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How Breeders Work Their Magic: Ch. 1 — Variation under Domestication

Gregory Radick

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> [One authority on animal breeding] speaks of the principle of selection as "that which enables the agriculturalist, not only to modify the character of his flock, but to change it altogether. It is the magician's wand, by means of which he may summon into life whatever form and mould he pleases."
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> Darwin, *Origin of Species* (1859), p. 31

Charles Darwin's theory of evolution by natural selection is cosmically thrilling. But the book that introduced it to the world begins in a deliberately un-cosmic, un-thrilling manner. For Darwin's ambition is to convince the reader that observations about ordinary processes happening around us right now, and checkable by anyone who takes the trouble to do so, lead ineluctably to the extraordinary conclusions that he defends in the book—conclusions, moreover, that no one can check observationally, however hard they try.[1]

Hence Chapter 1 is set not on the primitive, pre-biotic Earth that no human ever saw, but in the humble worlds of the farm, the garden, and the aviary, where humans for millennia have been bringing into being new varieties of the animals and plants which our ancestors managed to domesticate. Here Darwin lays the foundation for an analogical argument that he intended the name "natural selection" to keep before the reader's mind, linking what happens in nature to the artful or "artificial selection" engaged in by human breeders.[2] To this end, the chapter mounts a two-part case: first, for how astonishingly variable animals and plants become after domestication (pp. 7–29); second, for how impressively selection by humans has accumulated those domestication-induced variations into new varieties, ever more numerous and ever better adapted to human needs and desires (pp. 29–43).

At the very start of all of his chapters, Darwin provides a list of the topics covered. In what follows I will take my enumerated subheadings directly from Darwin's list. But I will embed his topics in an organizational structure of my own, so that the reader can grasp more fully how each topic fits within the larger scheme of the chapter and, ultimately, the argument.

I. Inheritable variation among domesticated animals and plants

A. Domesticated animals and plants as amazingly variable due to the effects of several causes

1. Causes of variability (pp. 7–11)

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[1] On the "uniformitarian" scientific ideal expressed in Darwin's ordering of the *Origin*, and how it can lead to disappointment for new readers—"they expect fanfare, and they get fantails," as Stephen Jay Gould quipped—see Gould, *The Structure of Evolutionary Theory* (Cambridge, MA: Belknap Press, 2002), p. 105.

[2] The most extensive historical and philosophical analysis of the analogical argument to date is in Roger M. White, M. J. S. Hodge, and Gregory Radick, *Darwin's Argument by Analogy: From Artificial to Natural Selection*. Cambridge: Cambridge University Press, 2021.

The opening pages of this opening chapter address something that our textbooks do not recognize as a fact. According to Darwin, if we compare animals and plants from our domesticated varieties with their wild counterparts, we will be struck by how much more *variable* the former are—that is, by how large the individual-to-individual differences are in domesticated organisms, and by how small those differences are in wild organisms, to the point where wild organisms of a particular kind basically appear to be uniform. Having declared that fundamental contrast in the "variability" (p. 7) of domesticated versus wild organisms, Darwin proceeds immediately to the question of what explains it. His lengthy answer is full of fascinating reports, reflections, and qualifications; but in brief, he suggests that the main cause is the disruptive effect that a change from natural conditions to human-created ones eventually has on the functioning of the reproductive systems in the domesticated organisms. As to what, exactly, about domestication might be responsible for this variation-making alteration in reproductive functioning, he offers tentative backing for a proposal from the English horticultural improver Thomas Andrew Knight (1759–1838), who credited the excess of food that pampering humans typically provide.

