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RESEARCH ARTICLE

Darwin's scientific gardener: John Scott, the 'physiological test' and the importance of character in Victorian science

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Abstract

This essay examines the working relationship between Charles Darwin and the Edinburgh gardener John Scott that developed in the wake of the publishing of the *Origin of Species* (1859). As the essay shows, Darwin sought to utilize Scott's horticultural knowledge and experimental expertise in order to provide some of the specialized botanical evidence that the *Origin* was not intended to provide. Scott, meanwhile, sought to use Darwin's patronage and tutelage in order to overcome his modest status as a gardener while making contributions to scientific knowledge. And for an intense two-year period (1862–4), Darwin and Scott's relationship was productive and mutually beneficial: not only did Scott's work supplement Darwin's ongoing botanical research on sexual development and fertility, but also his *Primula* experiments appeared to provide 'physiological' evidence of speciation via selective breeding. What the essay argues, however, is that there were limits to what Scott was able to achieve due in part to his social standing and perceived character that ultimately cast a shadow over his findings.

On 4 February 1864, the Scottish gardener John Scott made a stunning claim in a paper presented to the Linnean Society of London that detailed his fertility experiments with *Primula*. By using the tools of systematic botany, and the resources afforded to him by his position at the Royal Botanic Garden in Edinburgh, Scott produced a variety of *Primula* that was not fertile with its ancestor, claiming that he had therefore created '*a new and distinct species*' via the processes of domestic selection.[1] Unpacking the story of how this little-known gardener came to find himself in a position to put forward such an important claim in the midst of the heady evolution debates is the main task of this essay. But an important dimension of this story is that Scott had a powerful, influential and encouraging benefactor and mentor who communicated his paper to the Linnean Society and directed his research: Charles Darwin.

As Scott's Linnean Society paper makes clear, by the early 1860s botanical evidence had become central to ongoing debates about evolution. Darwin, of course, included evidence that cut across the flora/fauna divide in order to make a holistic case for his theory of evolution in the *Origin of Species* (1859). But Darwin also came to recognize that further botanical research could provide some of the specialized experimental evidence that the *Origin* was not intended to provide. In this way, as Vassiliki Betty Smocovitis points out,

[1] John Scott, 'Observations on the functions and structure of the reproductive organs in the *Primulaceæ*', *Journal of the Proceedings of the Linnean Society of London (Botany)* (1864) 8, pp. 78–126, 108, original emphasis.

'Darwin increasingly devoted his efforts to drawing on the study of plants not only to fortify, but also to extend his theoretical insights as first developed in the *Origin*'.[2] Thus Darwin's next book after the publication of the *Origin* was *On the Various Contrivances by Which British and Foreign Orchids Are Fertilised by Insects* (1862), a specialized analysis that considered in minute detail the sexual structure and development of many members of the orchid family. What Darwin showed was that despite being sexually hermaphrodite, orchids evolved to be cross-fertilized by visiting insects, leading to an array of 'curious contrivances'.[3] This seemingly innocuous study provided careful experimental evidence of natural selection at work, and played an important role in convincing many in the botanical community and beyond of the reality of Darwin's theory of evolution.[4]

But Darwin's study of orchids was just one part of an ever-expanding research programme that explored the nature of sexual development and sterility through time-consuming and painstaking crossing and hybridization experiments.[5] One factor motivating this was that Darwin was unable to provide direct, observable evidence for speciation. This was an issue that Darwin's important ally, Thomas Henry Huxley, invoked as standing in the way of a complete acceptance of natural selection because there was as yet no direct proof that one species had developed from another. Huxley postulated that this should be possible by establishing an extended breeding experiment whereby varieties produced by a common stock would not be able to interbreed, thus providing evidence of the creation of a new 'physiological' species.[6] Much of Darwin's subsequent botanical research set about exploring this issue, and it became central to his collaborative efforts with John Scott, who eventually claimed in his 1864 paper on *Primula* to provide the very experimental evidence that Huxley had been calling for.

After Scott came into contact with Darwin in November 1862, the two men engaged in an extensive correspondence over the next two years that involved working together on a large-scale crossing and fertilization project at Darwin's direction. During these two years Scott essentially became Darwin's 'scientific gardener', conducting many experiments on Darwin's behalf, while providing answers to Darwin's various questions that probed Scott's vast horticultural knowledge.[7] Scott was, in this regard, not unlike many other local purveyors of specialized knowledge that Darwin relied upon in his extensive network of correspondents, an 'invisible technician' in Steven Shapin's parlance, an important but relatively unseen and unknown contributor to a scientific project signified by someone else's name.[8] But Scott became, albeit briefly, more than that because Darwin came to recognize that Scott was capable of communicating scientific knowledge himself, and he became Scott's mentor by educating Scott about the finer points of inductive research

[2] Vassiliki Betty Smocovitis, 'Darwin's botany in the *Origin of Species*', in Michael Ruse and Robert J. Richards (eds.), *The Cambridge Companion to the 'Origin of Species'*, Cambridge: Cambridge University Press, 2008, pp. 216–36, 218.

[3] Charles Darwin, *On the Various Contrivances by Which British and Foreign Orchids Are Fertilised by Insects, and on the Good Effects of Intercrossing*, London: John Murray, 1862, p. 3.

[4] Richard Bellon, 'Inspiration in the harness of daily labor: Darwin, botany, and the triumph of evolution, 1859–1868', *Isis* (2011) 102, pp. 393–420.

[5] Richard Bellon, 'Darwin's evolutionary botany', in Michael Ruse (ed.), *The Cambridge Encyclopedia of Darwin and Evolutionary Thought*, Cambridge: Cambridge University Press, 2013, pp. 131–8; Bellon, 'Charles Darwin solves the "riddle of the flower"; or, why don't historians of biology know about the birds and the bees?', *History of Science* (2009) 47, pp. 373–406.

[6] T.H. Huxley, 'On species and races, and their origin', in *Proceedings of the Royal Institution of Great Britain* (1858–62) 3, pp. 195–200, 198.

[7] Darwin refers to Scott as a 'scientific gardener' in Charles Darwin to Joseph Hooker, 7 April [1864], in Frederick Burkhardt *et al.* (eds.), *The Correspondence of Charles Darwin*, 30 vols., Cambridge: Cambridge University Press, 1985–2023 (subsequently *Correspondence*), vol. 12, p. 126.

[8] Steven Shapin, 'The invisible technician', *American Scientist* (1989) 77(6), pp. 554–63.

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while encouraging Scott to situate his observations within a Darwinian framework. Not only did Scott embrace Darwin's mentoring with enthusiasm, but he was also soon presenting experimental work of his own that directly addressed the central empirical difficulties at the heart of selection theory. But Scott's sudden rise eventually confronted the social realities of Victorian gentlemanly science, personified in this story by Darwin's close friend, confidant and scientific adviser, Joseph Hooker, who, as we will see, ultimately frustrated Scott's advance.

Scott will be familiar to Darwin scholars as one of many who sustained an extensive correspondence with Darwin in order to provide him with specialized information. Scott appears, for instance, in Janet Browne's biography as the gardener who provides Darwin with some plants and horticultural knowledge and Darwin reciprocates by doing what he can to advance Scott's career.[9] Not much else has been written about Scott, however, even in specialized studies of Darwin's botanical researches and experiments.[10] Yet the story of Darwin and Scott's relationship is worth examining further because it provides insight into the lengths Darwin went to acquire and present botanical evidence in favour of his theory of evolution, which involved both mentoring and patronage while navigating different social contexts and various levels of expertise.[11] It also gives insight into the possibilities and pitfalls that confronted someone of a lower class and status looking to better himself by utilizing his natural knowledge. Indeed, Scott's rise from toiling in the gardens at Edinburgh to being heralded at the Linnean Society was not without difficulties that were associated with the relationship between class and character that was so central to the production of trustworthy knowledge in the Victorian period. As the work of Anne Secord has shown, it was entirely possible for artisans like Scott to become trustworthy purveyors of natural knowledge, but only if they were able to present themselves as embodying the character traits of a gentleman.[12] In the end, Scott was unable to convince the various parties involved that he was a deserving recipient of Darwin's patronage. Both his moral and scientific character were questioned as a result, along with his scientific findings.

No common man

Darwin encountered several unlikely correspondents after his book on *Orchids* was published in 1862, but perhaps none as unlikely or as remarkable as John Scott. Scott had taken the liberty of writing to Darwin to inform him of an error in his description of the sexual characteristics of the genus *Acropera*.[13] Rather than being offended, Scott's careful descriptions, along with his polite manner, led Darwin to look into the matter more carefully. Not only did he determine that Scott was right (and corrected his mistake in the second edition

[9] Janet Browne, *Charles Darwin: The Power of Place*, London: Pimlico, 2003, p. 211.

