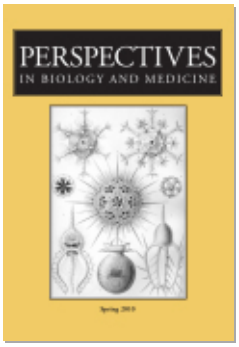
Like Grandfather, Like Grandson: Erasmus and Charles Darwin on evolution



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Perspectives in Biology and Medicine, Volume 53, Number 2, Spring 2010, pp. 186-199 (Article)

Published by Johns Hopkins University Press
DOI: https://doi.org/10.1353/pbm.0.0152

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ABSTRACT Last year (2009) marked the bicentenary of Charles Darwin's birth and the sesquicentenary of *The Origin of Species*. This article examines the influence of Erasmus Darwin on Charles's evolutionary thought and shows how, in many ways, Erasmus anticipated his much better-known grandson. It discusses the similarity in the mindsets of the two Darwins, asks how far the younger Darwin was exposed to the elder's evolutionary thought, examines the similarities and differences in their theories of evolution, and ends by showing the surprising similarity between their theories of inheritance. Erasmus's influence on Charles is greater than customarily acknowledged, and now is an opportune time to bring the grandfather out from behind the glare of his stellar grandson.

Charles Darwin never knew his paternal grandfather. Erasmus (1731–1802) died seven years before Charles was born. Erasmus was a well-known and highly successful physician and writer, but his influence on Charles is not widely appreciated. It may be that Charles himself was hesitant about making too much of this influence, as Erasmus had fallen out of favor with the British establishment in the revolutionary years at the end of the 18th century. Ellis, Frere, and Canning (later to be Foreign Secretary [1807–1809] and Prime Minister

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Earlier versions of this article were read at Marquette, Michigan; Birmingham, U.K.; and Brisbane, Queensland. The author thanks members of the audiences for constructive comments.

Perspectives in Biology and Medicine, volume 53, number 2 (spring 2010):186–99

[1827]) published a wicked parody of Erasmus's poetry in the *The Anti-Jacobin* (1798) and, as Charles wrote, "as soon as the grave closed over him he was grossly and often calumniated" (King-Hele 2003, p. 89). In this essay, I point to the many similarities between grandfather and grandson, and argue that Erasmus was a more important influence on Charles than has previously been acknowledged.

MINDSET

Grandchildren, as Charles's father often remarked, frequently resemble their grandparents. Charles agreed (C. R. Darwin 1839, p. 58). He remarked more than once, on his return from the *H.M.S. Beagle* circumnavigation, on the similarity of his handwriting and that of his grandfather (C. R. Darwin 1838, p. 83). Graphologists may draw their own conclusions. But this, at least, is a first indication that Charles was not unfamiliar with his grandfather's writings and ideas.

Like his grandfather, Charles possessed a powerful speculative intellect. His grandfather's masterworks, *Zoonomia* (1794–96) and *Temple of Nature* (1803), are filled with speculation concerning the natural world, human disease, and human mentality. The notebooks that Charles filled on his return from his voyage on the *Beagle* are similarly full of speculation on natural history, on the human mind, on man's place in nature, and on metaphysics (Barrett 1980; Gruber and Barrett 1974). At the peak of his powers, in his late twenties and early thirties, Charles was much more than "merely" a naturalist: he was a wide general thinker, almost a philosopher in the British empiricist tradition.

A second major characteristic that Charles shared with his grandfather was a strong inclination toward collection and classification. With Erasmus this was, of course, very much in tune with the spirit of the age. Collection and classification was an 18th-century enthusiasm. Every aristocratic household possessed its cabinet of curiosities. Erasmus, though no aristocrat, was no exception to this passion. His desire to get a grip on the natural world also led to his making the first English translation of Linnaeus's *Systema Naturae* and to the great medical compendium he spent 20 years putting together, *Zoonomia*, the 772-page second volume of which is devoted to a classification of diseases into orders, genera, and species. For the savants of the 18th century, a *classification* of "what was there" was a necessary preliminary to *understanding* "what was there."