For purposes of following the twists and turns of Darwin's reasoning through his discussion here, it will help, first of all, if you imagine that you need persuading before you accept this explanation; and secondly, if you appreciate that, in trying to overcome your resistance, Darwin is prepared to make all sorts of what he regards as minor concessions. In Darwin's second paragraph, for example, he confronts doubts about whether the disruptive effect of domestic conditions really occurs before conception. Why should we not suppose instead that the act of conception is the key moment, or that the disruption occurs at some time in the long period when the embryo is developing? In reply, Darwin dwells on a familiar frustration of would-be domesticators: the failure of otherwise healthy organisms, apparently thriving after confinement, to produce offspring. From such cases Darwin infers that everything else in newly domesticated organisms can be fine and yet, anomalously, their reproductive systems shut down. He concludes that when, despite this scope for total shutdown, those systems nevertheless function well enough for offspring to be produced, we should be utterly unsurprised to find that the functioning is imperfect, with the result that the offspring are imperfect copies of their parents. Even so, he immediately adds in the third paragraph, sometimes there is no discernible disruption under domestication, and—equally unsurprisingly—the offspring are then nearly as uniform as they would be under natural conditions.

2. Effects of Habit (p. 11)

The greater variability of domesticated versus wild organisms ceased to be treated as true in the decades around 1900. By no means coincidentally, belief in the inheritance of acquired characters and habits—so-called "Lamarckian" inheritance—declined during the same period, as part of the general embrace of the doctrine, due to the German biologist August Weismann (1834–1914), that what parents experience in their lifetimes has no effect on the hereditary material which they transmit to the next generation. Darwin, however, took permeability between parental experience and offspring inheritance for granted, and expected his readers to do so too.[3] In his first paragraph, he reports, with no fuss or fanfare, that after domestication, a few generations of continual exposure to the new conditions are required before animals and plants begin to show the variability that is his major theme in this part of the chapter. In other words, for Darwin, before the disruptive effect of the new conditions on

[3] On the long-run history of Lamarckian inheritance, see Snait B. Gissis and Eva Jablonka, eds.,*Transformations of Lamarckism: From Subtle Fluids to Molecular Biology* (Cambridge, MA: MIT Press, 2011).

reproductive systems becomes visible, they undergo incremental and invisible weakening, with each new generation inheriting weaker versions and, as the excess food (or whatever) takes its toll, passing on still weaker ones. And when, at last, the weakening reaches the point where the new variability sets in, it becomes permanent—which, Darwin goes on, is why breeders can still develop new varieties from animals and plants whose domestication happened a long time ago.

Although he regards domestication-induced disruption in reproductive systems as the most important cause of variability, he admits other, lesser causes. One is what he calls "the direct action of the conditions of life" (p. 11), as when an organism comes to be one color rather than another depending on whether it is fed on this or that sort of food. Another cause is a new habit acquired under the new conditions, resulting in an organ or limb or faculty becoming enhanced though use or diminished through disuse, and for offspring accordingly to inherit enhanced or diminished versions. Darwin cites several examples in evidence, including his own studies of wing and leg bones in domesticated versus wild ducks. It appears, writes Darwin, that under domestication, ducks have acquired weaker wings and stronger legs—which is exactly what we should expect from domesticated ducks flying less and walking more, generation after generation.

3. Correlation of Growth (pp. 11–12)

Next Darwin considers something that is as much a constraint on variability as a cause: the physiological ties within organisms ensuring that whenever some part X, whatever it is, changes in a particular direction, some other part Y will change too, likewise in a particular direction. In illustration he gives some very odd examples: if a cat has blue eyes, it will also be deaf; if a pigeon has a short beak, it will also have long feet (and vice versa); and so on. Darwin draws two lessons, pointing in opposite directions. One is that breeders do not have a free hand to shape varieties in absolutely every respect, since, due to the laws governing such correlations, the targeting of one part for emphasis or de-emphasis may have unavoidable consequences for the emphasis or de-emphasis of some other part, whatever a breeder's wishes. The other is that, under conditions of domestication, organisms become, in every part, variable, as has been impressively documented in the scientific literature on the oldest varieties. As Darwin puts it, "The whole organisation [of these animals and plants] seems to have become plastic, and tends to depart in some small degree from that of the parental type." (p. 12).