[10] There is, for instance, only a brief paragraph referring to the 'Scott–Darwin experiments' in Mea Allan, *Darwin and His Flowers: The Key to Natural Selection*, New York: Taplinger, 1977, p. 268. More details appear in Frederick Burkhardt *et al.*, 'Introduction', in *Correspondence*, vol. 11, pp. xxii–xxiii; vol. 12, pp. xviii–xix.

[11] On Darwin's ability to act as a mediator between the distinct worlds of natural history and domestic breeding see James Secord, 'Darwin and the breeders: a social history', in David Kohn (ed.), *The Darwinian Heritage*, Princeton, NJ: Princeton University Press, 1985, pp. 519–42. On Darwin as a patron see Henry-James Meiring, 'Scientific patronage in the age of Darwin: the curious case of William Boyd Dawkins,' *Studies in History and Philosophy of Science* (2021) 89, pp. 267–82.

[12] Anne Secord, 'Corresponding interests: artisans and gentlemen in nineteenth-century natural history', *BJHS* (1994) 27(4), pp. 383–408. On the complex relationship between self-fashioning and a shared rhetoric of authority in Victorian science see especially Ruth Barton, '"Men of science": language, identity and professionalization in the mid-Victorian scientific community', *History of Science* (2003) 41, pp. 73–119; Barton, *The X Club: Power and Authority in Victorian Science*, Chicago: University of Chicago Press, 2018; Paul White, *Thomas Huxley: Making the 'Man of Science'*, Cambridge: Cambridge University Press, 2003.

[13] John Scott to Darwin, 11 November 1862, in *Correspondence*, vol. 10, pp. 516–20.

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of *Orchids*), but also their correspondence immediately extended to other related botanical subjects.[14] Soon after Darwin wrote to Hooker to find out who this man was. 'If you know, do please tell me who is John Scott of Bot. Garden of Edinburgh; I have been corresponding largely with him: he is no common man'.[15] Hooker was told by someone that Scott 'was a very smart fellow' but otherwise knew nothing about him.[16]

In subsequent letters, Scott gave Darwin a description of his life, a practice that was common among men of a more humble status as a way of demonstrating their character and trustworthiness, which could not be assumed given their lack of independent means.[17] Born in 1836 at Denholm, Roxburghshire, Scotland, Scott explained that he had endured difficult circumstances on his journey towards embracing a scientific way of life. His parents, who were tenant farmers, died when he was aged only four, and he was raised by an aunt who gave him an 'ordinary education'.[18] His interest in botany began at a young age, however, and he was fortunate to be encouraged by his cousin, the botanist James Duncan. Because of this interest in botany, Scott apprenticed as a gardener at the age of fourteen and then joined the staff at the Royal Botanic Garden in Edinburgh, becoming a foreman at the propagating department in 1859.[19] He stressed to Darwin, however, that he had no real interest in gardening per se; he 'became a gardener – more for the purpose of gratifying a predilection for Natural History – than any love for this line of life'.[20]

Scott's description of his life fits well into the intersecting contemporary genres of self-help and scientific heroism that were prominent at the time. The most popular version of this was Samuel Smiles's *Self-Help* (1859), which stressed the relationship between character formation and improvement, focusing on working-class autodidacts who were able to better their lives while making contributions to social progress. Key examples for Smiles were natural philosophers and inventors who overcame their humble backgrounds to produce new knowledge of the natural world through their own hard work and embrace of the principles of self-improvement.[21] Smiles's popular work built on an already well-established philosophy that was embodied in the mechanics' institutes, promoted by institutions like the Society for the Diffusion of Useful Knowledge and articulated in works such as the anonymous *Pursuit of Knowledge under Difficulties* (1830).[22] Much like the scientific heroes whose lives were recounted in such works, Scott claimed that he was doing what he could to take advantage of his circumstances by contributing to natural knowledge.

It is, moreover, certainly understandable that Scott would have imagined gardening as a viable avenue to pursue his scientific interests while enabling social mobility. He would have been aware of prominent figures like John Lindley and Joseph Paxton who started out

[14] Charles Darwin, *On the Various Contrivances by Which British and Foreign Orchids Are Fertilised by Insects, and on the Good Effects of Intercrossing*, 2nd edn, London: John Murray, 1877, p. 172.

[15] Darwin to Hooker, 12 [December 1862], in *Correspondence*, vol. 10, p. 598.

[16] Hooker to Darwin, [14 December 1862], in *Correspondence*, vol. 10, p. 602.

[17] Secord, op. cit. (12), p. 388. See also Laura Brassington, 'The "janitor-geologist" and the "cold materialistic scientific men": James Croll's navigation of scientific societies', *Earth and Environmental Science Transactions of the Royal Society of Edinburgh* (2021) 112, pp. 209–20, for an example of a working-class practitioner who resisted such conventional practices.

[18] Scott to Darwin, 6 January 1863, in *Correspondence*, vol. 11, p. 19.

[19] Brief biographical discussions of Scott can be found in *Transactions of the Botanical Society [of Edinburgh]* (1882) 14, pp. 160–161; Sheila Dean, 'Scott, John (1836–80)', in Bernard Lightman, ed., *Dictionary of Nineteenth-Century British Scientists*, London: Thoemmes Continuum, 2004, pp. 1789–90; Andrew Grout, 'Scott, John (1836–1880)', *Oxford Dictionary of National Biography*, 23 September 2004, at https://doi.org/10.1093/ref:odnb/53027.

[20] Scott to Darwin, 6 January 1863, in *Correspondence*, vol. 11, p. 19.

[21] On the intersection of self-help and the scientific hero see Anne Secord, "'Be what you would seem to be": Samuel Smiles, Thomas Edward, and the making of a working-class scientific hero', *Science in Context* (2003) 16, pp. 147–73.

[22] [George L. Craik], *The Pursuit of Knowledge under Difficulties*, London: Charles Knight, 1830.

as gardeners, much like Scott, but who were able to take advantage of the mobility offered by the horticultural profession. Indeed, by the early nineteenth century, the gardening profession in Britain had expanded rapidly. A fairly formalized system of apprenticeship was established and while such training was labour-intensive, there was a range of positions to which gardeners could aspire, culminating in the significant status of head gardener. Some gardens offered more opportunity than others, particularly so-called 'teaching gardens' that had good equipment, many different plant species, and opportunities to enhance knowledge. One such garden was the Horticultural Society of London's Chiswick Gardens, which was established in 1823 to train young gardeners in the science of horticulture while displaying and cultivating the empire's growing botanical collections.[23] There were also, of course, the publicly funded gardens that provided a variety of opportunities for both training and mobility, such as the gardens at Kew and Edinburgh.

Scott was, therefore, a beneficiary of the expansion of the gardening profession. And his position at the Royal Botanic Garden in Edinburgh was seemingly ideal as it enabled him to pursue his experimental interests and attend lectures to enhance his knowledge in various areas. As the garden was affiliated with the University of Edinburgh there were educational opportunities as well as mentors capable of cultivating his botanical interests. Scott's immediate supervisor was James McNab, who had succeeded his own father in 1849 as superintendent and curator of the garden. As well as being central to the development of experimental gardening at Edinburgh, McNab was also a well-known plant illustrator and contributed to several horticulture journals.[24] McNab worked under the physician and botanist John Hutton Balfour, who held the dual position of Regius Keeper of the garden along with the chair of botany at the University of Edinburgh. While Balfour was not considered a premier experimentalist, he was recognized as an excellent teacher with a deep knowledge of the connection of botany to medicine, which complemented the university's desire to train its medical students in the basics of practical botany. Balfour also encouraged the development of a community of Scottish botanists that included local gardeners and other practitioners and collectors who eventually formalized into the Botanical Society of Edinburgh in 1836, the first meeting of which was held at Balfour's house.[25] This is all to say that while Scott may have been some way down the vocational hierarchy of horticulture in Edinburgh, he was there at a time of institutional and intellectual change that offered plenty of opportunities for mobility and growth.

Indeed, for a time at least it seems that Scott was encouraged by his superiors to pursue his botanical interests. He explained to Darwin that thanks 'to the kindness of Prof. Balfour, and Mr. Mc.Nab, [he] enjoy[ed] great facilities for such pursuits'.[26] Both McNab and Balfour were aware of his ongoing experiments, and encouraged him to report his findings to the Botanical Society. Balfour's early support of Scott is apparent in a letter he wrote to Darwin, thanking Darwin for the interest he showed in Scott: 'One of my gardeners is prosecuting the subject of … fertilization vigorously', Balfour wrote to Darwin. 'He is much indebted

[23] For an analysis of the profession of horticulture in nineteenth-century Britain, with a focus on Chiswick Gardens, see Fiona Davison, *The Hidden Horticulturists: The Untold Story of the Men Who Shaped Britain's Gardens*, London: Atlantic Books, 2019.

