Domesticity in the Making of Modern Science

Edited by

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and

Brigitte Van Tiggelen

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Contents

Tables and Figures

Tables

Figures

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Introduction: Domesticity and the Historiography of Science

Donald L. Opitz, Staffan Bergwik, and Brigitte Van Tiggelen

Nearly three decades ago, Steven Shapin argued that, among a range of venues in seventeenth-century England – places like the shops of apothecaries and instrument makers, coffeehouses, royal palaces, and college rooms – private residences of gentlemen were 'by far the most significant', with the 'overwhelming majority of experimental trials, displays, and discussions that we know about' having occurred within them.[1] Despite others' recognition of the wider applicability of this assessment well beyond this context, Alix Cooper noted in her survey of scientific homes and households in the early modern period, 'Few historians of science have paid attention to these kinds of "private" spaces.'[2] Attuned to the historiography of science's continued neglect of domestic space and related themes – domesticity, households, and families – this volume investigates the historical significance of domestic matters for the production of scientific knowledge.

The authors contribute to this effort with the benefit of rich perspectives offered by a range of disciplines including anthropology, gender studies, geography, sociology, and the history of science. A variety of contexts is considered, primarily within modern Europe, but also among colonial and postcolonial milieus. Elite households and their heads – including, perhaps emblematically, Charles Darwin and his family at Down House – are analysed, alongside twenty-first-century amateur, backyard recorders of climate data. *Domesticity in the Making of Modern Science* provides a unifying theme that enables us to consider the historical relationships and distinctions among a range of activities and contexts: from the 'high science' of post-Enlightenment gentlemanly and gentlewomanly amateurs, to the modern 'domestic science' of middle-class British and American farmwomen, to the fictive kinships of migrant scientists and engineers, to the crowdsourcing pursuits of 'citizen-scientists' in our present age.

Our point of departure is that the domestic sphere is not external to knowledge making, but rather a condition for and a consequence of research. Using domesticity as a focus, several fundamental questions in science studies can be addressed: How have domestic scientific cultures been shaped spatially and temporally? How does domesticity intersect with gender, class, and sexuality in knowledge-making practices? Which are the many, and historically varied, forms of scientific collaborations within and beyond households? How is the epistemological authority of science connected to the legitimacy of scientific forms of life, as they are practised and perceived within, and in relation to, private settings and their hierarchies? How is privacy and publicity mapped across the domestic threshold?

Despite the common historiographical assumption that 'public' institutional venues displaced 'private' homes as the primary sites of research, we argue that the domestic sphere has in fact remained critically important for the production of scientific knowledge, even amid dramatic shifts in the mapping of research space.[3] Yet, while we can say households have remained crucial, their roles, meanings, and occupied spaces have indeed transformed across contexts. Evident from the chapters by Paul White and Aalok Khandekar, for example, the home and family did not carry the same meanings for Charles Darwin as they do for present-day Indian 'technomigrants'. Even so, domesticity offers a crucial paradigm for understanding the production and understanding of knowledge among these distinctive contexts. Changes in norms and practices of the domestic sphere can be correlated with transformations in epistemology, scientific forms of life, and scientists' public personae. And, as White and others argue, domesticity itself can be understood as an historical development shaped by the very evolutionary ideas of scientists like Darwin.

Although there is an increasing body of research on science, family, and private life, the historiography has continued to maintain a strong demarcation between scientific authority and domesticity – in terms of geographic spaces and the social identities and knowledge associated with those spaces. Usually positioned in oppositional terms, professional and institutional vis-à-vis amateur and domestic, such mappings miss the more complex ways in which public and private, professional and amateur, civic and domestic, in fact intermingled. Similarly, historians have largely overlooked the extent to which domesticity as cultural ideology – drawing upon and yet transcending the physical and social dimensions of the household – shaped the making of institutions, professions, and, indeed, conceptual landscaping of the sciences within different geographical and temporal contexts.