B. Some associated topics: inheritance; domesticated varieties as reverting back to the forms of their wild progenitors; the haziness of the line dividing varieties from species

1. Inheritance (pp. 12–14).

Inheritance has already come up implicitly, in the passages where Darwin presumes that new conditions induce or elicit changes which are then passed on to offspring. But now he deals with it explicitly. "Any variation which is not inherited," he begins, "is unimportant for us" (p. 12). No matter how valuable to the farmer or gardener commercially, or to the organism itself in a state of nature (for escaping predators, for gaining access to food, for attracting mates), if an organism's offspring do not inherit it, then a variation can play no part in the future modification of that kind of organism. For Darwin's purposes, then, a lot hangs on whether the reader comes to believe that inherited variations are common enough to play the role that Darwin wants to assign to them.

Briskly, Darwin sets out his case, citing testimony from two authorities. There are, of course, the breeders, whose livelihoods depend on variations generally being inheritable. "No breeder doubts how strong is the tendency to inheritance," writes Darwin: "like produces like is his fundamental belief: doubts have been thrown on this principles by theoretical writers alone." (p. 12) And there are also the medical observers of patterns of inheritance in human families, most recently the French physician Prosper Lucas (1808–1885), whose magisterial two–volume treatise on "l'heredité naturelle," published in 1847–50, Darwin had studied closely and now praised. As Darwin explains, children who share pretty ordinary features with their parents may have inherited those features, or may simply have been exposed to the same, widely distributed environmental causes. But children who, as documented in Lucas' pages, share extraordinary, one-in-several-million features with their parents, although exposed to the same environmental causes as everyone around them, must have inherited those features. And if "strange and rare deviations of structure are truly inherited, less strange and commoner deviations may be freely admitted to be inherited" (p. 13).

So inheritance is the rule and non-inheritance the exception, Darwin concludes. But beyond that baseline, he goes on, much remains mysterious.[4] He ends by cataloguing some of the mysteries, among them why it is that some individuals end up resembling not their parents but a more distant, and even very distant, ancestor—a phenomenon known as "reversion." With the possibility of reversion affecting individual organisms thus raised, he turns to consider a related topic: reversion affecting domesticated varieties.

2. Character of Domestic Varieties [with a preview of natural selection] (pp. 14–15)

"Having alluded to the subject of reversion, I may here refer to a statement often made by naturalists—namely, that our domestic varieties, when run wild, gradually but certainly revert in character to their aboriginal stocks. Hence it has been argued that no deductions can be drawn from domestic races to species in a state of nature" (p. 14). From this start, the reader might think that Darwin will now argue against the idea that if a domestic variety goes feral, it will inevitably revert to the character of its wild progenitor species. After all, that idea, as Darwin introduces it here, had been held to undermine the soundness of looking to domesticated varieties or "races" (a casually introduced synonym) for light on the origin of natural species—and Darwin's whole argumentative project is premised on that strategy.

But the argument is in fact headed in a rather different direction. In the first half of the ensuing paragraph, we learn that, although Darwin finds the evidence for the expectation of feral reversion to be surprisingly poor and, for reasons that he explores fascinatingly, difficult to improve upon, he nevertheless thinks it is probably correct. Feral reversion, then, is not the problem. Darwin's real target turns out to be a related but different expectation, which we might call "non-feral reversion." Here is Darwin's epitome, along with his immediate dismissal:

> If it could be shown that our domestic varieties manifested a strong tendency to reversion,—that is, to lose their acquired characters, whilst kept under unchanged conditions, and whilst kept in a considerable body, so that free intercrossing might check, by blending together, any slight deviations of structure, in such case, I grant that we could deduce nothing from domestic varieties in regard to species. But there is not a shadow of evidence in favour of this view: to assert that we could not breed

[4] For further discussion see Robert Olby, "Darwin and Heredity," in Michael Ruse (ed.), The Cambridge Encyclopedia of Darwin and Evolutionary Thought (Cambridge: Cambridge University Press, 2013), pp. 116–23.