As his "Recollections" (1876–81) show, Charles inherited this disposition in spades. From early boyhood he collected and classified, even the stones on his father's path. In the earliest scrap of his handwriting that has come down to us, Charles carefully records a piece of tile he found at Wenlock on January 23, 1819 (Browne 1995). At Cambridge his hobby, or obsession, was collecting and classifying beetles. His undergraduate friend Albert Wray, later a distinguished archaeologist, cartoons Charles waving a collector's net astride a giant beetle. "Go it Charlie," he writes (Browne 1995, p. 111). In his "Recollections," Charles says that the pleasure he derived from "beetling" stemmed from a "passion for col-

lecting" (p. 378). This passion extended into his later life. The collections he sent back from the *Beagle* helped to establish his reputation as one of the leading scientists of the age whilst still in his late twenties.

Charles also shared with his grandfather a genius for friendship. Indeed, the very name *Darwin* derives from *Deorwine*, meaning "friend," in particular "friend of deer" (*deor*, Old English, "animal, beast"). Desmond King-Hele, Erasmus Darwin's principal biographer, regards this gift as one of Erasmus's leading characteristics. His role in the establishment of the Lunar Society is well known, and he was also instrumental in setting up at least three other societies in the English Midlands. A perusal of his letters shows the high-spirited sociability with which these societies were conducted (King-Hele 2007). Charles's gift for friendship was also strongly developed. It was displayed throughout his Cambridge career and later, on his return from his circumnavigation, he developed his facility at "networking" and made many significant friends. His social *nous* must have been tested to the full when he found himself sharing a cabin with the forceful but unstable Robert Fitzroy during the four years of the *Beagle* circumnavigation.

Associated with this gift is the well-known abhorrence of both Darwins for "the peculiar institution," slavery. Erasmus was deeply involved with his great friend and business partner, Josiah Wedgwood, in the antislavery campaigns at the end of the 18th century. He was outraged to learn that "muzzles or gags" were being made in nearby Birmingham for slaves "in our islands," and he wrote to Wedgwood asking whether they could not be exhibited in the House of Commons to bring home the barbarity being practiced (King-Hele 2007, p. 338). His outrage is also well expressed in Canto 3 of the 1789 *Loves of the Plants*:

> E'en now in Afric's groves, with hideous yell
> Fierce Slavery stalks, and slips the dogs of hell; . . .
> Throned in the vaulted heart, his dread resort:
> Inexorable Conscience holds his Court; . . .
> Hear him, ye Senates! Hear this truth sublime,
> "He who allows oppression, shares the crime." (ll. 443–56)

Charles was passionately of the same opinion. Indeed, it was something of a family crusade (Desmond and Moore 2009). It is thus not surprising to find that when Charles first encountered slavery in South America, he reacted with abhorrence. "I have stayed in a house" he writes, "where a young household mulatto, daily and hourly, was reviled, beaten and persecuted enough to break the spirit of the lowest animal. . . . It makes one's blood boil, yet heart tremble, to think that we Englishmen and our American descendants, with their boastful cry of liberty, have been and are so guilty" (C. R. Darwin 1845, ch. 21).

Associated with this family abhorrence of man's inhumanity to man is, of course, the human sympathy entailed in the practice of medicine. Both Erasmus and Charles's father, Robert, were highly successful physicians. Erasmus's reputa-

tion was, indeed, so high at the end of the 18th century that George III asked more than once that he should leave the Midlands and come to London to be his personal physician (he didn't), and Robert was the preeminent physician of early 19th-century Shrewsbury. Charles himself was expected to follow in his father's footsteps and he helped his father in his medical rounds before enrolling in the Edinburgh Medical School. Successful practice of medicine in the late 18th and early 19th centuries required not only sympathetic understanding but also an acute ability to notice and interpret the symptoms of illness. In his "Recollections," Charles remarks on the acuteness of his father's powers of observation. Charles shared this attentiveness. When asked, towards the end of his life, what he felt distinguished him from others, he replied, simply: "Noticing things which easily escape attention and observing them carefully" (C. R. Darwin 1876–81, p. 423).

Lastly, in this short resumé of the mental similarity between grandfather and grandson, it is worth remarking on one final shared characteristic: tenacity. Erasmus's granddaughter Violetta wrote: "I know of nothing more wonderful than the variety of his talents. . . . but he made his mark in all that he undertook" (King-Hele 1999, p. 372). In his "Recollections," Charles noted that a similar tenacity was one of his intellectual characteristics. Like his grandfather, and perhaps for rather similar reasons, this tenacity allowed him to work at his major publication, *The Origin* (in Erasmus's case, *Zoonomia*) for 20 or so years before publishing.