[24] Peter D.A. Boyd, 'McNab, James (1810–1878)', *Oxford Dictionary of National Biography*, 21 May 2009, at https://doi.org/10.1093/ref:odnb/99630.

[25] Richard Bellon, 'A question of merit: John Hutton Balfour, Joseph Hooker and the "concussion" over the Edinburgh chair of botany', *Studies in History and Philosophy of Biological and Biomedical Sciences* (2005) 36, pp. 25–54. See also D.E. Allen, 'Balfour, John Hutton (1808–1884)', *Oxford Dictionary of National Biography*, 23 September 2004, at https://doi.org/10.1093/ref:odnb/1192; Lorna Helen Morrow, 'Geographies of botanical knowledge: the work of John Hutton Balfour 1845–1879', PhD thesis, the University of Edinburgh, 2018; and Harold R. Fletcher and William H. Brown, *The Royal Botanic Garden Edinburgh 1670–1970*, Edinburgh: Her Majesty's Stationery Office, 1970, pp. 125–37.

[26] Scott to Darwin, 6 January 1863, in *Correspondence*, vol. 11, p. 19.

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to you for your kind encouragement. He has just put into my hands a paper which I hope to read at next meeting of the Botanical Society'.[27] Balfour was referring to the fact that Scott's experiments had led him to write a paper on the fertilization of orchids that would be presented to the society on 14 May 1863.[28] This was the second paper Scott had presented at the society after being elected an associate on 10 July 1862. His first paper was on the topic of fern spores.[29]

Scott's experimental work was soon praised as a great success and a reflection of the opportunities that were made available by the gardening programme at the Botanic Garden to someone of Scott's drive and abilities. As Douglas Maglagan explained in his Presidential Address to the Botanical Society in 1863,

> I listened with very great pleasure when it [Scott's paper on orchids] was read to the Society, not only because the paper was interesting in itself, but because it afforded a convincing proof of the value of the school of instruction which we possess in our Botanic Garden, where we have in valuable combination the extensive cultural establishment, so ably superintended by Mr McNab, and the scientific laboratory and class-room of Professor Balfour. I cannot but think it highly creditable to the whole establishment, as well as most meritorious on the part of the author, that such papers should emanate from one who is engaged in the work of practical gardening.[30]

Scott was, therefore, considered a wonderful product of the programme of 'practical gardening' at Edinburgh, a programme that involved both instruction and opportunity. And when Scott first came into contact with Darwin, in November 1862, his prospects for gratifying his deep-seated interests in natural history looked very promising, so much so that he was soon conducting experiments on Darwin's behalf and producing Darwinian papers of his own.

The physiological test

It did not take long for Darwin to recognize that Scott had a vast wealth of knowledge about many of the plant species Darwin was also working on, and that he was also engaged in fertility experiments, the very focus of Darwin's ongoing botanical research. As a botanist, Darwin always claimed the status of a novice, and this is how he presented himself to Scott, writing, 'Botany is a new subject to me'.[31] Meanwhile Scott presented himself as an intrusive gardener who had local, specialized knowledge to bring to bear on Darwin's much grander endeavours. Scott also had ready access to botanical specimens that Darwin had difficulty acquiring elsewhere. Before long gifts were exchanged: Darwin received detailed answers to many of his questions as well as plants, flowers and seeds; Scott received copies of Darwin's books along with an offer from Darwin to help Scott with his own work, notably the orchids paper he was to present at the Botanical Society of Edinburgh. In other words, Darwin reciprocated Scott's information with the offer of mentorship.[32]

[27] John Hutton Balfour to Darwin, 22 April 1863, in *Correspondence*, vol. 11, p. 346.

[28] John Scott, 'Experiments on the fertilisation of orchids in the royal botanic garden of Edinburgh', *Transactions of the Botanical Society [of Edinburgh]* (1863) 7, pp. 543–50. Note that Scott would end up reading the paper himself. See Scott to Darwin, 21 May [1863], in *Correspondence*, vol. 11, p. 429.

[29] John Scott, 'Remarks on the nature and peculiarities of the fern-spore', *Transactions of the Botanical Society [of Edinburgh]* (1863) 7, pp. 352–70.

[30] Douglas Maclagan, 'The President's Opening Address [12 November 1863]', *Transactions of the Botanical Society of Edinburgh* (1866) 8, pp. 1–14, 4.

[31] Darwin to Scott, 12 November [1862], in *Correspondence*, vol. 10, p. 523.

[32] On the role of the gift exchange between artisans and eminent naturalists see Secord, op. cit. (12), pp. 404–6.

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Darwin's mentoring included giving Scott advice on how to communicate his botanical research, both with regard to basic issues of readability and in relation to the use of theory. About the issue of readability, Darwin expressed surprise after reading a draft of Scott's paper at the overly complicated language Scott employed to express himself. Darwin suggested, for instance, getting rid of clunky formulations as the 'latter' and 'former' and simply writing in the same ordinary language as his letters, with clear and uncomplicated prose.[33] About the use of theory, Darwin stressed the need to be cautious. As we will see, Scott proved very receptive to embracing a Darwinian perspective when interpreting his experiments, but Darwin worried that he was perhaps too explicit. 'I would suggest to you the advantage at present of being very sparing in introducing theory in your papers', Darwin wrote; 'let theory guide your observations, but till your reputation is well established be sparing in publishing theory'. Darwin here was speaking from experience, as he claimed he had 'formerly erred much in geology in that way', referring to his early coral reef papers.[34] His point, however, was that Scott should not reject theory but rather be more cautious about its use until he had built up his reputation before plunging directly into contentious theoretical debates, much as Darwin had done.

That said, early on in their correspondence Darwin was quick to reply to some of Scott's seemingly anti-Darwinian views and make his case for the alternative perspective. Scott admitted, for instance, that he did not think Darwin's 'struggle for existence' accounted for the fact that often the 'strongest individuals may continually be fertilized by the weaker'.[35] Sending Scott a copy of the latest edition of the *Origin* proved to be useful as Darwin directed Scott to read certain passages where he had already reflected on these supposed problems. As Darwin explained, structures that Scott perceived as 'weak' were likely formerly useful: 'Pray read what I have said on "correlation"', Darwin wrote; 'Orchids ought to show us how ignorant we are of what is useful'.[36] Scott proved to be receptive to Darwin's tutelage, so much so that he explicitly framed his study of orchids as contributing to Darwin's larger project, and this was the specific context that led Darwin to caution Scott about his overt use of theory.

At the time, what was perhaps more vital for Darwin was securing Scott's help with his experimental programme on sterility. This programme was driven in part by an argument that was often made by Darwin's great defender Huxley, namely that Darwin's theory of evolution would be found wanting until empirical evidence could be provided that showed the processes of selection leading to the creation of a new, 'physiological' species. While Huxley was forthright about the empirical difficulties that stood in the way of a definitive proof of evolution, he was clear about the kind of proof that could be provided. He postulated the framework for a long-term experiment that would employ the methods of selective breeding to produce a variety that was fertile with itself while no longer being capable of reproducing with its ancestor stock. Huxley claimed that this 'test of a physiological species' would provide proof, once and for all, that evolution by selection actually took place.[37] But until that proof was provided,

[33] See Darwin to Scott, 11 December [1862], in *Correspondence*, vol. 10, pp. 594–595; Darwin to Scott, 31 May [1863], in *Correspondence*, vol. 11, p. 468.

[34] Darwin to Scott, 6 June [1863], in *Correspondence*, vol. 11, p. 483. On Darwin's shifting identity in relation to his early use of theory see Alistair Sponsel, *Darwin's Evolving Identity: Adventure, Ambition, and the Sin of Speculation*, Chicago: University of Chicago Press, 2018.

[35] Scott to Darwin, 3 March 1863, in *Correspondence*, vol. 11, p. 190.

[36] Darwin to Scott, 6 March 1863, in *Correspondence*, vol. 11, pp. 213–14.

[37] [T.H. Huxley], 'Darwin on the origin of species', *Westminster Review* (1860) 17(2), pp. 541–70, 552. See also Huxley, *On Our Knowledge of the Causes of the Phenomena of Organic Nature*, London: Robert Hardwicke, 1863, pp. 132–56, 147; Huxley, op. cit. (6), p. 198.