> our cart and race-horses, long and short-horned cattle, and poultry of various breeds, and esculent [fit for human consumption] vegetables, for an almost infinite number of generations, would be opposed to all experience. (p. 15)

In other words, Darwin concedes that if the distinctive characters of domesticated varieties were so superficially imposed as to be constantly slipping away to reveal the wild-progenitor characters beneath, then nothing could be learned from the farm and the garden about nature. But millennia of experience suggest that the characters which human have bred in to long-established domesticated varieties are more than stable enough to serve Darwin's argumentative purposes.

He ends the paragraph with a short but significant preview of where that argument is headed: "I may add that when under nature the conditions of life do change, variations and reversions of character probably do occur; but natural selection, as will hereafter be explained, will determine how far the new characters thus arising shall be preserved." Here Darwin spells out crucial preconditions for the analogical argument that he will mount in Chapter 4 between the production of varieties by the actions of human selectors and the production of varieties-unto-species by the selective effects of the struggle for existence. What makes selective modification by humans possible is inheritable variation, brought on by changed conditions. We have reason to believe that, in nature too, changed conditions bring about inheritable variation (though plainly, given the apparent uniformity of wild species, such variation is less conspicuous); and so, in Darwin's view, it follows that we have reason to believe that, provided there is a struggle for existence, selective modification can take place in nature too.

3. Difficulty of distinguishing between Varieties and Species (pp. 15–16)

In the analogical argument to come, Darwin will aim to show that natural selection in its effects is different only in degree, not in kind, from artificial selection, and relatedly that the difference between a new species and a new variety is one of degree and not of kind. Here he continues to prepare the ground with some apposite reflections on domesticated varieties and natural species. He suggests that, notwithstanding how much more variable domesticated varieties are when compared with natural species, and how striking, even "somewhat monstrous" (p. 16), are some of the characters to be found only under domestication, domesticated varieties of a single species "differ from each other in the same manner as, only in most cases to a lesser degree than, do closely-allied species of the same genus in a state of nature." (p. 16) And in support of this different-in-degree-not-kind view, he adduces the frequent disagreements among competent naturalists as to whether a particular breed should be judged as a mere variety of a species or as a species in its own right, descended with fidelity from a wild progenitor species. "If any marked distinction existed between domestic races and species," Darwin adds, "this source of doubt could not so perpetually recur." (p. 16)

C. *Wild progenitor species and their domesticated descendants*

1. Origin of Domestic Varieties from one or more Species (pp. 16–20)

Next Darwin asks whether there is anything in general to be said about how many "parent-species" or "aboriginal stocks" are involved in the begetting of a group of domesticated varieties. His answer is that the number is different for different groups. For some groups, like the domesticated pigeons (as he will argue at length in the next section), the evidence

favors descent from a single wild ancestor. For other groups, like the domesticated dogs, he thinks the evidence favors multiple wild ancestors.

Darwin's pigeon answer is justly famous, for its intellectual quality as well as for its status as an illustration of the tree-of-life genealogical pattern that we rightly associate with the *Origin*, along with the theory of natural selection. Darwin's dog answer, by contrast, is not at all well known, and was and remains controversial. By the lights of current science, it is wrong: all domesticated dog varieties are now believed to descend from ancestral wolves. But what troubled an early reader of the *Origin*, Darwin's geological mentor Sir Charles Lyell (1797–1875), was that, in allowing for multiple-origins stories in principle, and then in backing one such story for dogs, in this chapter as well as in Chapter 7, Darwin had made a mistake that was not just scientific (Lyell backed a single, wolfy origin) but moral and political. For, Lyell intimated to Darwin, people wanting to argue that the different human races had separate origins—a view associated with American slaveholders, in justification of their abhorrent treatment of black men and women—could now hold up the *Origin* in support.