CHARLES'S EXPOSURE TO HIS GRANDFATHER'S EVOLUTIONARY IDEAS

In addition to these temperamental similarities, Nurture played an important part. Charles was more familiar than he admitted (or perhaps realized) with his grandfather and his grandfather's writings. Charles's father and grandfather were close before Erasmus died in 1802. Indeed, King-Hele lists more letters from Erasmus to Charles's father than to any other correspondent save Josiah Wedgwood. Moreover, the correspondence increased toward the end. In one of his last letters, written in April 1801, Erasmus thanks Robert for coming over from Shrewsbury ("so much to your inconvenience") to give him a thoroughgoing medical examination (King-Hele 2007). It is reasonable to suppose that Robert must often have spoken of Erasmus when Charles was growing up at The Mount in Shrewsbury, and if so, his evolutionary ideas would have been discussed. Robert never published on this topic. Indeed, apart from an early contribution to the Royal Society on ocular spectra (inspired, probably, by Erasmus), Robert prudently never published at all. Charles, however, writes in his "Recollections" that a major reason for his inability to accept the tenets of the Christian faith was that it seemed to condemn both his greatly loved father and elder brother to

outer darkness for their atheism and this, he writes, "is a damnable doctrine" (p. 392). It is not, therefore, absurd to imagine lively discussions of Erasmus's evolutionary ideas around the dinner table at The Mount.

Although Erasmus died in 1802 and Charles was not born until 1809, Erasmus's second wife, Elizabeth, lived on at Breadsall Priory, just outside Derby, until 1832, remaining mentally acute until the end. When Charles was growing up he visited her several times, and she showed him the chair and sofa on which his grandfather had died. She had kept them in the place where they had been in April 1802. Charles's grandmother was by all accounts a sprightly and vivacious old lady and the family called Breadsall Priory "Happiness Hall." Once again Charles must have heard conversation about his grandfather and his doings.

Finally, there is no doubt that Charles was familiar with his grandfather's major work, *Zoonomia*. In his "Recollections" he writes that when, as a medical student in Edinburgh, he was exposed to Robert Grant's transformationist thought, he remembered that he had "previously read the *Zoonomia* by my grandfather" and that he "listened in silent astonishment" to Grant's enthusiastic account of Lamarck's ideas and recalled that his grandfather had had a similar theory (p. 371). Exactly when he had read the *Zoonomia* he does not say, but it must have been in his impressionable adolescent years, perhaps when he was helping his father with his medical rounds in Shrewsbury. He perused it again some 10 or 15 years later, when he was working on his evolutionary ideas after returning from the *Beagle* voyage. His list of "books read" and "books to be read" during this period includes his grandfather's three major works—*Zoonomia*, *Temple of Nature*, and *Botanic Garden* (see http://Darwin-online.org.uk/). He writes that although he had greatly admired Zoonomia when he first read it, he now found it too speculative. Later still, however, when he was putting together his Preface to Krause's *Life of Erasmus Darwin* in the 1870s, he reread *Zoonomia* once again and wrote: "The more I read of Dr Darwin the higher he rises in my estimation" (Colp 1986, p. 11). So he is known to have read Erasmus's masterwork at least three times: once as a teenager, once as a 30-year-old, and once in his sixties. His grandfather's thought must have penetrated the recesses of his mind. Indeed, he writes in his "Recollections" that his early familiarity with Erasmus's ideas "may have favoured my upholding them under a different form in my *Origin of Species*" (p. 371).

Erasmus and Charles on Evolution

Having rapidly reviewed the lines of possible influence connecting Charles with his grandfather, let us look at the similarity and difference of their evolutionary ideas. Erasmus probably became an evolutionist after Josiah Wedgwood sent him a number of "curiosities" (i.e., fossils) from the excavation of the Harecastle canal tunnel in Shropshire. In a letter to Wedgwood dated July 2, 1767, he replies half jokingly that "the bone seems to be the third vertebra of the back of a camel . . .

and the impressions on some of the rocks appear to be those of ferns and irises." He goes on to ask Wedgwood to let him know the strata in which they were found, their thicknesses and order (King-Hele 2007, p. 77). Three years later he had his famous motto, *E conchis omnia* ("all from shells"), painted on his coach door. This caused something of a scandal amongst the ecclesiastical authorities in Lichfield, and Canon Seward was moved to liken the doctor to Epicurus and write:

> He too renounces his Creator,
> And forms all sense from senseless matter;
> Makes men start up from dead fish-bones,
> As old Deucalion did from stones;
> Great wizard he, by magic spells
> Can build a world of cockle shells . . .
> O Doctor! change thy foolish motto,
> Or keep it for some lady's grotto,
> Else thy poor patients well may quake,
> If thou no more canst mend and make. (Seward 1784, ll. 23–34)

This is a recurrent complaint. When *The Origin* was published in 1859, Charles was also accused of being an Epicurean (Wilberforce 1860). Erasmus, however, thinking of his medical practice and of the need to support his young family, decided that discretion was the better part of valor and painted over the offending motto.