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as Huxley argued in *Man's Place in Nature* (1863), 'the Darwinian hypothesis must be provisional'.[38]

Darwin was aware of this problem, which he directly addressed in the *Origin* in the chapter on hybridism. There he complicated some of the assumptions that underpinned Huxley's 'physiological test' by arguing that sterility and fertility should be viewed as characteristics that existed on a scale that was affected not by some universal break or affinity between varieties and species but rather by 'constitutional and structural differences'.[39] In discussing this issue, Darwin relied extensively on '[Karl Friedrich von] Gärtner's admirable work on the hybridisation of plants'. By counting the seeds produced by crossing different varieties of *Verbascum*, Gärtner discerned different degrees of fertility ranging from the 'absolute zero of fertility' to 'perfect fertility'.[40] By determining this range, Gärtner believed he could pinpoint the precise divisions between species. At the time of writing the *Origin*, however, Darwin argued that Gärtner's results were too conflicted to make any generalizations about the issue of species differentiation. As he explained to Huxley, 'The whole case [of sterility] seems far too mysterious to rest valid attack on the theory of the modification of species'.[41]

But when Darwin's research on the sexuality of plants continued in the early 1860s, he returned to thinking about Gärtner's work in relation to his own crossing experiments with orchids and *Primula*. Darwin became particularly interested in Gärtner's crossings between differently coloured varieties and species that produced different degrees of sterility. Perhaps these experiments could provide a model for the evidence required of Huxley's physiological test. This is why Darwin determined in late September of 1861 'to try Gärtners wonderfull & repeated statement, that pollen of white & yellow vars, whether used on the varieties or on distinct species has different potency'. He thus wrote to Hooker, 'I do not think any experiment can be more important on the Origin of Species; for if [Gärtner] is correct, we certainly have what Huxley calls new physiological species arising'.[42]

This issue of the 'physiological test' in relation to Gärtner's experiments was on Darwin's mind when Scott first wrote to him. Therefore, once Darwin recognized that Scott had 'the true spirit of an Experimentalist & [was] a good observer', he asked whether Scott had ever experimented on the 'relative fertility of varieties of plants' like the experiments of 'Gärtner on the varieties of Verbascum'.[43] In a subsequent letter, Darwin asked outright whether Scott would be willing to repeat Gärtner's *Verbascum* experiments.[44] Darwin perhaps felt free to make such an open request at this point because he had just sent Scott copies of his books along with detailed comments advising Scott about his orchids paper.

Scott replied with the 'most sincere thanks' for Darwin's gifts and stated that it would be his 'pleasure to carry out your schemes'.[45] The only thing Scott requested was that Darwin send him a detailed description of the experiments that he wanted performed. This Darwin did in an enclosure that provided the basic framework for his experimental programme that would test 'the relation of well-marked, but undoubted varieties in fertilising each other'. He therefore proposed reproducing Gärtner's experiments on *Verbascum* and also suggested an analogous set of experiments with *Primula*, a suggestion that would prove to be truly significant.[46]

[38] T.H. Huxley, *Evidence as to Man's Place in Nature*, London: Williams and Norgate, 1863, p. 107.
[39] Charles Darwin, *On the Origin of Species*, London: John Murray, 1859, p. 248.
[40] Darwin, op. cit. (39), p. 255.
[41] Darwin to Huxley, 11 January [1860], in *Correspondence*, vol. 8, p. 30.
[42] Darwin to J.D. Hooker, 28 September [1861], in *Correspondence*, vol. 9, p. 284.
[43] Darwin to Scott, 19 November [1862], in *Correspondence*, vol. 10, p. 538.
[44] Darwin to Scott, 11 December [1862], in *Correspondence*, vol. 10, p. 595.
[45] Scott to Darwin, 17 December [1862], in *Correspondence*, vol. 10, p. 609.
[46] Darwin to Scott, 19 December [1862], in *Correspondence*, vol. 10, pp. 614–15.

Absolute zero of fertility

Darwin suggested *Primula* as an option for testing Gärtner's experiments in part because it was already central to his botanical research programme on fertility and sexual development. In November 1861, Darwin had presented on the sexual development of *Primula* at the Linnean Society explaining the peculiar existence of short- and long-styled forms of primroses and cowslips. Darwin argued that while the two forms were hermaphroditic, he came to understand that they were also sexually dimorphic, or 'heterostyled' as he would later put it (following Friedrich Hildebrand).[47] And by comparing the internal structure of their sexual elements as well as their relative fertility, Darwin came to the conclusion that the primroses and cowslips were 'most fertile when intercrossed, that is when heteromorphically united rather than homomorphically united'.[48]

For Darwin, this observation provided some useful implications for his theory of evolution. For a start, it further complemented the central argument he was to make in *Orchids* concerning the preference for cross-fertilization. A similar process could be observed at work with the cowslips and primroses as crosses between the two forms were clearly preferred. But perhaps more importantly, Darwin came to recognize that sterility itself seemed to arise within the species to promote cross-fertilization at the expense not just of self-fertilization but of homomorphic fertilization as well. Far from being developed to keep two species distinct, Darwin argued that sterility promoted the blending of distinct individuals, thereby undermining its supposed status as a sign for species differentiation.[49] This was an attractive counter to Huxley's desire for experimental evidence for the creation of new species via domestic selection.[50] Darwin's studies of the fertility of heterostyled forms of *Primula*, and later of *Linum* and *Lythrum*, became a useful way to make this argument.

It turns out that Scott had also been working on *Primula*. After giving Darwin a brief summary of his experiments and observations of the species, Darwin was truly impressed: 'What a capital observer you are! & how well you have worked the Primulas. All your facts are new to me'.[51] Scott had been experimenting on dimorphic and non-dimorphic species of *Primula* and had many observations to add to Darwin's work on the subject. Moreover, Scott's *Primula* research seemed much more extensive. What so excited Darwin was a now missing list that included Scott's observations about dozens of species of *Primula* that promised not just to complement Darwin's views, but also, with the right sort of guidance, to extend them in important ways. Darwin even advised that Scott should write up a paper on the subject for the Linnean Society, a task that Scott enthusiastically embraced.[52]

Darwin's *Primula* paper acted as a basis for Scott's own observations as he focused on providing an account of the varying fertility rates of dimorphic and non-dimorphic species of *Primula*. Scott's results, however, did not always accord with Darwinian expectations, and on one occasion Scott suggested modifying those results. Darwin's response to this suggestion was unflinching:

[47] See Charles Darwin, *The Effects of Cross and Self Fertilisation in the Animal Kingdom*, London: John Murray, 1876, p. 2.

[48] Charles Darwin, 'On the two forms, or dimorphic condition, in the species of *Primula*, and on their remarkable sexual relations' (read 21 November 1861), *Journal of the Proceedings of the Linnean Society of London (Botany)* (1862) 6, pp. 77–96, 94.

[49] Darwin, op. cit. (48), p. 94.

[50] Joy Harvey, 'Fertility or sterility? Darwin, Naudin and the problem of experimental hybridity', *Endeavour* (2003) 27(2), pp. 57–62, 59.

[51] Darwin to Scott, 3 December [1862], in *Correspondence*, vol. 10, p. 583.

[52] Darwin to Scott, 25, 28 May [1863], in *Correspondence*, vol. 11, p. 448.

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> By no means modify even in **slightest** degree any result. – Accuracy is the soul of Natural History. It is hard to become accurate; he who modifies a hair's breadth will never be accurate. It is a golden rule, which I try to follow, to put every fact which is opposed to one's preconceived opinion in the strongest light. – Absolute accuracy is the hardest merit to attain & the highest merit.[53]

Frustratingly, Scott's letter that includes the suggestion of modifying his results is no longer extant. Therefore what exactly Scott proposed to modify is unclear. What is clear, however, is that Scott was worried that some of his findings on the self-fertility of the non-dimorphic cowslip conflicted with Darwin's theory. It is also clear that Scott was becoming overly concerned to make his observations conform to Darwin's (perceived) needs. But in doing so Scott failed to recognize the 'golden rule' of scientific research. Scott thus informed Darwin that he would never do anything of the sort again, and would 'act in accordance with the judicious counsel you have given me'.[54] This is evidence of Darwin's mentoring at work, and how he sought to teach Scott the inductive method. This episode, therefore, could be interpreted as a useful 'teachable moment' that Darwin does not appear to have had a second thought about, though it is possible that he should have.