Darwin did not agree, and nor did he change his mind about whether dogs had a single origin or multiple origins, going on to defend the latter at length in the book which is, in effect, a truly staggering scaling up of this chapter: *The Variation of Animals and Plants Under Domestication*, published in two volumes in 1868. But as a passionate and lifelong anti-slaver, Darwin was never going to take lightly the possibility that he had given aid to the enemy. His correspondence with Lyell about dogs and humans took place in the months immediately before the *Origin* was published. More or less the first thing Darwin did after publication was to put together and send out a questionnaire on the expression of the emotions in human races around the world: the start of gathering evidence in support of what Darwin later called "a new argument in favour of the several [human] races being descended from a single parent-stock."[5]

> 2. Domestic Pigeons, their Differences and Origin [with a preview of the tree of life] (pp. 20–29)

Part of what made Lyell's suggestion plausible to Darwin was that, throughout the 1840s and 1850s, work by naturalists on the single or multiple origins of domesticated varieties had become thoroughly entangled in the slavery question, along just the lines Lyell sketched. When, in the late 1850s, Darwin took up a serious interest in pigeon breeds and their origins, he was not a lone pioneer, but someone joining an up-and-running debate whose implications for the slavery question were sometimes made explicit.[6] What is more, in concluding that all of the domesticated pigeon varieties descend from a single, still extant wild ancestral pigeon species, *Columbia livia,* known in English as the "rock dove" or "rock pigeon" (because it is usually found living on rocky cliffs), he was not being boldly original but endorsing what had become the consensus view among naturalists, as he emphasized: "Great as the differences are between the breeds of pigeon, I am fully convinced that the common opinion of naturalists is correct, namely, that all have descended from the rock-pigeon (Columbia livia), including under this term several geographical races or sub-species, which differ from each other in the most trifling respects." (p. 23)

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[5] For the story of how antislavery politics led, via Lyell's objections to Darwin on dogs, to Darwin's *Queries about Expression*, see Gregory Radick,"How and Why Darwin Got Emotional about Race," in Efram Sera-Shriar, ed., *Historicizing Humans: Deep Time, Evolution, and Race in Nineteenth-Century British Sciences* (Pittsburgh: University of Pittsburgh Press), pp. 138–71, "new argument" quotation on p. 141.

[6] Adrian Desmond and James Moore, *Darwin's Sacred Cause: Race, Slavery and the Quest for Human Origins* (London: Penguin, 2009), pp. 199–266.

Even so, Darwin's argument for that conclusion is a masterclass of expression and reasoning. He begins (pp. 21–3) with a virtuoso description of the remarkable diversity of structures and habits across pigeon breeds—the English carrier, the short-faced tumbler, the runt (actually a very large bird), the barb, the pouter, and so on. So extensive are the differences between these breeds, he continues, that if they were wild, an ornithologist would rank them as species. So why think that all of them are descendants of just the one wild species, the rock pigeon? Darwin now sets out ten subsidiary arguments in support (pp. 23–28), pausing midway (pp. 26–27) to summarize the first five as follows:

(1) "the improbability of man having formerly got seven or eight supposed species of pigeons to breed freely under domestication";
(2) "these supposed species being quite unknown in a wild state, and their becoming nowhere feral";
(3) "these [hypothetical aboriginal] species having very abnormal characters in certain respects, as compared with all other [wild] Columbidae, though so like in many other respects to the rock-pigeon";
(4) "the blue colour and various marks [characteristic of the rock pigeon] occasionally appearing in all the breeds, both when kept pure and when crossed";
(5) "the mongrel offspring being perfectly fertile"

He then gives the remaining five:

(6) everywhere that it is found, *Columbia livia* has not only proved domesticable but bears much in common with domesticated pigeon breeds;
(7) even with two maximally divergent breeds, such as the English carrier and the short-faced tumbler, "by comparing the several sub-breeds of these breeds . . . we can make an almost perfect series between the extremes of structure" (p. 27);
(8) for whatever features are most distinctive of a particular breed, you will find that, within the breed, there is a lot of variability for those features: a tell-tale sign that the features have been developed cumulatively by selection;
(9) historical evidence suggests that people have been breeding pigeons in a serious way for millennia;
(10) because male and female pigeons form permanent pair bonds, lots of different breeds can be kept together but with no loss of breed distinctiveness