But if Erasmus felt it unpropitious to advertise his evolutionary thought, he nevertheless kept on thinking. Towards the end of his life, in the mid- to late-1790s, when he felt that his work was almost done, he began to publish his evolutionary ideas. These appear in explicit form in the first volume of *Zoonomia: or the Laws of Organic Life* (first edition 1794) and in his last great poem, *The Temple of Nature*, published posthumously in 1803. In the first canto of *The Temple of Nature*, we find the following passage:

> ORGANIC LIFE beneath the shoreless waves
> Was born and nurs'd in Ocean's pearly caves
> First forms minute, unseen by spheric glass,
> Move on the mud, or pierce the watery mass;
> These, as successive generations bloom,
> New powers acquire, and larger limbs assume;
> Whence countless groups of vegetation spring,
> And breathing realms of fin, and feet, and wing. (ll. 295–302)

These lines encapsulate a vision of the living world not so dissimilar to that which his grandson was to promulgate some 60 or 70 years later. Intriguingly, he was also close to the evolutionary mechanism which Charles was to make famous in *The Origin*: struggle for survival and selection of the "fittest."

Like his grandson, Erasmus was impressed by "the great changes introduced into various animals by artificial or accidental cultivation" and cites, in particular, horses, dogs, sheep, rabbits, and pigeons (E. Darwin 1796, 1:504). Unlike his grandson, however, he did not develop a large correspondence with pigeon fanciers, sheep breeders, and so on to learn the intricacies of the techniques employed. Perhaps this was because he just needed the general principle.

It was the fact that domestic animals could be and were selectively bred that impressed him. Erasmus saw that it could also apply in the natural world as much as in the world of stock breeders. He saw that if they could change the shape of dogs and pigeons in the comparatively short period of historical time, then how much greater would be the changes wrought by natural forces over "geological time," and he went on to specify what seemed to him the principal forces in play.

In *Zoonomia*, Erasmus writes that the "three great objects of desire which have changed the forms of many animals by their exertions to gratify them, are those of lust, hunger, and security" (1:507). *Lust*, he writes, leads to sexual selection: "The final cause of this contest amongst the males seems to be, that the strongest and most active animal should propagate the species, which should thence become improved" (1:507). *Hunger* leads to the development of different means of procuring food:

> The nose of the swine has become hard for the purpose of turning up the soil in search of insects and of roots . . . beasts of prey have acquired strong jaws and talons . . . some birds have acquired harder beaks to crack nuts, as parrots, others for the softer seeds of flowers, or the buds of trees, as finches. . . . All of which seem to have been gradually produced during many generations by the perpetual endeavour during many generations of the creatures to supply want of food. (1:508)

Security was "the third great want amongst animals." He writes of security, that it "seems much to have diversified the forms of their bodies, and the colour of them [in order to escape] other animals more powerful than themselves" (1:508).

Erasmus is close to his grandson's definitive solution of the species problem. In the first case, lust, the notion of survival of the fittest in the struggle for life is explicit. Only the most successful males win a female and thus propagate their characteristics. In the second two cases, hunger and security, his thought is less clear. He does not spell out, as his grandson did, that the most effective beaks for cracking nuts, for instance, are selected over time from a variety of more-or-less effective designs. He is diverted by embryological musings and a conviction that organisms possess "the faculty to improve by their own inherent activity" (1:509). Nevertheless, his grandson's idea is not too far away. In the 1801 third edition of *Zoonomia*, he observes, for instance, that had hermaphrodites such as the "shell-snail" and the "dew worm" been able to fertilize themselves, then new varieties would not occur and "no new species from the same genus, could have been procreated" (2:309).