Indeed, despite Scott's faux pas, Darwin proved to be forgiving, no doubt because some of the other facts Scott uncovered did accord well with natural selection. What particularly interested Darwin were Scott's results from crossing differently coloured primroses and cowslips. These were the experiments that Darwin suggested as analogous to Gärtner's *Verbascum* experiments.[55] As we have seen, Darwin greatly esteemed Gärtner's experiments for the way they indicated that sterility and fertility were best understood along a spectrum and he convinced Scott that parallel experiments with *Primula* could be germane. Indeed they were. Scott claimed to produce 'the most astonishing results' when crossing red with white and yellow primroses, the reciprocal unions of which yielded not a single seed. According to Scott this was possibly a case of 'the attainment of the very zero of fertility between varieties of a species', a truly astonishing result that could prove transformative for considerations of the relationship between sterility and species creation. 'Individuals of varieties perfectly sterile when crossed; yet productive at the same time with own-pollen, is certainly curious if it is not in reality due to the cause I suppose', Scott wrote.[56] Darwin was impressed but advised caution: Scott should try and reproduce the results before committing them to print, so that the facts could be fully established: 'It is not likely that you will be anticipated, & it is a great thing to fully establish, what in future time will be considered an important discovery'.[57] Unfortunately, Scott did not have the time or the ability to reproduce these tantalizing results.

Scott therefore continued working through several drafts of his paper and Darwin arranged for it to be read at the Linnean Society on 4 February 1864. While the first part of the paper gave an extensive description of dimorphic and non-dimorphic species of *Primula*, the more significant second part of the paper 'tested the influence of dimorphism on hybridism'.[58] Here Scott described his various experiments on reciprocal unions of differently coloured primroses, though he admitted that he had not been able to repeat the reported results as per Darwin's instructions. That said, Scott argued that it was important to lay these findings before the society because of 'their bearings … on certain highly

[53] Darwin to Scott, 2 July [1863], in *Correspondence*, vol. 11, p. 519.
[54] Scott to Darwin, 23 July [1863], in *Correspondence*, vol. 11, p. 559.
[55] Scott to Darwin, 23 July [1863], in *Correspondence*, vol. 11, p. 560 n. 14.
[56] Scott to Darwin, 23 July [1863], in *Correspondence*, vol. 11, p. 558.
[57] Darwin to Scott, 25 [July 1863], in *Correspondence*, vol. 11, p. 562.
[58] Scott, op. cit. (1), 92.

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important points in theoretical natural science'.[59] The significant point was that he was unable to produce any seed when he sought to fertilize the modified descendent with the pollen from the parental form, which thereby demonstrated 'the *conditional* existence of physiological divergences sufficient in extent to induce complete sterility'.[60] Repeating a phrase Scott used in his letter to Darwin, he argued that his results had thus shown 'the absolute zero of fertility … attained between undoubted varieties of a species!'[61]

Even more compelling was Scott's description of his hybrid experiments with cowslips. Scott initially planned on experimenting on the short- and long-styled forms of the cowslip but then discovered a third, non-dimorphic and red variety that, much like the red primrose of his previous experiment, produces 'a higher degree of sterility resulting from its unions with the two normal forms of the species [the short- and long-styled forms], than that which results from the unions of other distinct species of Primulas!' Because of this, Scott believed 'that this *non-dimorphic* form is, in fact, judged by the physiological test so much insisted on by Prof. Huxley, *a new and distinct species*'.[62] This was a truly astonishing observation as Scott had ultimately claimed to produce a new species via selective hybrid breeding. But had Scott provided enough evidence to pass Huxley's physiological test? And would anyone even notice, given Scott's lack of standing in the scientific community?

Initially, Darwin was unable to generate much interest when the paper was read before the society, though leading botanist George Bentham spoke 'warmly' of the paper from his position as chair.[63] Bentham also subsequently proposed that Scott be elected an associate of the Linnean Society, knowing that he would not be able to afford a regular candidacy but that his contributions to botany should be recognized as a benefit to the society.[64] This was certainly a good outcome for Scott (though he was unable to accept the position due to his relocation to India, discussed below), but Darwin clearly wanted more substantial feedback about the content of the paper.

With that in mind, Darwin made sure that the published version, which appeared in the September 1864 issue of the Linnean Society's proceedings, received some notice. Behind the scenes, he orchestrated highly favourable reviews that appeared in both the *Natural History Review* and the *American Journal of Science and Arts* that stressed the paper's key finding: that Scott had provided the necessary evidence required by Huxley's test by producing a physiological species through variation, which is how Asa Gray put it in the *American Journal of Science*.[65] And at least one of Darwin's correspondents immediately grasped the significance of what Scott had done. After being alerted to Scott's piece by Gray's review, the British American entomologist Benjamin Dann Walsh wrote to Darwin about the 'remarkable fact' that Scott 'brings out, that the red variety of the common Primrose absolutely refuses to intercross with the normal form'. From Walsh's reading, 'such facts as these … knock the ground away completely from under the Creative Theory'.[66] Unfortunately for both Darwin and Scott, however, such overwhelming confidence in the significance of Scott's observations proved rather short-lived.

It turns out that there was a limit to what Scott could accomplish, no matter how remarkable were the results of his experiments. He was, after all, an outsider to the English scientific community, and viewed largely as a novice. Gray pointed this out in his otherwise

[59] Scott, op. cit. (1), p. 97.
[60] Scott, op. cit. (1), p. 100, original emphasis.
[61] Scott, op. cit. (1), p. 98.
[62] Scott, op. cit. (1), p. 108, original emphasis.
[63] Hooker to Darwin, 5 February 1864, in *Correspondence*, vol. 12, p. 37.
[64] Hooker to Darwin, [before 9 February 1864], in *Correspondence*, vol. 12, p. 44.
[65] [Asa Gray], 'Dioico-dimorphism in the primrose family', *American Journal of Science and Arts* (1865) 39(115), pp. 101–4, 104.
[66] B.D. Walsh to Darwin, 29 May 1865, in *Correspondence*, vol. 13, p. 155.

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favourable notice, writing, 'The paper is long … with occasional vagueness or obscurity of language, from the attempt of an acute, but perhaps rather untrained mind to indicate the bearings of the subject further than they have been clearly made out'.[67] The message was that Scott's 'untrained mind' was not able to make clear the significance of the findings, even with Darwin's coaching. More problematic, however, was Hooker's view of Scott. From his perspective, Scott was a gardener, who needed to fulfil his duty as such before entering the scientific community as a respected botanical experimenter. Because of this, Hooker ultimately frustrated Darwin's efforts to fast-track Scott, who was willing to do almost anything for his wealthy patron but at the expense of his actual occupation.

Mistaken calling

As is well known, Hooker was Darwin's closest friend and scientific adviser, particularly about all things botanical. He was also, from 1855, the assistant director of Kew Gardens, and would become director when his father died in 1865. He understood both the worlds of scientific botany and professional gardening, and because of this brought a slightly different perspective to Darwin's work with Scott, a perspective that was also informed by his different social status. Hooker may have come from a respectable family, but he was not independently wealthy, as Darwin was. He needed to work for a living, and because of this central fact spent much of his life adapting his scientific interests to the institutional settings of his employment and vice versa.[68] After taking an MD at the University of Glasgow, Hooker was appointed assistant surgeon with the Royal Navy aboard HMS *Erebus*; he then worked for the Geological Survey; and after several years of searching for some sort of scientific position was appointed at Kew, which gave him much stability but did not entirely liberate him from administrative work. As we have seen, while he did not initially know who Scott was, he was familiar with the specific context of Scott's position. In 1845, Hooker was the leading candidate for the chair of botany at the University of Edinburgh, which would have also made him the Regius Keeper of the Royal Botanic Garden. But it was Balfour who was offered the position, and not without controversy.[69]

When Hooker first learned of Darwin's discovery of Scott and the work the two men were doing, he was supportive and generally impressed by what Darwin had to say about Scott. He also couldn't understand why Scott would 'throw away his papers' at the Botanical Society of Edinburgh and encouraged Darwin to set Scott's expectations higher. He also lamented that Scott was working under Balfour, as Balfour seemed incapable of cultivating good botanists due to his lack of philosophical expertise.[70] There was clearly still some bitterness on Hooker's part at losing out to Balfour all those years ago. Hooker's view of Scott began to change, however, when Scott informed Darwin of difficulties he was encountering at work.

Scott's difficulties initially arose as a result of his hesitation to accept Balfour's offer of a foreign posting in India. Scott, who was then in the midst of conducting experiments for Darwin, sought his mentor's advice, and was advised to take the position. Unfortunately, in the intervening time, Balfour had offered the position to someone else. From this point, Scott's work conditions suffered. McNab began to treat Scott poorly and refused to allow Scott to attend lectures to improve his botanical knowledge, thereby hindering his advance. Scott believed that it was possible that both McNab and Balfour were displeased that he was

[67] [Gray], op. cit. (65), p. 101.

