SACRED BOVINES

Celebrating Darwin's Errors

How should we mark the Darwin Bicentennial?

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Charles Darwin was truly amazing. In 1859 he introduced a robust understanding of descent with modification by means of natural selection. His concepts would help unify taxonomy, biogeography, comparative anatomy, heredity, morphological analysis, embryology, paleontology, population dynamics and ecology, and even human moral behavior. Darwin showed how to explain organic "design" as well as the limitations of contingent history, adaptive structures as well as vestigial ones. Every lesson in biology, properly framed, expresses and celebrates Darwin's achievement.

How, then, might one mark so august an occasion as his 200th birthday, February 12th this year (also the sesquicentennial year of his premier work, *On the Origin of Species*)? Many will no doubt want to parade Darwin's many triumphs. But allow me to take exception to the common view (another sacred bovine?) that science is best reflected only by its successful theories. If science is fundamentally about discovery, then its "failures" or errors along the way may be just as important as the ultimately reliable insights (Allchin, 2004; Allchin, 2008). I wish to celebrate science *as a process*. Here, then, I acknowledge Darwin's mistakes and show how understanding them gives us a deeper understanding both of Darwin and of science more generally. My tribute is to forego the mythologized legend and appreciate so remarkable a scientist as Darwin in familiarly human terms.

Was Darwin Ever Wrong?

First, one may note that Darwin's errors generate interest largely because of his many achievements. His credentials are unimpeachable. If he made mistakes, it was not for want of scientific ability. One cannot rudely dismiss his errors as due to ineptitude.

Indeed, Darwin's contributions are wider and their theoretical coherence deeper than popularly known (Ghiselin, 1969). He produced four volumes on the taxonomy of barnacles, demonstrating his skills in detailed observation and phylogenetic analysis. In his first work after the *Origin*, he showed the importance of orchid morphology in promoting outcrossing through pollination, thereby contributing further to an understanding of the role of sex and genetic recombination in evolution. Later, he explained heterostyly – the occurrence of flowers with different length styles – as illustrating the same general principle. Add, too, his work on the anatomy and physiology by which emotions are expressed, grounding a study of mental phenomena and social communication in concrete observables. In his last work, Darwin correctly interpreted the role of worms in forming topsoil (what he called "vegetable mould").

Darwin was also a skilled experimentalist (Dennison, 2006). Chapter 11 in the *Origin* summarizes some of his experiments on the effects of sea water on seed germination – a "test" of his ideas about how plants traversed the ocean. Biology teachers, in particular, may know that Charles and his son Francis investigated "the power of movement in plants"–documenting, measuring, and isolating the locus of phototropisms. These studies followed earlier experiments on the positive effects of plant hybridization. Darwin would surely be remembered for these works even if he had never written the *Origin* or *Descent of Man*.

In short, there is no deficit of Darwin's achievements.

Yet Darwin's conclusions were not always correct. Perhaps the most notorious of his ill-fated claims was his "retreat" to Lamarckian-like processes (Eiseley, 1961, pp. 216-221; Ghiselin, 1969, pp. 162-164). While variation was essential to the process of natural selection, Darwin could not explain its sources. Sharp criticism worsened the problem. Darwin, rather than leave his theory incomplete perhaps, ultimately appealed to external forces (use or disuse, or habit, say) in generating favorable variants. That seemed to echo Lamarck's earlier idea (now discredited) of the inheritance of acquired characters. Darwin also claimed that domestication itself increased the rate of variants.

Many admirers today wonder: How could The Great Darwin have succumbed to such nonsense? Indeed, modern portrayals of Darwin often treat this politely as a blemish or mild embarassment. They tend to "excuse" it as a product of the times. (What idea is not a product of its time?) –Or they downplay Darwin's level of commitment, implying that he didn't *really* believe it. Of course, such dismissals never extend to Darwin's correct claims. Historical judgments are easily shaded by later outcomes. Too often, we tend to manipulate the past to fit our own ideals. We render the science as more perfect than it really was – or is now.