Erasmus concludes this 18th-century foreshadowing of his grandson's theory by writing that

> From thus meditating on the great similarity of the structure of the warm-blooded animals, and at the same time of the great changes they undergo both before and after nativity; and by considering in how minute a portion of time many of the changes of animals above described have been produced (i.e. by domestication); would it be too bold to imagine that in the great length of time, since the earth began to exist, perhaps millions of ages before the commencement of the history of mankind, would it be too bold to imagine, that all warm blooded animals have arisen from one living filament, which THE GREAT FIRST CAUSE endued with animality. (E. Darwin 1796, 1:509).

He then goes on to consider the "cold-blooded animals . . . the fish tribes . . . the numerous tribes of insects . . . the vermes . . . and last of all the various tribes of vegetables" (1:509–11). With regard to the latter—and remember that Erasmus was not only the translator of Linnaeus but also the creator of a botanic garden in Lichfield—he writes of a "perpetual contest for light and air above ground, and for food and moisture beneath the soil" (1:511). Here the notion of a struggle for existence, of a Hobbesian war of all against all, is made quite explicit. This dark notion crops up every so often in Erasmus's work. He writes of the vast overpopulation that would result if all the seeds of plants, offspring of aphids or spawn of herring were to survive. "All these" he writes in *The Temple of Nature*, "increasing with successive birth / Would each o'erpeople ocean, air and earth" (E. Darwin 1803, Canto 4, ll. 347–48). He is clear that Malthusian-type checks must operate: "War, and pestilence, disease and dearth / Sweep the superfluous myriads from the earth" (ll. 373–74).

Finally, Erasmus concludes this section of *Zoonomia* with a comprehensive vision of the living world:

> Shall we then say that the vegetable living filament was originally different from that of each tribe of animals above described? . . . or, as the earth and oceans were probably peopled with vegetable productions long before the existence of animals; and any families of these animals long before other families of them, shall we conjecture that one and the same kind of living filament is and has been the cause of all organic life? (1796, 1:511).

But here we come to a major difference between Erasmus and his grandson. Erasmus was still in thrall to the time-honored concept of a "great chain of being." That the living world has evolved, he is sure, but he is also sure that it has evolved to some purpose. He is full of 18th-century optimism. Even his gloomy musings on the cruelties of the struggle for existence—"one great Slaughter-house the warring world" (E. Darwin 1803, Canto 4, l. 65)—are ultimately countermanded by an energetic hope. The despair of the slaughterhouse is balanced by his invitation to "Shout round the globe, how Reproduction strives /

With vanquish'd Death,—and Happiness survives" (ll. 451–52), and his description of the great chalk and limestone cliffs as "mighty monuments of past delight" (l. 450).

"All nature," he writes in the third edition of *Zoonomia*, "exists in a state of perpetual improvement by *laws impressed on the atoms of matter* [my italics] by the great CAUSE OF CAUSES; and that the world may still be in its infancy, and continue to improve FOR EVER AND EVER" (1801, 2:318). Erasmus was sufficiently a deist to insist (at least in print) that the idea of a God as "first cause," who imbued the "first specks of animated earth" with an "upward" direction and then stood back, was a far more impressive vision than that of a personal God interfering in miraculous ways to fine-tune the process. "What a magnificent idea of the infinite power of the GREAT ARCHITECT!" he writes in chapter 39 of *Zoonomia*: "THE CAUSE OF CAUSES! PARENT OF PARENTS! ENS ENTIUM!" (1796, 1:513). He concludes the chapter by quoting from Psalm 19:104: "The heavens declare the glory of GOD, and the firmament sheweth his handywork!" (p. 537).

Grandson Charles's view was bleaker. He several times reminded himself (unsuccessfully) not to use the terms "higher" and "lower" with respect to animals. He saw no necessary "great chain of being" with humans at the top, or (at the least) at the top of earthly beings. His view was better represented by a tangled bush (C. R. Darwin 1837, pp. 21, 25). Natural selection "merely" formed animals and plants to survive as best they could in the ever-changing environments in which they found themselves. There was no inevitable movement "upwards," no striving towards a "point omega." Indeed, he derides Lamarck for promulgating precisely this idea. In an 1863 paper in the *Athenaeum*, he refers to W. B. Carpenter's instancing the lack of change in Foraminifera over geological time as an objection to his theory, noting that "this objection is grounded on the belief—the prevalence of which seems due to the well-known doctrine of Lamarck—that there is some necessary law of advancement, *against which law I have often protested*" [my italics]. "Animals," he continues, "may even become degraded, if their simplified structure remains well-fitted for their habits of life, as we see in certain parasitic crustaceans."