[68] This is one of the central arguments of Jim Endersby, *Imperial Nature: Joseph Hooker and the Practices of Victorian Science*, Chicago: University of Chicago Press, p. 29.

[69] For an analysis of the controversy see Bellon, op. cit. (25).

[70] Hooker to Darwin, 10 June 1863, in *Correspondence*, vol. 11, p. 491.

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collaborating with Darwin, and he was hopeful that Darwin might help him in his endeavour to find employment elsewhere.[71]

Given that Scott was becoming a promising disciple and was in the middle of an important experimental programme testing Darwin's key arguments about hybridism and sterility, Darwin felt compelled to come to Scott's aid. He forwarded Scott's letter outlining his difficulties to Hooker, who, as assistant director of Kew Gardens, would be able to advise and possibly assist. 'You can confer a real service on a good man, John Scott, the writer of the enclosed letter, by reading it & giving me your opinion', Darwin wrote to Hooker. 'I assure John Scott is a truly remarkable man'.[72] This is precisely when Hooker's opinion of Scott began to change.

Hooker proved much less sympathetic to Scott's plight than Darwin. Scott may have been a careful experimenter and useful observer, but, first and foremost, he was a gardener under the charge of respectable employers. Hooker did 'not like', for instance, Scott 'quarrelling with McNab, of whom I never heard complaints as a bad master'. He also personally had several negative experiences with gardeners just like Scott, who expect to take advantage of their paid positions to better themselves. 'Of all men in the world', Hooker complained, 'Gardeners (especially intelligent ones) are the most troublesome to deal with'. Hooker, therefore, sympathized with McNab, who would have to try and 'get his fair days work out of his men for fair days wages', meanwhile those men are attending lectures and conducting experiments that lead to 'all sorts of very unexpected & inexpedient delinquencies'. It must be understood, Hooker explained to Darwin, that the experiments he so desired 'kill plants, as well as promote science!'[73] Darwin had to admit that Scott had done a 'stupendous number' of experiments for him, so he sent Scott a 'preaching' note that he should get on with McNab and ensure 'that the ordinary work is fully done'.[74] Hooker, meanwhile, suggested that he would at the very least 'bear Scott in mind' should he hear of any positions that become available.[75]

Scott said little about his work situation for the next several months and then rather suddenly informed Darwin, just a month after his paper on *Primula* was read at the Linnean Society in February 1864, that he found his position untenable and was forced to leave.[76] He became 'completely chagrined with my masters behaviour to me', and had no choice but to resign. They overlooked him when new foreign positions became available and he 'felt this repeated overlooking very deeply'. He thus determined to complete the experiments that he had undertaken for Darwin and then handed in his notice.[77] Darwin, who no doubt felt partially responsible for this situation, again wrote to Hooker but this time with a remarkable proposal. Given that Scott had proven himself to be 'willing to follow instructions' and showed 'much originality in varying his own experiments', Darwin wondered whether it would be possible to create a position at Kew for Scott that would be funded entirely by Darwin himself. This was actually a great opportunity, Darwin explained to Hooker: 'years may pass before another man appears fitted to investigate certain difficult & tedious points – viz relative fertility of varieties of plants … and secondly whether a plant's own pollen is less effective than that of another individual'.[78] Hooker, however, was unable to overlook the difficulties. It would be impossible for Scott to work under a foreman while also getting

[71] Scott to Darwin, 22 May 1863, in *Correspondence*, vol. 11, p. 435.

[72] Darwin to Hooker, 23 May [1863], in *Correspondence*, vol. 11, p. 438.

[73] Hooker to Darwin, [23–7 May 1863], in *Correspondence*, vol. 11, pp. 439–40.

[74] Darwin to Hooker, 29 May [1863], in *Correspondence*, vol. 11, p. 461; Darwin to Scott, 25, 28 May [1863], in *Correspondence*, vol. 11, p. 449.

[75] Hooker to Darwin, 10 June 1863, in *Correspondence*, vol. 11, p. 491.

[76] Scott to Darwin, 10 March 1864, in *Correspondence*, vol. 12, p. 67.

[77] Scott to Darwin, 28 March 1864, in *Correspondence*, vol. 12, p. 96.

[78] Darwin to Hooker, [1 April 1864], in *Correspondence*, vol. 12, p. 108.

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special treatment as Darwin's personal botanist. Gardeners were by nature, according to Hooker, a jealous bunch and would possibly sabotage Scott's experiments. Employing Scott in this way was out of the question.[79]

More problematic, however, was that Hooker had taken it upon himself to seek out a reference for Scott from Balfour, and it reinforced some of Hooker's concerns. In the letter Balfour explained that Scott became so absorbed in his work for Darwin that he neglected his regular duties. He also had a poor manner. 'From all I heard', Balfour wrote, 'he appeared to have a bad temper & to be rather sullen'. He doubted that Scott could act 'as a superintendent of others' and believed that he would only 'do well in a situation where he was allowed to carry on his observations on plants in the way he chose & without control'.[80] One might expect that Hooker would view Balfour's letter with a bit more scepticism, particularly given Balfour's well-known anti-Darwinism. The second edition of his *Outlines of Botany* (1862), for example, claimed that Darwin's views were 'both erroneous and dangerous'.[81] But Hooker's response is quite understandable in the social context of science at the time. Hooker would have felt a gentlemanly affinity with his peer Balfour, who shared similar institutional responsibilities. Balfour's account of events, along with his description of Scott's character, was therefore to be trusted and accepted.[82] 'It is very awkward', Hooker explained, 'for one really sees no avenue for the poor fellow'. As a poor-mannered gardener only interested in experimental botany, he had, quite simply, 'mistaken his calling'.[83]

Darwin seemed to accept that there was little Hooker could do for Scott given Balfour's testimonial, and that Scott's outlook for a position that would suit his temperament was limited: 'I fear the millennium may come before a private gent[n] may want a scientific gardener', Darwin wrote.[84] But then he received a letter from a thoroughly depressed Scott on 14 April 1864 that was perhaps a little too honest. Scott explained that his previous position was for a time ideal as it gave him the ability 'to acquire a knowledge of science'. The 'mechanical drudgery of gardening' was an avenue for social mobility whereby he could make real contributions to scientific knowledge. But now that that avenue was gone, his former happiness was replaced by 'an inward dread of life's future'.[85] Darwin was clearly worried by Scott's worsening state of mind and forwarded the letter to Hooker. 'I will not plague you about Scott again; but do read enclosed … Can you give him any hope of being taken at Kew? I do not know how humble a place he would accept – I am awfully tempted to have him here; but Emma begs me rather to send him £100 [instead]'.[86]

It turns out that sending Scott's letter to Hooker had the very opposite effect of that Darwin intended. Scott's letter gave Hooker all the evidence he needed to recognize that 'Scott is a man who cannot be helped; I see from his last letter … that he is quite unfitted for making his way in the world'. What annoyed Hooker was Scott's admission that he only accepted the 'drudgery of gardening' for the benefits it afforded his self-fashioning as a man of science. He failed to realize that by refusing to accept his position and fulfil the duties required of it, he had absented himself from the all-important 'struggle for life'. Hooker

[79] Hooker to Darwin, [2 April 1864], in *Correspondence*, vol. 12, pp. 111–12.

[80] J. H. Balfour to Hooker, 5 April 1864, enclosed in Hooker to Darwin, 6 April 1864, in *Correspondence*, vol. 12, p. 123.

[81] John Hutton Balfour, *Outlines of Botany*, 2nd edn, Edinburgh: Adam and Charles Black, 1862, p. 442; Bellon, op. cit. (25), p. 47.

[82] The connection between personal virtues, trust, and the burgeoning profession of science that is invoked here is thoroughly examined in Steven Shapin, *The Scientific Life: A Moral History of a Late Modern Vocation*, Chicago: University of Chicago Press, 2008.

[83] Hooker to Darwin, 6 April 1864, in *Correspondence*, vol. 12, p. 122.

[84] Darwin to Hooker, 7 April [1864], in *Correspondence*, vol. 12, p. 126.

[85] Scott to Darwin, 14 April [1864], in *Correspondence*, vol. 12, p. 140.