In closing the section, Darwin tell us (pp. 28–9) that he has set out his reasons at such length because he appreciates intimately how hard it can be to accept that so much diversity traces back to just a single wild progenitor. "[W]hen I first kept pigeons and watched the several kinds, knowing well how true they bred, I felt fully as much difficulty in believing that they could ever have descended from a common parent, as any naturalist could in coming to a similar conclusion in regard to the many species of finches, or other large groups of birds, in nature." (p. 28) That sly preview of the farm-to-nature analogical argument to come is the first of two that Darwin now gives. The second comes at the end of a famous passage worth quoting from at length:

> One circumstance has struck me much; namely, that all the breeders of the various domestic animals and the cultivators of plants, with whom I have ever conversed, or whose treatises I have read, are firmly convinced that the several breeds to which each has attended, are descended from so many aboriginally distinct species. Ask, as I have asked, a celebrated raiser of Hereford cattle, whether his cattle might not have

> descended from long-horns, and he will laugh you to scorn. I have never met a pigeon, or poultry, or duck, or rabbit fancier, who was not fully convinced that each main breed was descended from a distinct species. . . . The explanation, I think, is simple: from long-continued study they are strongly impressed with the differences between the several races; and though they well know that each race varies slightly, yet they ignore all general arguments, and refuse to sum up in their minds slight differences accumulated during many successive generations. May not those naturalists who, knowing far less of the laws of inheritance than does the breeder, and knowing no more than he does of the intermediate links in the long lines of descent, yet admit that many of our domesticated races have descended from the same parents—may they not learn a lesson of caution, when they deride the idea of species in a state of nature being lineal descendants of other species?

II. **Selection by human breeders**

1. Principle of Selection anciently followed, its Effects (pp. 29–33)

So, how did humans do it? How did we transform all of that domestication-induced variability into so many distinctive varieties, so well adapted to our sense of the useful and the beautiful? In keeping with English traditions in natural history and natural theology stretching back to the seventeenth century and best represented in the age before Darwin's in the writings of the Reverend William Paley (1743–1805), Darwin takes this point about well-adaptedness to be of the first importance, for animals and plants in the wild, adapted to their conditions of life, as much as for their human-adapted domesticated descendants.[7] Indeed, Darwin takes adaptedness to be such a pronounced feature of living things that he dismisses out of hand any putative explanatory theory that fails to address it. In the book's Introduction he says as much in connection with theories of the origin of wild species (pp, 3–4). Now he says it in connection with theories of the origin of domesticated varieties. Yes, in small ways, and maybe even, in rare cases, in large ways, the causes of variability have contributed to the making of new breeds, without human intervention. But, in Darwin's view, it is utterly implausible to suppose that natural causes by themselves would have produced breeds as distinctively useful and/or pleasing to humans as, say, heavy horses that pull carts versus light horses that run races. Humans did not just get lucky in finding those suited-to-us varieties as they are now. On the contrary, those varieties are so suited to us now because we made them that way. And the chief instrument in our variety-making toolbox, according to Darwin, is selection: the repeated choosing for mating of those individual animals and plants that vary, however slightly, in the direction that the selecting human favors. As Darwin puts it: "The key is man's power of accumulative selection: nature gives successive variations; man adds them up in certain directions useful to him. In this sense he may be said to make for himself useful breeds." (p. 30).

Darwin then surveys how well documented the use of selection by animal breeders has been, along the way expressing admiration for the combination of talent and skill that the most successful breeders bring to the task of discriminating the best individuals from the rest. (Often, Darwin reports, the difference is so subtle as to be undetectable to the inexpert.) The use of selection among horticulturalists is less well documented, though Darwin says that its signature may be seen in the fact that varieties of a particular kind are typically most diverse

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[7] On the distinctively English emphasis on the good design of organisms and Darwin's role in perpetuating it see Gregory Radick, "Is the Theory of Natural Selection Independent of its History?", in Jonathan Hodge and Gregory Radick, eds., *The Cambridge Companion to Darwin,* 2nd edition (Cambridge: Cambridge University Press, 2009), pp. 147–72, esp. pp. 155–8.

in the features of interest to humans and least diverse in the features of no interest to us. He gives as an example an English berry called the gooseberry. In the different varieties of gooseberry, the fruit varies in all sorts of ways—size, color, shape, and so on—but the leaves vary hardly at all.