But although grandfather and grandson differed in this, they agreed (perhaps surprisingly to modern ears) in one final matter: the mechanism of heredity.

Erasmus and Charles: Inheritance of Acquired Characteristics

In Chapter 39 of *Zoonomia*, Erasmus develops his theory from a passage in David Hartley's mid-century *Observations on Man*:

> The ingenious Dr Hartley in his work on man and some other philosophers, have been of the opinion, that our immortal part acquires during this life certain

> habits of action or of sentiment, which become forever indissoluble, continuing after death in a future existence. . . . I would apply this ingenious idea to the generation, or production, of the embryon, or new animal, which partakes so much of the form and propensities of the parent. (1796, 1:483–84)

But *how* were acquired characteristics inherited? What was the biological mechanism? Erasmus argues that "the primordium, or rudiment of the embryon, as secreted from the blood of the parent, [consists] of a simple living filament" (p. 496). He continues by suggesting that "different fibrils and molecules are detached from different parts of the male caudex" and affect this "living filament secreted in the blood of the male," and that the latter thus carries "some of the acquired habits or propensities peculiar to the parent." He concludes that

> the living filament is part of the father, and has therefore certain propensities, or appetencies, which belong to him; which have been gradually acquired during a million of generations, even from the infancy of the habitable earth; . . . But as the first nutriment is supplied by the mother, and therefore resembles such nutritive particles, as have been used by her for her own nutriment or growth, the progeny takes in part the likeness of the mother. (p. 531)

It is, perhaps, surprising to modern readers to find that grandson Charles also argues for the inheritance of acquired characteristics. He saw two reasons for this. First, in the 10 or so years after the publication of the first edition of *The Origin*, a fundamental objection to his theory had emerged. Darwin's extensive analyses of the records of stockbreeders, which had done so much to establish his theory, had also impressed him with the fact that hybrids tended to exhibit a *mixture* of the characteristics of both parental strains. In the second edition of *The Variation of Animals and Plants under Domestication* (1875) he offers the following graphic example: "When two commingled breeds exist at first in nearly equal numbers, the whole will sooner or later become intimately blended" (p. 64). Interestingly, he goes on to give the same example his grandfather used in *Zoonomia*. Erasmus had written that the offspring of a white man and a black woman "is always of the mulatto kind" and in the third generation shows a "beautiful mixture of the two types" (E. Darwin 1796, 1:518–19). Charles generalizes this to the population level and writes of the interbreeding between individuals of a colony of "an equal number of black and white men." In three centuries, he calculates, "not 1/100th part of the whites would exist." The vast majority would be mulattos blending the features of both races (C. R. Darwin 1875, 2:64). Clearly, all variation between interbreeding individuals would soon be eliminated. It was essential that some large-scale source of variation should be operating to make up for the loss due to blending inheritance.

The second reason for Charles's support for the inheritance of acquired characteristics was observational. In the second volume of *Variation of Animals and Plants under Domestication* he writes:

> How again, can we explain the inherited effects of the use, or disuse, of particular organs? The domesticated duck flies less and walks more than the wild duck, and its limb bones have become diminished and increased in a corresponding manner in comparison with those of the wild duck. A horse is trained to certain paces, and the colt inherits similar consensual movements. The domesticated rabbit becomes tame from too close confinement, the dog, intelligent from associating with man, the retriever is taught to fetch and carry; and these mental endowments and bodily powers are all inherited. (2:367)

Acquired characteristics provided the variation on which natural selection worked: it provided the grist for evolution's mill. Herbert Spencer (1864) observed that "either there has been inheritance of acquired characteristics or there has been no evolution!" (p. 621) Charles faced his grandfather's problem: *how* were acquired characters inherited? "How," as he writes, "can the use or disuse of a particular limb or the brain affect a small aggregate of reproductive cells, seated in a distant part of the body, in such a manner that the Being developed from these cells inherits characters of either one or both parents?" His solution in *The Variation of Animals and Plants under Domestication* was the "provisional hypothesis," as he calls it, of *pangenesis*.

He did not regard pangenesis as a mere appendage to his work, but as one of his most important contributions. He wrote to Lyell in 1867 that he had thought it over for nearly 30 years and (with characteristic modesty) was "inclined to think . . . it will be a somewhat important step in Biology" (F. Darwin 1887, 3:72). His co-discoverer, A. R. Wallace, was highly complimentary, writing that "It is a positive comfort to me to have any feasible explanation of a difficulty which has always been haunting me and which I shall never be able to give up till a better supplies its place, and that I think hardly possible" (Wallace 1868, 1:196).

