usurp entirely the direct intereaction between the environment and the individual (*i.e.*, that which was crucial to the only evolutionary mechanism Darwin had accepted at that point). Indeed, the very opposite is the case. Wilkinson specifically suggested that selection is to be used to improve on characteristics formed by direct interaction. Thus: ". . . the great variety [of breeds] which we behold at present, is owing to food, to climate, or to other collateral and accidental circumstances . . ."[33] which selection can then work on. Sebright wrote another pamphlet on animal instinct at a time later than the one here quoted, in which the main theme was that instinct is the product of the direct interaction of the organism and environment carried over many generations, and on the page after he discussed the two pamphlets we are here discussing. Darwin discussed this later pamphlet and spoke of it as an "admirable essay."[34] Third, Sebright was at pains to stress the impermanence of the effects of selection.

> A breed of animals may be said to be improved, when any desired quality has been increased by art, beyond what that quality was in the same breed, in a state of nature: the swiftness of the race-horse, the propensity to fatten in cattle, and the fine wool in sheep are improvements which have been made in particular varieties of the species to which these animals belong. What has been produced by art, must be continued by the same means, for the most improved breeds will soon return to a state of nature, or perhaps defects will arise, which did not exist when the breed was in its natural state, unless the greatest attention is paid to the selection of the individuals who are to breed together.[35]

[32]In this, Sebright's selection goes a step beyond E. Blyth's pre-Darwinian selective ideas which Eiseley used to accuse Darwin of drawing upon unacknowledged, vital sources. (L. Eiseley, "Charles Darwin, Edward Blyth, and the Theory of Natural Selection," *Proc. Am. Phil. Soc.*, **103** [1959], 94–158. This paper has relevant papers by Blyth as an Appendix). I hope it is not necessary to emphasize that it is not my intention in this paper to accuse Darwin of plagiarism from Sebright's pamphlet. I think Darwin used its information; but there was no question of suppressing or concealing the source, because the source did not contain a theory of evolution. Had it done so, then this would surely have been noticed in the more than 25 years between the pamphlet's writing and Darwin's reading of it. I wonder indeed if Blyth got his (non-evolutionary) ideas from Sebright? Possibly this was so—Blyth like Sebright supposes "natural selection" to be a counter to breeding in-and-in—although I suspect that Sebright's speculations were in fact just meanderings on what was generally accepted as "common knowledge." (Note also how Sebright's second paragraph contains a strong hint of sexual selection through male combat.)

[33]Wilkinson, "Remarks," 2, 3.

[34]C, 134; see note 22, above.

[35]Sebright, "Improving," 5, 6.

This, of course, was the very point that Lyell had made in his *Principles* when he argued against any analogy between domestic and wild organisms supporting an evolutionary theory. In this context, however, it is most interesting to note that Wilkinson, as we have seen, was much more hopeful about the lasting effects of selection. Not only was he prepared to say that selection could lead to differences like specific differences, but he was also prepared to say: "The longer also these perfections have been continued, the more stability will they have acquired, and the more will they partake of nature itself."[36] This sentence Darwin put in quotes with two lines beside it.

Nevertheless, despite these reservations which I think we should draw—we certainly cannot claim that Darwin would have got a complete notion of a naturally occurring selection process which could lead to speciation just from the pamphlets. I, for one, in the light of these pamphlets and Darwin's reaction to them ("excellent observations," "whole art of making varieties may be inferred"), would feel extremely uncomfortable arguing, as does Sandra Herbert, that before Malthus "it does not seem that Darwin held a sufficiently unambiguous notion of artificial selection to have enabled him to anticipate finding, as a mechanism for evolution, a similar process at work in untended nature."[37] Darwin had a very unambiguous notion of artificial selection and the analogy to wild organisms thrust right at him,[38] and he seems to have taken at least some note of them, even if he did not then, as his own later accounts rather imply, drop everything in the search for the force behind natural selection.