The present volume extends several strands in the historiography. A rich literature has analysed the interplay between science, private life, and gender norms, particularly in relation to women's research as part of collaborative couples. A fair share of women's 'invisible' work has been performed outside the institutions of academic and professional science.[4] Occasionally, knowledge making has had the character of a family business, in most cases with husbands representing families' collective work 'onstage' and wives, sisters, and children performing the (often tedious) observations and calculation work 'offstage' – yet often making original discoveries, and often subtly shaping the forms of knowledge put into public circulation.[5] Accordingly, studies on women in science have paved the way for questions about science and private life. Moreover, these studies resonate with historical research on gender and the fluid, historically shifting boundary between private and public.[6] Collectively, these bodies of literature have enabled us to envision domesticity as a serious focus of study within the history of science. As in the case of collaborative couples, we conceptualize the household as an arena within which gender emerges as a relational category.[7] Various chapters of this volume illustrate how men's identities as knowledge producers were just as profoundly shaped by the rhetoric and practices of the domestic sphere, as were women's, and a few of the chapters here focus in particular on how these gendered identities – or bodies – were formed in relation to each other. Clearly, domestic spaces are not merely sites where we can study the shaping of femininity within the sciences; these spaces also profoundly influenced the expression of scientific masculinities.[8]

This volume also builds upon the field's increasing attention to the spaces of knowledge. Since the 1980s, a growing literature in the history of science has engaged knowledge making as a socially and culturally embedded practice with a focus on material, spatial settings. This growing area of study has benefited from a heightened interest in spatiality across the humanities and social sciences. Scholars adopting spatial perspectives have argued that the place of knowledge is an active ingredient in knowledge production beyond merely providing a container for fact making.[9] Ideas and practices associated with particular spaces become part and parcel of the authority and legitimacy of the knowledge therein produced. The spaces offer more than sites for knowledge making; their very materiality shapes the forms of their occupants' collaborations, practices, and knowledge products. But research drawing upon the methods of historical geography has focused primarily on 'museums, gardens, laboratories, field stations', with few exceptions.[10] Our volume adds a variety of households to this agenda. The occupants of private homes often shared worldviews and accumulated scientific power. The household, as several chapters here show, constituted a space where scientific data, specimens, and instruments were accumulated, developed, and distributed.[11]

As much as the history of science has been adamant on understanding the local situatedness of scientific knowledge, new research has also attended to mapping large-scale networks. The practices and cultures of science have reached far beyond the walls of the laboratory and academy, and network approaches provide ways for understanding the many interactions and knowledge-making processes that include, yet transcend, institutional settings.[12] This methodology throws new light on domestic sites as well: they can function as hubs in scientific networks, connecting dispersed places, materials, and actors, as illustrated among several of the chapters here.[13] Network approaches complement spatial perspectives on science, and homes can be viewed as places of (typically) small-scale collaboration at the same time as they offered bases for extensive, multilayered knowledge networks. The historical cases in this volume indicate how private relationships functioned in relation to more formalized, qua professional, affiliations, and how homes were positioned as spatial nodes within broader geographies of knowledge. Throughout the history of modern science, households, with their blood relations or intimate social ties, remained fundamental for generating and upholding networks based on collegiality, trust, and status.[14]

In treating a range of subjects in the chapters that follow, the authors respond to three primary themes that also provide a structure for the book. Part I considers homes as domestic sites of knowledge production, with particular attention to how domesticity served to establish, or undercut, scientific authority. In Part II, the chapters problematize the very domestic spaces of practice by considering how they, and their domestic ideologies, have been constructed alongside, and within, discourses of science and technology. Then, Part III focuses on the scientific family, whether conceptualized in terms of blood relations or 'fictive kinships'. The chapters of this section, to varying degrees, consider the familial dynamics of collaboration, inheritance, kinship, and mobility – collectively, how these have shaped the scientific life and knowledge making. In the remainder of this Introduction, we highlight the individual chapters as they speak to these three major themes.

The estate of knowledge: Domestic sites and scientific authority

'Homemade' is a term often used by modern biographers and historians, applied retrospectively to describe the setting and equipment of researchers known to have utilized their homes for scientific work. 'Homemade' connoted quaint and romantic, as contrasted with the sterile, standardized institutional laboratories of the twentieth century.[15] As the chapters of Part I show, the domestic siting of research both established and yet problematized the identity of scientific researchers and the credibility of their scientific results, often aligning with gendered conventions. Whereas households could be situated within broader geographies of science in ways that positioned them as calculation think tanks, observatories, and experimental workshops in relation to academic institutions authorizing knowledge, households could also be competitors with emerging sites of research, vying for status in the making of credible knowledge.