But Darwin professed what he professed. Other options were available at the time. Indeed, the co-discoverer of natural selection, Alfred Russel Wallace, saw no need to *explain* variation. He chided Darwin in a letter in 1866:

> *Such expressions have given your opponents the advantage of assuming that* favorable *variations are* rare accidents, *or may even for long periods never occur at all and thus [the] argument would appear to many to have great force. I think it would be better to do away with all such qualifying expressions, and constantly maintain (what I certainly believe to be the fact) that variations of every kind are always occurring* in every part of every species, *and therefore that favorable variations are* always ready *when wanted.*

For Wallace, the mere fact of variation was enough to answer critics. He continued:

> *You have, I am sure, abundant materials to prove this, and it is, I believe, the grand fact that renders modification and adaptation to conditions almost always possible. I would put the burden of proof on my opponents to show that any one organ, structure or faculty, does* not vary, *even during one generation, among the individuals of a species and also to show any* mode *or* way, *in which any such organ, etc. does not vary.*
>
> (Quoted in Eiseley, 1961, p. 191)

Wallace is a convenient touchstone for assessing Darwin's error on this occasion.

Darwin made other mistakes, as well – some trivial, some less so. First (ironically), Darwin failed to properly label his finch specimens from the Galápagos Islands – those that would later bear his name. Ornithologist John Gould, who worked on his collection, noticed the error and helped remedy it by consulting further specimens collected by others on the *Beagle* voyage (Sulloway, 1982; Browne, 1995, pp. 359-360).

Later, having once established descent with modification as a general doctrine, Darwin endeavored to fill in some of the details. Here, his proposals met with mixed success. Darwin proposed that modern chickens are descended from red-footed junglefowl. Recently, geneticists have identified the foot-color gene, indicating that they get their *yellow* feet instead from having hybridized with *grey* junglefowl (Eriksson et al., 2008). (Critics of Darwinism have been having a field day with this little blooper!) Darwin erred, too, in thinking of the fossil *Eozoon* as primitive biota, helping to fill the apparent gaps in the early history of life. Further analysis revealed it to be an inorganic mineral formation, as Darwin himself acknowledged (Gould, 1980). These errors are all relatively minor. Yet they remind us that small mistakes occur commonly in science. When findings become relevant, further studies tend to either confirm earlier results or reveal how perceived patterns were based on incomplete information.

Biases in Discovery

Darwin's errors (like those of other great scientists) can often be coupled to one of his notable discoveries. The paired conclusions ironically drew on the same underlying concept or exhibited the same style of thinking. Each case highlights Darwin's distinctive perspective (or "bias" perhaps). Sometimes, then, erroneous ideas and successful ideas had a common origin.

Consider two of Darwin's early theories in geology. Both applied Charles Lyell's principle of uniformitarianism – viewing the past as a cumulative product of gradual forces still present today. In the first case, Darwin addressed the natural history of coral atolls. He reasoned that reefs formed around islands, which then gradually eroded, leaving hollow rings. It was an act of sweeping historical imagination based on observational fragments about coral growth and location. The idea helped launch Darwin's career – and it proved correct (Ghiselin, 1969, pp.21-30; Browne, 1995, pp. 316-319).

Darwin applied the same kind of large-scale gradualist thinking to the "parallel roads of Glen Roy," a series of stony ledges lining a valley in Scotland. He imagined that they were the debris of successively lower shorelines, left by a receding ocean. Here, Darwin was wrong. The ledges were glacial moraines, left by a retreating glacier, not an ocean. Darwin, to his credit, acknowledged his "great blunder" when Louis Agassiz's theory of glaciation and ice ages gained prominence (Rudwick, 1974; Browne, 1995, pp. 376-378, 431-433). Darwin was right and wrong (on different occasions) by relying on the same Lyellian reasoning in both cases.

A second major discovery intimately combined with error concerns Darwin's reasoning about human descent. Darwin's gradualism fostered much productive thinking about transitional forms – for example, in his phylogeny of barnacle sexual systems. Yet the concept had especially powerful implications in the context of his social status. British society was stratified. Darwin enjoyed membership in the upper class. He was also a white European at a time when Europeans (notably the British) dominated the globe. This context shaped perceptions of other races, easily construed in a hierarchy. While voyaging on the *Beagle*, for example, Darwin was appalled by the habits of the natives of Tierra del Fuego:

> *It was without exception the most curious and interesting spectacle I ever beheld: I could not have believed how wide was the difference between savage and civilized man: it is greater than between a wild and domesticated animal, inasmuch as in man there is a greater power of improvement.* Darwin, 1845, p. 218

Improvement there was. One of the Fuegians had been taken to London, educated, and entered into elite society. When he returned, however, he seemed content to revert (as Darwin saw it) to his "primitive" habits. It was all too easy for Darwin to consider racial differences as inherent and to rank them on a scale from "savage" to "civilized." That conception proved both fruitful and dramatically misleading.