So, what then is the true story of Darwin's discovery of natural selection? What I think we must start from is the fact that all the time Darwin had a theory of evolution—one based on the direct interaction between individual organism and environment—although it is clear that he was never entirely satisfied with it as the sole cause of evolutionary change.[39] Thus he was certainly not, at the time of reading Sebright and Wilkinson, striving desperately to find any kind of mechanism of evolutionary change in order to fill a complete void in his thinking. Hence, there was no question of his consciously seizing upon their information as his first vital clue on the way to an evolutionary theory. Rather theirs would have been information he would have accepted without great excitement[40]—perhaps thinking of it as providing some

[36]Wilkinson, "Remarks," 5. [37]Herbert, "Darwin, Malthus, and Selection," 212.

[38]It is important to note that there is no reason to think the Wilkinson and Sebright pamphlets atypical, or that they were Darwin's sole source of information about organisms bred by man. The pre-Malthusian parts of the notebooks abound with entries about breeders, based on private as well as printed communications. Included in these must be several references to what were probably private communications to Darwin from Sebright.

[39]Mainly because it seemed inadequate to explain the ubiquitous adaptation to be found in the organic world. Thus, for example, in the second notebook Darwin wrote: "We never may be able to trace the steps by which the organization of the eye passed from simpler stages to more perfect preserving its relations—the wonderful power of adaptation given to organization.—This really perhaps greatest difficulty to whole theory.—" (C, 175).

[40]As I have said, this could easily be (and probably was) information he already had.

help in evolutionary change (but certainly not the only or even the major help). Then came the reading of Malthus, and suddenly Darwin realized what a fantastic, constant pressure there is on organisms in the race to survive and reproduce. At this point, as Darwin himself said, I cannot see why the analogy from domestic organisms (which he had already had presented to him and had noted earlier in the year) should not have helped him to make the final step. A piece of information which he already had, which hitherto he had not considered to be particularly vital, was suddenly seen to be the key to a whole new mechanism of evolutionary change. Previously, natural selection (i.e., of the kind Sebright discussed) had not been thought to be so useful because it was, as it were, "dragged down" by the analogy from domestic organisms (although it was recognized through this analogy); after Malthus, it was seen that natural selection can far outstrip its analogical relative.

A solution of this kind does, I think, fullest justice to the facts as we now know them. First, Malthus is seen to be of absolutely crucial importance in the discovery of the theory of evolution based on natural selection. This is in line with what is suggested both by Darwin himself and by nearly every recent commentator (including those I am here criticizing). Without Malthus, selection in nature was unimportant (and probably not very effective) in Darwin's eyes. Second, when once we grasp how Darwin already had a theory of evolution, we can see why even when he had a natural form of selection presented to him, Darwin's notebooks do not start suddenly to abound with passages suggesting both that he had a conception of natural selection which he thought to be the only cause of evolutionary change and that he was actively seeking the force driving it. He was certainly not overly impressed with the idea of a natural kind of selection, mainly because it came from an analogy with domestic organisms and he could see so many difficulties with such analogies, and also because he already had a mechanism of evolutionary change. It is here, therefore, that we can see that Darwin's own later accounts are so misleading because they certainly do suggest that when once he had a notion of natural selection he recognized its full importance and put all else aside in the quest for its cause. Neither of these suggestions is true.[41] But third, I think my solution is to be preferred, certainly over the recent accounts I am criticizing, because it takes seriously Darwin's own claims about the importance of artificial selection (and the analogy which can be based on it), and I would suggest that in the light of Darwin's pamphlets on breeding one should take such claims seriously.[42]

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[41]The *Autobiography* is triply misleading because it also implies that Darwin rejected completely any evolutionary theory based on the direct confrontation of individual and environment (119). In fact, although the problem of adaptation gave Darwin qualms about the total adequacy of this kind of mechanism (note 35, above), he did accept such a theory (as we have seen).

[42]In this paper I have been concerned solely with the role of artificial selection in Darwin's *discovery* of his theory of evolution through natural selection. In "The Value of Analogical Models in Science," *Dialogue*, **12** (1973), 246–53, I argue that after he had discovered his theory, artificial selection (and the analogy between it and natural selection) had a new but equally vital role for Darwin—namely, one of *justification*.