As the chapters collectively demonstrate, social status mattered in the reception of household scientific industry. Aristocratic status could confer resources and social connections upon a scientific household that positioned its lord, or lady, as a leading scientific authority. As Julie Davies shows in her chapter on Mary Somerset, Duchess of Beaufort, the late seventeenth-century English aristocratic home provided a base from which wider, international networks radiated, as well as where botanical collections were assembled, processed, illustrated, catalogued, and publicized. Within the context of the early Royal Society of London, a gentlewomanly savant of Somerset's stature – and her female peers, including the illustrious Margaret Cavendish, Duchess of Newcastle – enjoyed access and prestige within the homosocial space of the new experimental natural philosophy, and yet, as a woman, this relied upon her connections established through male members of her household and wider social circle. As Davies details, Somerset's Badminton House and its environs sustained a botanical industry, drawing upon the estate's staff of gardeners, family members, and other volunteers, and this resulted in Somerset's production of a significant 12-volume herbarium. As a gentlewoman, her supervision of 'botanizing at Badminton House' included granting savants access to her collections as well as lending her critical skills in classification and artistic skills in illustration. Yet her gender defined her domestic experience, plagued as it was by bouts of melancholy, and shaped the limited recognition she received from her scientific contemporaries and the subsequent historical record.

A parallel story is told by Isabelle Lémonon in her chapter on the 'scientific work and network' of Marie Dupiéry. Within the context of Enlightenment France, Dupiéry pursued astronomy and chemistry within domestic spaces, first in Paris and then in Mareil-en-France. Like Beaufort, Dupiéry relied upon her access to scientific academies, particularly the Académie des sciences of Paris, even though, as a woman, she could not enjoy formal status as an elected member. As Lémonon details in her rich portrait of Dupiéry, based on careful analysis of hitherto untapped archived sources, scientific homes of amateurs functioned as calculation workshops within quite large-scale industries devoted to the production of calendars and navigation tables, and those homes often consisted of teams of assistants managed by women. Lémonon is careful to avoid merely categorizing such women as 'invisible technicians', and she urges us to consider them as akin to research associates or 'savants', though contemporaries were quick to qualify that designation with such phrasings as 'fellow sister'.[16] Moreover, with a careful analysis of Dupiéry's finances, Lémonon challenges the common historiographical assumption that women's participation in the sciences was mostly voluntary and removed from the academic/professional sphere: the income Dupiéry and her female peers generated through their paid research and illustrating assistance, tutoring, and lecturing suggests a more complex status. As recently emphasized by Mary Terrall in her book on René-Antoine Ferchault de Réaumur, household scientific industries functioned in relationship to the projects and directives of scientific academies, and Lémonon extends this research by adding the cases of Dupiéry and her male colleague, Jérôme Lalande.[17]

Moving forward in chronology, Paul White analyses one of the most renowned nineteenth-century gentlemanly homes in the history of science, Charles Darwin's Down House, in Kent, England. Through vivid examples of collaborative, familial research, White's chapter demonstrates the domestic situatedness of the production of natural knowledge at Down, explaining how family and work intertwined in ways that characterized not only the nature of Darwin's practice, but also constituted a form of domesticity that served as an object of study. White interprets the domestic Darwin as an 'institution', acting as a centre of authority from which the research of others was directed. Darwin's extended community and collegial ties drew not from impersonal bureaucratic allegiances or professional obligations, but rather from the more emotional, affective interactions formed within his household and beyond. Domestic social conventions thus distinguished between friends and foes, irrespective of the dissention waged against Darwin's scientific theories. Immersed within gendered, Victorian conventions for domesticity, Darwin used his own home, and its occupants, as an observation field from which to study the effects of domestication and develop his ideas on the origin of domestic bonds, the sexual division of labour, and the role of family in evolution and human culture.

Whereas White notes how Julius Sachs notoriously targeted the lack of apparent 'control' among Darwin's 'homely experiments with cork and card', as contrasted with the specialized, standardized equipment and spaces of institutional laboratories, Claire G. Jones introduces a gendered dimension to the valuation of 'homemade science' in her analysis of the portrayals and reception of the domestic experiments of palaeobotanist Henderina Scott and physicist Hertha Ayrton.[18] In her comparative analysis of these two British female scientists, both active in the decades around 1900, Jones notes similarities between their experiences – their marriages to men of science, their reliance upon domestic spaces for their research, the undervaluation of their work judged precisely as products of domesticity, the fact they were both pejoratively feminized according to their sex, and their limited access to scientific institutions. Despite the barriers Scott and Ayrton faced, as Jones shows, they independently advanced research agendas and made significant contributions within their respective fields – Scott, her application of early cinematographic technology to record the growth and movement of plants; Ayrton, her study on sand ripples, which overturned George Darwin's explanation and won her a medal of the Royal Society of London, who otherwise barred her access to its fellowship.[19] Although these cases underscore the gender discrimination operative during this period of professionalization of science, they also beg the question of women's 'incidental concomitant exclusion' as a result of the sidelining of domestic sites; as before, the domestic sphere continued to provide space and resources for women's pursuit of science, yielding important gains.[20]