When Darwin began considering human ancestry, he saw immediately that the problem was not primarily anatomical. Humans had long been classified as primates. The challenge was accounting for the origin of mental faculties and moral sensibilities. Darwin's early musings turned to the Fuegian episode. He wrote to himself in the fall of 1838:

> *Nearly all will exclaim, your arguments are good but look at the immense difference. between man, –forget the use of language, & judge only by what you see. compare, the Fuegian & Ourang & outang, & dare to say difference so great; ... "Ay Sir there is much in analogy, we never find out."* (*M Notebook*, p. 153)

Darwin essentially cast the Fuegians as intermediates between orangutans and "fully developed" humans, such as himself and his peers. Darwin's ability to stratify races facilitated his linking apes and humans through a series of gradual changes. "Savages" became convenient transitional forms in moral and mental development (Herbert, 1974/1977; Browne, 1995, pp. 234-253, 382-383).

The relevance of Darwin's social status and experience sharpens by comparing him, once again, with Alfred Wallace. Wallace came from the working class. While collecting in the Malay archipelago, he learned to respect the natives' local knowledge and benefitted from their assistance. In 1855 he wrote to a friend:

> *The more I see of uncivilized people, the better I think of human nature and the essential differences between civilized and savage men seem to disappear.*

If even such "brutes" could show kindness, Wallace reasoned, then all humans apparently shared an undiluted moral sense. He echoed those sentiments in 1873:

> *We find many broad statements as to the low state of morality and of intellect in all prehistoric men, which facts hardly warrant.*

Wallace, in contrast to Darwin, saw moral and mental discontinuity between man and beast. Wallace certainly acknowledged that humans had primate ancestry – anatomically. Still, he maintained that the human mind was unique and emerged by some guided process other than natu-

ral selection. Wallace never considered, as Darwin did, the evolution of morality (Allchin, 2007a). Wallace erred in that. At the same time, however, he did not succumb to Darwin's error — viewing races hierarchically (Eiseley, 1961, pp. 303-314, quotes on p.303).

Darwin's insight — the evolution of cognitive abilities and the moral sense — was thus partly due to an error — ranking races biologically. We now explain the origins of human culture and ethics with quite different benchmarks (Katz, 2000). Appreciating the origin of Darwin's error is significant for a complete understanding of science. It should not surprise us, perhaps, that Darwin's view of human origins was taken by others to support racial ideologies, however inappropriately so (Barkan, 1992; Stepan, 1982). The seed for that view was in Darwin's own thinking. Darwin was not politically racist, however. He and his whole extended family denounced slavery, for instance (Browne, 1995, pp. 196-199, 213-214, 244-246). Biological facts (erroneous or not) do not themselves justify value judgments. But that does not prevent people from trying to do so. Darwin's error had major cultural consequences, although not by Darwin's own hand.

A third major discovery-mistake pair stemmed from Darwin's views on competition (Ghiselin, 1969, pp. 48-49, 59-61; Young, 1975; Browne, 1995, pp. 542-543). Those views also had cultural roots. Victorian England exhibited widespread poverty and great disparities in wealth. The social inequity was considered (by the wealthy, at least) as a "natural" outcome of competition for resources. Thomas Malthus in his 1801 "Essay on Population" portrayed food as inevitably limited and competition unavoidable. Reading that essay in 1838 prompted Darwin's insight on natural selection. Darwin transformed the cultural notion of a "struggle for existence" into a creative organic force. For him, competition fueled the "logic" of differential survival and adaptation.

But Darwin overstated the role of competition. He also saw it causing the origin of species. Competition within a species, he imagined, would promote specialization. With continued competition, specialized forms from the same population would ultimately diverge. Darwin seemed deeply impressed by the power of competition:

> *One may say there is a force like a hundred thousand wedges trying [to] force every kind of adapted structure into the gaps in the economy of nature, or rather forming gaps by thrusting out weaker ones.* (*D Notebook,* pp. 134e-135e; echoed in Darwin, 1859, p. 67)

Modern evolutionary biologist Ernst Mayr (1994), however, has faulted Darwin for advocating what he calls an undemonstrated form of sympatric speciation. Similarly, geochemist Kenneth Hsü (1986) claims Darwin inaccurately portrayed interspecific competition as the chief cause of extinction, thereby obscuring geophysical events (especially relevant in mass extinctions).