[86] Darwin to Hooker, 19 [April 1864], in *Correspondence*, vol. 12, p. 148.

then compared Scott's journey with the journeys of other men of science of similarly lowly upbringings, such as Lindley, Huxley, John Tyndall, Michael Faraday and Robert Graham, individuals who had first established themselves as useful members of society before taking on a scientific life. Unlike these men, Scott had not first 'established himself as a useful member of Society'. Scott therefore needed to learn to help himself before he could be gifted a position at Kew or, as Darwin half-heartedly suggested, at Down House. Hooker advised that Darwin inform Scott of the impracticality of his scientific desires and 'urge him to a nobler course than that to which he is rapidly tending … & do not, my friend, exaggerate the importance of his labors *in relation to his* duty as a man'.[87] While Darwin, for his part, was thankful that Hooker had spent so much time writing to him about Scott, he thought that Hooker's view of Scott's character was not entirely fair. 'I cannot but think', Darwin wrote, 'you take a rather hard view of his character'.[88]

It is instructive that Hooker and Darwin had such differing views of what they referred to as Scott's character. From Darwin's perspective, Scott was making the most of his modest status, by entering a profession that allowed him to pursue his real interests in botany. And because of Scott's 'burning zeal for science' along with his clear capabilities, Darwin was willing to support that endeavour as much as he could.[89] But from Hooker's perspective, Scott had obligations to his institution of employment that should not be swept aside in favour of Darwin's patronage. This reflects Hooker's habitation of a slightly different social world from Darwin, one that required him to pursue his scientific interests alongside public service, whether as a surgeon with the Royal Navy or assistant director of Kew Gardens. Self-reliance and hard work were important dimensions of the gentlemanly scientific identity that Hooker and others like him cultivated in order to make science a respectable, paying vocation.[90] In this regard, Hooker's example of the physicist John Tyndall is a telling one given that Tyndall, much like Hooker, was explicit about the connection between duty, labour and moral development that he embraced in a scientific identity that he cultivated over many years as he laboured as a surveyor and then public teacher before pursuing his scientific interests by taking a PhD at Marburg University in Germany.[91] This is the kind of thing Hooker was getting at when he said that Scott had to learn to fulfil his 'duty as a man'. While Darwin ultimately disagreed with Hooker's view of Scott's character, he promised to not return to the subject of Scott again: 'I have caused you most unreasonable trouble about him'.[92]

The place for Scott

A month after this exchange, however, Hooker had a change of heart about Scott. He determined that perhaps 'India would be the place for him'. Hooker had been recently informed about some opportunities that had opened up in forest management and in the tea and coffee industries, positions that would 'offer abundant means of following any pursuit, & Scotts temper would be no objection'.[93] It is unclear what caused Hooker's rather sudden change of opinion, but it is significant that Hooker was only willing to help Scott find a position in India and not in England. Indeed, as Hooker explained, 'Scotts peculiar temper will

[87] Hooker to Darwin, 20 April 1864, in *Correspondence*, vol. 12, p. 150, original emphasis.
[88] Darwin to Hooker, 25 April [1864], in *Correspondence*, vol. 12, p. 153.
[89] Darwin to Hooker, [1 April 1864], in *Correspondence*, vol. 12, p. 108.
[90] Endersby, op. cit. (68), p. 9. See also Richard Bellon, 'Joseph Hooker's ideals for a professional man of science', *Journal of the History of Biology* (2001) 34, pp. 51–82; Barton, *The X Club*, op. cit. (12), p. 24.
[91] Ian Hesketh, 'Technologies of the scientific self: John Tyndall and his journal', *Isis* (2019) 110, pp. 460–82.
[92] Darwin to Hooker, 25 April [1864], in *Correspondence*, vol. 12, p. 153.
[93] Hooker to Darwin, 19 May 1864, in *Correspondence*, vol. 12, p. 196.

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be no obstacle to the Hindoos & Mussulmen working well under him.'[94] What this suggests is that there were two different systems of status at work here: one at home, where Scott's mobility was limited by his poor manners and mistaken calling; and one in the empire, where a white man's 'peculiar temper' was not an obstacle to that advancement in the context of his treatment of those regarded as racially inferior. Hooker, moreover, could not have been more helpful in smoothing the way for Scott's transition to India. And after he met Scott in person when Scott visited Kew Gardens on 13 August 1864 while in London to organize his voyage to India, Hooker found Scott to be 'a thoroughly respectable & intelligent looking man'. From that point on, his opinion of Scott changed dramatically.[95] Hooker eventually recommended Scott for a temporary position as gardener at the Botanic Garden at Darjeeling, a position that Scott was offered as soon as he arrived.[96] Darwin also played his part in Scott's relocation, paying for Scott's voyage to India and covering his expenses until he was settled, which came to about £115.[97] This relocation was not ideal for Darwin, as Scott was no longer able to complete the systematic programme of experimentation that he had begun under Darwin's direction. But from Scott's perspective a new position in India that included paid travel expenses was not a bad outcome.

Moreover, Scott's life improved dramatically almost as soon as he arrived in India in December 1864, just two months after his paper on *Primula* was published. After initially hiring Scott to a temporary position, Thomas Anderson promoted Scott to the position of curator of the Botanic Gardens in Calcutta, a position that included a house along with a yearly salary of £240.[98] This solidified Scott's transition to India, but it also substantially increased his duties, which left him no time to continue experimenting on Darwin's behalf. As he explained to Darwin, 'My duties as Curator of the Botanic Gardens have been and yet are engrossing my time so completely, that I have been quite unable to engage in the experimental illustrations of many subjects which lie very near my heart'.[99] Before he left for India, however, Scott completed his experiments on *Verbascum*, experiments that Darwin had suggested to confirm or contest Gärtner's observations that he found so important for understanding the development of sterility.[100] Surprisingly, Scott's results were different to Gärtner's in important respects, and he argued that those differences were evidence in favour of 'Darwin's remark that sterility is simply a superinduced quality due to incidental differences in the reproductive system'.[101] Scott ended up writing a draft of his findings on his voyage and sent it to Darwin once he arrived.

Unfortunately, that Scott had cobbled the paper together during his voyage was only too clear. Darwin sent the draft to Hooker, who found it unfit for publication despite the usual signs of Scott's 'industry & ability'. The main issue was that because he was offering such a fundamental challenge to Gärtner's well-regarded observations, 'the experiments should have been repeated'. This was because Scott's 'discord with Gærtner either shakes the whole value of his system of experimentation, or shows that similar experiments give different results, or that one of the observers is wrong'. What is more, Hooker had the naturalist

[94] Hooker to Darwin, [4 June 1864], in *Correspondence*, vol. 12, p. 227.

[95] Hooker to Darwin, [15 August 1864], in *Correspondence*, vol. 12, p. 306.

[96] Hooker to Darwin, [19 September 1864], in *Correspondence*, vol. 12, p. 330; Hooker to Darwin, [26 January 1865], in *Correspondence*, vol. 13, p. 39.

[97] Scott to Darwin, 2 August 1864, in *Correspondence*, vol. 12, p. 295 nn. 1–2.

[98] Hooker to Darwin, [17 February 1865], in *Correspondence*, vol. 13, p. 61; Scott to Darwin, 21 July 1865, in *Correspondence*, vol. 13, pp. 204–6.

[99] Scott to Darwin, 22 January 1867, in *Correspondence*, vol. 15, p. 45.

[100] Darwin to Scott, 19 November [1862], in *Correspondence*, vol. 10, p. 538; Darwin to Scott, 11 December [1862], in *Correspondence*, vol. 11, pp. 595–6.

[101] John Scott, 'On the reproductive functional relations of several species and varieties of Verbasca', *Journal of the Asiatic Society of Bengal* (1867) 36(Pt 2), pp. 145–74, 174.

and 'scientific arithmetician' Thomas Thomson look at Scott's paper, and he found significant errors in Scott's calculations: 'the Denominators are obviously arbitrary & useless'.[102] Scott was understandably disappointed and embarrassed upon receiving Hooker's and Thomson's reports and admitted it was written in haste.[103] He ended up putting it aside for some time before revising his calculations and eventually having it published in the *Journal of the Asiatic Society of Bengal* in 1867. Significantly, Darwin did not attempt to publicize the work as he had done with Scott's earlier paper on *Primula*. While Darwin does refer to how Scott's *Verbascum* experiments contradicted those of Gärtner in his *Variation of Animals and Plants under Domestication* (1868), he stressed that Scott's 'fluctuating results … seem hardly sufficient to overthrow the conclusions arrived at by Gärtner from experiments tried on a much larger scale'.[104]

More importantly, Darwin also began to question Scott's *Primula* findings that seemed so promising with regard to fulfilling Huxley's physiological test. As Scott did not reproduce the results as Darwin suggested, Darwin set about testing the results himself. These experiments were disappointing. In December 1865, in response to Walsh's letter quoted above in support of how Scott's experiments further undermined special creation, Darwin was forced to tell Walsh that he had been 'counting seeds of experimental Primulas; amongst others the seedlings from John Scott's Primulas & these afford widely different results from what he gives'.[105] As Darwin further explained to Hooker, he was not able to produce the absolute zero of fertility when crossing differently coloured *Primula* as Scott was, and he began 'to doubt his accuracy'.[106] Given that Darwin had earlier chastised Scott for wanting to modify the results of one of his *Primula* experiments by stating that 'he who modifies a hair's breadth will never be accurate', it is worth wondering whether Darwin was now subtly questioning Scott's honesty along with his accuracy. Whatever the case, at this point it had become clear to Darwin that Scott's most promising results were not reproducible.