Constructions of domestic science and technology

The leveraging of domesticity as a means for promoting women's work in science constituted a common strategy not only within individual cases of practice, but also within broader movements. The case of Agnes Pockels, a German contemporary of Scott and Ayrton, is perhaps emblematic in the former respect; the self-identified 'hausfrau' declined the offer of university laboratory space to remain working at her home in Braunschweig, where she balanced care of her ageing parents alongside an enduring series of investigations into the behaviour of surface films. Although her apocryphal discovery of surface tension in the kitchen sink often masked the reality of her sophisticated experimental arrangements and apparatus, and the specificities of her findings, she nevertheless won international renown for her independent research without undue criticism of – in fact, precisely in honour of – the domesticity of her work. As Brigitte Van Tiggelen recently pointed out, Agnes enjoyed a scientific form of life at home that her brother, Friedrich Pockels, chair of theoretical physics at the University of Heidelberg, could only long for; as a former teacher and professional colleague, as well as his own wife, observed, whereas Friedrich's professional life was plagued with disappointment, his highest joy was found at his house. The gendering of professional and domestic life in the case of the Pockels siblings suggests how domesticity could provide a respectable freedom and flexibility otherwise unavailable amid the demands of academic obligations.[21]

Nevertheless, women's access to institutional resources, as suggested in Agnes Pockels's case, remained exceptional and highly contingent, and reformers desired more structural changes. Some recognized the ideological power of domesticity as a strategic lever, and educational movements both in Europe and America sought to establish 'domestic science' as an academic field, drawing upon, and advancing, women's acknowledged skills within the domestic sphere.[22] The resulting range of programmes created opportunities for women to pursue allied scientific subjects, at times creating 'niche' fields for women, at other times propelling their careers in unanticipated ways. Donald L. Opitz explores these themes in detail in his chapter focusing on the movements in Britain and the United States to educate and employ women in agriculture, in which he traces the articulation and application of an ideology of 'separate spheres' that, he argues, served to propel women's scientific training as opposed to thwarting it. Within new collegiate institutions for women to learn the science and practice of 'the lighter branches of agriculture' (encompassing such fields as dairying and horticulture), domesticity permeated the schemes' rationale, curricula, job placement strategies, physical spaces, and symbolic features. Such 'domestications of agricultural science education' accompanied British and American efforts throughout the latter nineteenth century and into World War I, particularly amid the campaigns to recruit women into the wartime 'land armies'. Trainees' potential for contributing to domestic economies – at the levels of both household and nation – remained a durable argument throughout the early advocacy of women's higher education in agricultural science. As Opitz notes, the agricultural context for women's science education provided an important means through which women entered the sciences, even as more traditional routes remained barred.

Probing a different form of gendered discourse that constructed notions of domesticity, Katy Price analyses the fictional stories and advertisements of 1920s pulp magazines in America and Britain, especially those concerned with the new wireless technologies, for determining how gendered identities were actively negotiated in relation to the home's technological surroundings. Price's chapter moves beyond standard sociological analyses of listeners' gendered experiences of radio technologies by focusing instead on popular culture's construction and deployment of gendered bodies and domestic sites. As Price shows, pulp fiction could portray radio as a disruptive or calming force within the home, whereas wireless literature cautiously promoted women's roles as wireless operators while exhibiting fears over the potential creation of unwomanly 'Marconi amazons'. Indeed, the chapter carefully attends to the construction of masculine and feminine bodies – avuncular narrators, peacetime radio salesmen, radio wives, 'wireless widows', and the like – thereby offering a more diverse set of possibilities for radio femininity and masculinity than accounted for in the sociological and historical literature.