2. Methodical and Unconscious Selection (pp. 33–7)

Darwin now addresses an anticipated objection: that selection cannot possibly be responsible for the making of new varieties by humans over millennia, because the use of selection for breed improvement has been around for less than a century. In response, Darwin introduces a distinction between what he calls "methodical selection" and "unconscious selection," but which, for the twenty-first-century reader, are better termed "deliberate selection" and "un-deliberate selection." It is true, Darwin concedes, that fully deliberate selection, in which the breeder aims to improve a variety in a particular direction and so breeds only from individuals judged closest to the ideal, generation after generation, is quite recent. But Roman and Chinese sources show that the general principle was well understood in antiquity. Furthermore, improvement from selection can occur even in the absence of such understanding and deliberation. He gives as an example a case where, in just half a century, two breeders who started out with pure-bred sheep from the same flock, and who each sought only to keep his flock pure by breeding from the best, ended up with flocks so different from each other as to seem to belong to different varieties. All that was needed to produce so much divergence was the common desire to keep up a standard plus slightly different notions of what that standard was.

Indeed, Darwin goes on, selective improvement does not require even that much. It is enough for people looking after domesticated animals and plants simply to have favorites. Here is how Darwin puts the point:

> If there exist savages so barbarous as never to think of the inherited character of the offspring of their domestic animals, yet any one animal particularly useful to them, for any special purpose, would be carefully preserved during famines and other accidents, to which savages are so liable, and such choice animals would thus generally leave more offspring than the inferior ones; so that in this case there would be a kind of unconscious selection going on. We see the value set on animals even by the barbarians of Tierra del Fuego, by their killing and devouring their old women, in times of dearth, as of less value than their dogs. (p. 36)

For Darwin, the Fuegians, encountered on the *Beagle* voyage, were the lowest of the low in the scale of human races. (Like Abraham Lincoln—they were born on the same day—Darwin thought slavery was a moral abomination *and* that each race found its place in a hierarchy that extended from the most highly civilized down to the lowest "savages.")[8] Once again, Darwin appeals to what can be observed now—humans at their most savage—to ground a plausible inference about what cannot be observed: the millennia of selective improvement of plants and animals that, in his view, must have taken place long before records began being kept. It is to that long but undocumented period of selection that we owe much of what we find pleasing in our domesticated animals and plants. When Darwin declares unconscious selection to be "more important" (p. 34) than methodical selection, he has in mind the outsized role that the former has played in the making of our varieties.

[8] See, e.g., Gregory Radick, "Did Darwin Change His Mind about the Fuegians?" *Endeavour* 34: 51–4.

3. Unknown Origin of our Domestic Productions (pp. 37–40)

As Darwin sees it, once we appreciate the scale of this debt to unconscious selection, we cease to wonder at the fact that, often, the origins and history of our domesticated varieties are obscure. He makes this point first in relation to plant varieties, adding that the absence of "a single plant worth culture" (p. 38) in places such as Tierra del Fuego is not due to a weird paucity of cultivatable plants in those places, but to the fact that the cultivatable plants that are there never benefitted from the sustained unconscious selection that improved such plants in more civilized places. Likewise, although the uncivilized places have their share of domesticable animals, the varieties that emerge there, like dogs, are less protected from wild conditions than they would be under civilization, with the result that savage animal breeds are partly the product of unconscious selection and partly the product of natural selection. "On the view here given of the all-important part which selection by man has played, it becomes at once obvious, how it is that our domestic races show adaptation in their structure and in their habits to man's wants or fancies." (p. 38) There follows what is, in effect, a fascinating aside on how what attracts unconsciously selecting humans in animals and plants is external novelty, of whatever kind. For Darwin, that quirk of humans explains how the world came to have in it such varietal oddities as tumbling pigeons, because, in all probability, no one ever thought, with a sigh of longing: "oh, if only there were pigeons that punctuate their flights with automatic somersaults!" Instead, one day someone noticed a pigeon born with a very slight tendency to in-flight somersaulting, liked what they saw, and gave that pigeon extra love and attention and, crucially, opportunities for mating. It also explains why the outsides of our domesticated plants and animals are endlessly diverse, but their insides much of a muchness.