What was this "provisional hypothesis"? It was surprisingly similar to the mechanism described in his grandfather's *Zoonomia*. The pangenesis proposal reminds us of the fibrils and molecules imagined by Erasmus. Charles does not specify fibrils or molecules, but he suggests that all parts of the body continuously throw off particles or "gemmules" that ultimately aggregate to form the reproductive cells. "Hence," he concludes, "it is not the reproductive organs or buds which generate new organisms but the units of which each individual organism is composed" (C. R. Darwin 1875, 2:321).

The pangenesis idea was immediately contested, not least by Charles's half-cousin, Francis Galton, who carried through a long series of experiments (1869–71) in which he transfused blood between different breeds of rabbit and showed that they still bred true. Gemmules, he concluded, were not to be found in the vascular system (Galton 1871). Darwin was, however, not particularly perturbed. In his response to criticisms in the second edition of *Variation under Domestication*, he argued that he had never said that gemmules were to be found in the blood.

He pointed out that pangenesis was intended to apply to non-sanguinous animals as well as those with blood-systems and, most importantly, that it was intended also to apply to plants. Gemmules must somehow pass from cell to cell without the aid of the vascular system (C. R. Darwin 1875, 2:303, fn.).

Charles went further. In an echo of Erasmus's reference to Buffon's report of the inheritance of mutilations—tail-less dogs in Rome resulting from generations of tail-docking (E. Darwin 1796)—he cites Brown-Sèquard's report of the inheritance of surgically induced epilepsy in guinea pigs and goes on to mention several other neurosurgical interventions that were also said to be inherited (C. R. Darwin 1881).[1] Perhaps Charles, nearing the end of his life, was beginning to believe that these reports might throw light on the inheritance of the "consensual movements" in equines which he had instanced in the chapter on pangenesis in *Variation under Domestication*.

CONCLUSION

How similar are grandfather and grandson? I hope to have shown that there is indeed a great deal of similarity, in their mindsets, their intellect, and their theories about evolution. There are also, of course, important differences. Erasmus still held to the ancient idea of a "great chain of being," a ladder with humans at the top. He had, however, given it a new optimistic dynamism. His vision was imbued with all the energetic optimism of the "new men" of the 18th-century Midlands. He might have appreciated Emerson's (1909) well-known lines: "Striving to be man the worm / Mounts through all the spires of form."

Charles saw no inevitable progress from monad to man. There was no law of perpetual improvement impressed on the atoms of matter. Some living forms were simply more successful than others in their endeavor to survive in complex and changing environments, and these passed their characteristics on to their offspring. There was no "great chain of being," no ladder with humans at the top—rather a bush with organisms adapted to survive in a myriad different environmental niches.

Erasmus and Charles were, however, at one in this: they both saw the evolutionary process as dependent on the inheritance of acquired characteristics. Charles knew nothing of the work of Mendel (1866) nor of Weismann (1902), both of whom showed, in their different ways, that neither blending inheritance nor the inheritance of acquired characters occurred. In our time we recognize that the molecular biology of protein synthesis prevents the flow of information from proteins (phenotype) back through the ribosome to nucleic acids (genotype).

Thus, in conclusion, we can see that Erasmus and Charles Darwin mark stages

[1]Darwin is referring to a recent report from a Eugène Dupuy of San Francisco and to a much earlier set of experiments by Brown-Séquard (1860).

in the development of the theory of organic evolution. Erasmus saw, through a glass darkly, the lineaments of his grandson's theory of Malthusian overproduction and selective retention. He was, however, still in the grip of the ancient concept of a great chain of being, an inevitable "improvement," "for ever and ever." He still confused evolution with embryonic development. Charles, in contrast, was clear. Organic evolution was not to be confused with development, with the unrolling of some pre-inscribed scroll. There was no inevitable progress from fish to philosopher. But, like his grandfather, he could not escape a belief in the inheritance of acquired characteristics. A century later biologists have shown that this does not and cannot occur; the evolutionary process is the outcome of random variation and selective retention. There is no permanent inheritance of acquired characteristics. The consequence, as Theodosius Dobzhansky (1973) so memorably said, is a theory without which "nothing in biology makes sense."

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