Carol Morris and Georgina Endfield explore the theme of active negotiation of domesticity in yet a further context, specifically the contemporary amateur practice of meteorology within private homes and gardens in the UK. Similar to Paul White's attention to how Darwin both utilized and constructed his domestic environment, Morris and Endfield analyse the ways in which amateur meteorologists belonging to the Climatological Observers Link (COL) situated their meteorology within domestic settings and yet negotiated the spaces, routines, and meanings of those settings. A key finding from their study is that, despite the home's primacy among sites for observing and recording weather facts, many impediments challenged the production of climate knowledge at home. At the same time, characteristics of the domestic environment shape that very knowledge; as Morris and Endfield emphasize, 'home is where the weather is'. As such, they advance the idea of 'home-made meteorological science' as the co-construction of domesticity and science, in this case meteorology. Similar to other amateur scientific pursuits of science at home, COL members often involved their entire families in the work, illustrating once again the importance of family collaboration, and dynamics, for the progress of that work.

Familial science: Sustaining knowledge across generations and distances

The close reliance of science upon familial infrastructures was not always apparent, however. In the venerable monastic and ascetic traditions of scholarly work, there was a tendency to view the procreative family as antithetical to creative work, whereas (homo)social kinship and hierarchical loyalties were normative. However, as women made inroads into professional research in the nineteenth and early twentieth century, the husband and wife team as a collaborative unit became more common, representing a socially progressive model for family life in general, in which physical and intellectual procreation were no longer at odds. The eugenic movement amalgamated this, around 1900, in its emphasis on the importance of the procreation of the intellectually gifted (within a thoroughly patriarchal framework), and the scientific family itself became a social ideal. Historical research on families in science has mainly addressed married couples working together, but less has been said about the way families have created, maintained, and distributed academic power across generations.[23]

The contributions to this section raise a broader set of questions that explore the scientific family as both an ideal and a practice from the early twentieth century to the present day: What is the relationship between the family and the migration of knowledge and its producers? How has the family functioned so enduringly as a metaphor for scientific collaboration? How has the family as a cultural and social regime regulated scientific endeavours and their pursuit across generations? How did the family and household function in the reproduction of science? And how has the value of family with respect to science shifted across contexts?

In their contribution, Konstantinos Tampakis and George Vlahakis examine the simultaneous shaping of influential families and scientific disciplines in nineteenth-century Greece. Through a study of the Orfanidis and Christomanos families, they indicate how private relations became a context within which different forms of 'capital' in Pierre Bourdieu's sense could be produced and maintained. The family as a social community and arena was crucial for academic power as well as for the construction and reproduction of scientists' identities. Indeed, the family harnessed symbolic and cultural capital, even when different generations pursued different occupations.

Furthering the theme of generational shifts, in his contribution, Staffan Bergwik addresses the mechanisms involved in the inheritance of knowledge. In early twentieth-century Sweden, oceanographer Otto Pettersson worked hard to create an heir from his own kin that could take over the oceanographic discipline he had built. He created an infrastructure where his goals were achieved, and his son Hans became the heir. Nonetheless, transferring knowledge was a contested process. Resources were exchanged between father and son, but their relationship was marked by severe tensions. The family and the household offered resources – a place to do research, money, an academic position – yet it also obstructed Hans Pettersson's ability and will to produce independent research. As Bergwik discusses, inheritance within the family generated a conflict between repetition and originality.

In the case of the Petterssons, the family controlled a scientific household on the west coast of Sweden, which included an oceanographic laboratory. However, the family was not only an ideal among individual scholars like Otto Pettersson. It was also subject to political discussions and initiatives in the first half of the twentieth century. In his chapter, Sven Widmalm combines a case-study analysis of a scientific family with a study of state policies impinging on academic family dynamics. Societal structures of family life were debated and acted upon among Swedish politicians and reformers, and Widmalm's chapter traces the parallel development of family and research policy. The social democratic states of Scandinavia are often viewed as typical welfare regimes. Nevertheless, as Widmalm discusses, even though both family and science policy aimed to open broader labour markets for women and scientists, there were few connections between the two spheres of welfare policies. Accordingly, real change in the gender structure of science would be slow in coming. The lack of change in gender equity in the academic natural sciences is illustrated in Widmalm's empirical case, the physical chemist The Svedberg. A key player in the nascent research policies of Sweden, Svedberg was also a promoter of new and less authoritarian models for organizing laboratory work. Nonetheless, as Widmalm concludes, corresponding changes towards gender equity in Svedberg's own marriages are not discernible.