Conclusion

It is one of the well-known dimensions of Darwin scholarship that Darwin relied on an extensive network in support of his researches and that this led him to correspond with a diverse array of natural observers. While Darwin typically used the information they provided as he saw fit, and often offered some guidance or instructions on the kind of observations he was looking for, there were a few occasions when he encountered individuals who he believed could produce specialized studies of their own that could be fitted into a Darwinian framework.[107] This episode of John Scott is a wonderful example of how he did just that. We have seen that once Darwin became convinced of Scott's abilities, along with his willingness to carry out Darwin's 'schemes', Darwin proposed an extensive programme of experimentation that was designed to add further understanding to the relationship between hybridity and sterility. Moreover, in order to take full advantage of Scott's aid, Darwin not only educated Scott about the true meaning of natural selection in relation to botanical subjects, but also sought to impart the scientific virtues that he had methodically embraced over the years – patience, a devotion to truth, a cautious use of theory – so

[102] Hooker to Darwin, [10 March 1865], in *Correspondence*, vol. 13, p. 79.

[103] Scott to Darwin, 21 July 1865, in *Correspondence*, vol. 13, pp. 204–6.

[104] Charles Darwin, *The Variation of Animals and Plants under Domestication*, 2 vols., London: John Murray, 1868, vol. 2., pp. 106–7.

[105] Darwin to Walsh, 19 December [1865], in *Correspondence*, vol. 13, p. 327.

[106] Darwin to Hooker, 22 December [1865], in *Correspondence*, vol. 13, p. 328.

[107] See, in particular, Evelleen Richards, *Darwin and the Making of Sexual Selection*, Chicago: University of Chicago Press, 2017, which discusses Darwin's cultivation of Edward Blyth, William Tegetmeier and John Weir in relation to his theory of sexual selection.

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that his views would be taken seriously by a conservative scientific establishment. And he taught Scott how to communicate his observations in keeping with the established manner of scientific publishing.

We know that Darwin's mentoring of Scott was not entirely unique because Darwin had earlier engaged in a similar mentoring process with the naturalist and collector Henry Walter Bates. While Bates was at the time certainly more integrated into the British scientific community than was Scott, there are still some telling parallels. For instance, once Bates informed Darwin about his observations of mimicry in butterflies in 1861, Darwin encouraged Bates to present his work at the Linnean Society and then read drafts of the paper, providing similar advice about clarity and the proper use of language as he offered Scott.[108] He also paid for the expensive coloured plates that were included in the published version and then organized for Bates's travel book to be published by John Murray.[109] Bates would go on to become an accomplished naturalist in his own right, and his work on mimicry would become a key piece of evidence that Darwin and his supporters would often invoke in favour of natural selection. There are, no doubt, other examples worth exploring in this regard, from his encouragement of Mary Treat's work on insectivorous plants to the mentoring he did later with some of his children, notably his son Francis, who collaborated with Darwin on his studies of plant movements.[110]

In the case of Scott, it is clear that Darwin came to believe that he could be mentored, not unlike Bates, and produce reliable specialized studies in support of natural selection. But there were social limitations to Scott's ability to accept and benefit fully from Darwin's mentoring and patronage. Whereas Darwin saw Scott as a remarkable man, who had overcome difficult circumstances to put himself in a position to make scientific claims of his own, Hooker saw someone quite different. From Hooker's perspective, Scott sought to ignore his circumstances rather than overcome them. Hooker believed that Scott needed to fulfil his duty to society and his station, much like other lower-class men of science who had come before him, before he should expect membership in the world of British science. Until then, Scott's observations quite simply could not be trusted. And, unfortunately, the failure of Scott's *Primula* and *Verbascum* experiments tended to confirm Hooker's point of view as opposed to Darwin's. As Hooker wrote to Darwin upon learning about his inability to reproduce Scott's results, 'John Scotts observations were always too much for me' given that they were 'obtained by snatches at a time when [Scott] should have been doing something else & was always in dread of being caught'.[111]

This is not to say that Scott was not of use to Darwin. While Darwin was forced to explain that Scott's hybrid experiments resulting in a new physiological species were unreliable, he was still able to use many of Scott's other observations that contributed in general to his work on heterostyly and on hybrid and cross-fertilization that so problematized Huxley's physiological test.[112] What is more, while Scott's relocation may have undermined his ability to continue to act as Darwin's scientific gardener, he instead became an important local

[108] Henry Walter Bates to Darwin, 26 March [1861], in *Correspondence*, vol. 9, pp. 72–6; Darwin to Bates, 4 April [1861], in *Correspondence*, vol. 9, p. 80; Darwin to Bates, 15 December [1861], in *Correspondence*, vol. 9, pp. 370–2.

[109] Darwin to Bates, 3 December [1861], in *Correspondence*, vol. 9, p. 280; Darwin to Murray, 28 January [1862], in *Correspondence*, vol. 10, pp. 54–5; Henry Walter Bates, 'Contributions to an insect fauna of the Amazon valley', *Transactions of the Linnean Society of London* (1862) 23, pp. 495–566; Bates, *The Naturalist on the River Amazons*, 2 vols., London: John Murray, 1863.

[110] Dawn L. Sanders, 'Behind the curtain: Treat and Austin's contributions to Darwin's work on insectivorous plants and subsequent botanical studies', *Jahrbuch für Europäische Wissenschaftskulur* (2010) 5, pp. 285–98; Peter Ayres, *The Aliveness of Plants: The Darwins at the Dawn of Plant Science*, London: Pickering & Chatto, 2008, pp. 99–114, 172.

[111] Hooker to Darwin, [23] December 1865, in *Correspondence*, vol. 13, p. 331.

[112] See Darwin, op. cit. (104), vol. 2, p. 109 n. 25; Charles Darwin, 'On the character and hybrid-like nature of the offspring from the illegitimate unions of dimorphic and trimorphic plants', *Journal of the Linnean Society of London*

contact for Darwin's future work on the expression of the emotions, and is cited throughout for his observations of expressions in India.[113] From this perspective, therefore, Scott very much looks like one of Darwin's many invisible labourers, who provided Darwin with facts for his own use, labourers who may or may not be mentioned in the texts of his works, but are given little role to play in the actual development of natural knowledge.[114]

This essay has sought to show, however, that there is another less well-known story to be told about Scott and Darwin. As has been shown, Scott's own experimental expertise and efforts brought him close to solving the great empirical problem that would in theory prove evolution by natural selection once and for all, namely the creation of a new 'physiological' species via the processes of domestic selection. But by moving to India, Scott was never given the opportunity to substantiate his discovery, or to continue to play such a direct role in contributing to the development of evolutionary botany. He did continue to work on botanical subjects relevant to his work in India, notably writing a major paper on the tree ferns of Sikkim, and a manual on opium cultivation.[115] He was eventually made a fellow of the Linnean Society on 20 February 1872, a membership for which he paid when he insisted on reimbursing Darwin for covering his relocation expenses eight years before. In the end it was Hooker who nominated Scott and conceived the idea of using the funds to cover the membership fee.[116] Perhaps by 1872, Hooker recognized that Scott had finally fulfilled his duty to society and to himself.

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(Botany) (1868) 10, pp. 393–437, 414, 416, 420–2, 427, 435; Darwin, *The Different Forms of Flowers on Plants of the Same Species*, London: John Murray, 1877, pp. 30, 34, 43–5, 48–53, 73–5.

[113] Charles Darwin, *Expression of the Emotions*, London: John Murray, 1872, pp. 21, 187–8, 232, 241, 248–50, 260, 267–8, 276, 280, 316.

[114] For a recent study of Darwin's use of invisible labourers in relation to his studies of *Cirripedia* see Bruno Alves Valverde and Cristina de Campos, '"Pray observe how time slips by": collaborators, assistants, and the background dynamics in the publication of Darwin's *Cirripedia Project*', *Journal of the History of Biology* (2024) 57, pp. 349–77.

[115] John Scott, 'Notes on the tree ferns of British Sikkim', *Transactions of the Linnean Society* (1874) 30, pp. 1–44; Scott, *Manual of Opium Husbandry of Behar and Benares*, Calcutta: Bengal Secretariat Press, 1877.

[116] Scott to Hooker, 31 October 1872, in *Correspondence*, vol. 20, p. 474.

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