While competition may surely lead to selection, not all selection need be based on competition. Even differential reproduction (sexual selection) Darwin framed as competition: competition for mates. Yet radiation of forms in new adaptive zones, for example — so nicely exemplified by the Galápagos finches — results more from opportunity in new niches than from competitive elimination. Other times, species seem to sustain themselves merely by holding on in extreme environments (Allchin, 2007c). Nor did Darwin seem oriented to appreciate the indeterminacy of genetic drift. Viewing life competitively both enabled Darwin to discover natural selection—and blinkered him from seeing its limits clearly.

Understanding Darwin's erroneous thinking about competition is important for our culture today. For many,

Darwinism implies what is inaptly called "Social Darwinism" — namely, Herbert Spencer's social ideology of unrestrained competition. In particular, the metaphor of Spencer's phrase "survival of the fittest" haunts our culture, even among individuals who have not learned biology (Allchin, 2007b, c). Again, roots of such misapplied concepts may be found in Darwin and his use of language. Noting the source and scope of the error can help us establish a more informed conception of natural selection and differentiate it from cultural ideology.

Learning From Error

So: Darwin could be wrong. Even about some important things. So what? The errors certainly do not justify rejecting all Darwin ever wrote. Nor should they tarnish his image. Rather, I think, they give Darwin a fine, human patina.

Understood together, Darwin's many mistakes also offer valuable lessons about the nature of science. First, what leads to error in science? —As illustrated in the cases above, sometimes the very same thing that leads to discovery! Darwin's unique viewpoint was critical in both instances. It could foster insight in one context, while blinding him to alternatives in others. Fresh perspectives always have potential. Yet success is not guaranteed. We might thus be wary of some mystical property called "genius" that purports to yield unqualified insight. Darwin's discoveries and errors came from identifiable life experiences. Science is thus likely to benefit from diversity of backgrounds. Still, generating new ideas, while essential, is only half of science. The ideas — some right, some wrong — must also fit with a typically growing reservoir of relevant information.

Second, how is error in science remedied? Deeper evidence, of course. But that truism does not tell us, more importantly, how the new evidence is found. Here, alternative perspectives were needed to cross-check Darwin's original view. Agassiz's experience in the Swiss Alps was an important complement to those who had encountered glaciers remotely, if at all. Wallace's background in the lower classes was integral to counterbalancing assumptions about social hierarchy. Frederich Engels, likewise, from his new communist perspective, was well situated to see economic ideology reflected in Darwin's theory (Allchin, 2007b). To function effectively, science needs alternative perspectives — from various cultures, social classes, genders, disciplines, biographical backgrounds, etc. Contrasting views help highlight deficits in the evidence, or expose conceptual blinkers. Once again, we should not fail to notice the collective social dimension of science (and with it, the value of diversity among scientists).

Finally, if we understand how errors occur, can't we eliminate them from science? Isn't the whole point of science to escape error and provide trustworthy knowledge? Here, one virtue of studying history may emerge. Science itself seems structured like Darwin's concept of natural selection. It balances novel conceptual variants with selective retention, including testing and other checks and balances. No algorithmic "scientific method" seems able to transcend the basic strategy of trial and error — not if we value new discoveries. The cost of innovation seems to be the risk of failure.

Some critics would have us believe that every little slip made by Darwin — or one of his followers — threatens the whole conceptual edifice he helped build. How impoverished is their understanding of science! Errors are integral to science. But with appropriate critical perspectives, we find them. With appropriate evidence, we remedy them. We can discuss all the errors noted here because we have indeed learned from them. —And every lesson has helped ultimately to hone and strengthen the towering theory built on Darwin's sure foundation.

Science would never progress without the courage to fail. Every new idea, even if supported by some evidence, risks being wrong. Darwin was a bold theorizer — and a patient collector of factual details. Taking pride in his achievement means also taking pride in his ability to fail on occasions. It may also remind us of the communal structure of science, whereby errors are noticed and remedied, just as other ideas are cross-examined and confirmed. Darwin's legacy ultimately reflects a monumental collective effort. Accordingly, we may justly commemorate Charles Darwin's Bicentennial by celebrating his errors.

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