Darwin rounds out his discussion by returning to how unsurprising we should find the obscurity of the origins of our varieties, illustrating at length with the example of how, step by unnoticed step, new dog breeds can emerge from existing ones without anyone intending such an outcome, or being able to say afterwards when and where, exactly, the new breed made its debut. Better remembered than the illustration itself is a brief but illuminating analogy that he makes in introducing it: "a breed, like a dialect of a language, can hardly be said to have had a definite origin." (p. 40)[9]

4. Circumstances favourable to Man's Power of Selection (pp. 40–43)

In his final reflections Darwin turns to the question of the circumstances that promote selective improvement. He picks out four factors. First, among the animals or plants there should be high variability, "as freely giving the materials for selection to work on" (p. 40). Second, the number of animals or plants kept should be as large as possible, not only to increase the probability of finding interesting variations (though Darwin stresses that the truly skillful breeder can work his magic equally well with uninteresting variations), but to decrease the probability that the best individuals will mate with markedly inferior ones. Third and, in Darwin's view, most importantly, the superintending humans need to be scrupulously attentive, as they are when the animals and plants involved are most valuable. And fourth, there needs to be a way of preventing unwanted, improvement-diluting crossings. In Darwin's closing paragraph, summarizing the contents as a whole, a theme that has been a minor element in the chapter up to now—the role of crossing as distinct from selection in the improvement of plant and animal varieties—bulks unexpectedly large. It is as though, on

[9] On Darwin's later development of this analogy, see Gregory Radick, "Race and Language in the Darwinian Tradition (and what Darwin's Language-Species Parallels Have to do with it)," *Studies in History and Philosophy of Biological and Biomedical Sciences* 39: 359–70.

reaching the chapter's end, Darwin suddenly realized that he had intended to say more on that theme, and so hastily overcompensates. But his final sentence is as expected: a restatement of how "the accumulative action of Selection," now with a capital S, is, when it comes to the adapted-to-human forms of our domesticated animals and plants, "by far the predominant Power." (p. 43)

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To look ahead a little: we now take our leave of variation under domestication and its selection by humans. The scene shifts to the natural counterparts of these two topics, variation under nature (Chapter 2) and the struggle for existence. (Chapter 3). In nature too, Darwin aims to persuade us, there is inheritable variation in animals and plants, brought on chiefly by changes in conditions; and there is a process that, by its selective effects, accumulates that inheritable variation in adaptive directions. But, he then argues in Chapter 4, via the analogical argument that he foreshadowed at several points in Chapter 1, the natural selective process can go further than the artificial one, producing not merely new varieties within existing species but new species. The rest of the book amounts to a defense of that claim for the greater, species-making power of natural selection (Chapters 5 to 9), then a demonstration of the remarkable explanatory work it can do when brought to bear on the most disparate patterns (Chapter 10 to 13). That, in outline, is the "one long argument" (p.459) that Darwin boasted about making in his Conclusion.[10] But he thought that the argument in outline was unconvincing. To become convinced, people needed not only to read the book but to think through its argument, including all of the arguments-within-arguments composing it, for themselves—to live with it, as Darwin had, mulling it over, with all the many connections kept firmly at the front of their minds. It was, and remains, a dauntingly challenging prospect. I hope that this chapter makes getting started, at least, a little less so.

[10] For the argument's conformity to the *vera causa* tradition, in which one proceeds by establishing first a cause's existence, then its adequacy, then finally its responsibility, see White, Hodge and Radick, *Darwin's Argument by Analogy*, pp. 106–36.