As an effect of the new and flat organization that Svedberg promoted, members of his laboratory were sometimes described as part of a 'family'. This fact points to a crucial point of departure for all the contributions to Part III: the 'scientific family' can be a legal and biological entity, but also a cultural and social unit, formed around knowledge-making practices. In her study of present-day plant scientists, Helena Pettersson explores how boundaries between legal and biological family on the one hand, and social kinship on the other, cannot be understood as *a priori*. Rather, such demarcations are culturally negotiable and a product of historical processes. In current globalized and nomadic research, social kinship is a pronounced feature of the scientific life. As Pettersson displays, scientists form 'fictive kinships' resembling paternal, avuncular, and sibling relationships. These associations have career-long implications and weave together fields, even globally.

Aalok Khandekar further develops the theme of global knowledge migrants and their relations to 'family' as idea and practice in his study of notions of 'global Indianness' among Indian 'technomigrants'. Moving in the transnational circuits of highly skilled migration, these migrants often celebrate Indian family values and traditions. Such norms are a key locus of a perceived 'authentic Indianness'. Indian engineering students and professionals live far away from local and controllable households like that of Otto and Hans Pettersson in early twentieth-century Sweden. They are not subject to national welfare policies like those discussed by Widmalm. Nevertheless, strong affective investments in the family are a prominent feature in the transnational circuits of Indian technomigration. Of course, profound transformations in the ways family life is perceived and practised has occurred over the course of the twentieth century. Nevertheless, the importance of the family is intact. As Khandekar argues, the family 'is central to the very functioning of the knowledge economy'.

Concluding remarks

In contrast to the five-volume *History of Private Life*, our single volume's treatment of the relationship between domesticity and science can be illustrative at best, too cursory at worst.[24] Indeed, as Alix Cooper remarks in the afterword, 'much remains to be explored'. As she observes, although our focus rests primarily on the modern and contemporary periods in Continental Europe, Britain, and the United States, recent scholarship has also examined earlier centuries and geographies situated beyond the 'West', especially in East Asia. Here we have posed questions that illuminate three overarching themes regarding the role of domesticity in the history of science, yet what is the takeaway? We suggest, as all of our contributors do, that domesticity – whether conceptualized as space, practice, ideology, object of enquiry – is historically inextricable from the process of scientific knowledge making, even long after the institutional laboratory has acquired emblematic status as the privileged site, 'set apart', for the controlled investigation of nature.[25] Whereas the gentlemanly 'house of experiment' may be a rarity today among the more common phenomena of homemade meteorological stations and garage laboratories, we nevertheless observe the enduring roles of domestic spaces and familial kinships in linking research communities locally and globally.

To this end, as many of the contributions of this volume show, domesticity has permeated far beyond the household, into the many other spaces, practices, social configurations, and discourses of knowledge production and distribution. Again we expose science as a collective enterprise and, seen through the conceptual lenses offered by this volume, a highly domestic one. We encourage science studies scholars to more fully explore the historiographical potential suggested in the chapters that follow, by inquiring further into the role of domesticity in the making of modern science.

Notes

1. S. Shapin (1988) 'The House of Experiment in Seventeenth-Century England', *Isis, 79*, 373–408: 378.
2. A. Cooper (2006) 'Homes and Households', in K. Park and L. Daston (eds) *The Cambridge History of Science*, Vol. 3: *Early Modern Science* (Cambridge: Cambridge University Press), pp. 224–37: 224.
3. Summarizing this argument is Cooper, 'Homes and Households', p. 237: 'With the rise of scientific academies and other such institutions in the second half of the seventeenth century, the domestic model came gradually to be eclipsed by other, more visible sites for the production of natural knowledge in specialized research facilities.'
4. P. Abir-Am and D. Outram (eds) (1987) *Uneasy Careers and Intimate Lives: Women in Science, 1789–1979* (New Brunswick: Rutgers University Press); H.M. Pycior, N.G. Slack and P. Abir-Am (eds) (1996) *Creative Couples in the Sciences* (New Brunswick: Rutgers University Press); D. Coen (2007) *Vienna in the Age of Uncertainty: Science, Liberalism, and Private Life* (Chicago: University of Chicago Press); and A. Lykknes, D.L. Opitz and B. Van Tiggelen (eds) (2012) *For Better or for Worse? Collaborative Couples in the Sciences* (Basel: Birkhäuser). On women's 'invisible' work in science, see M.W. Rossiter (1982) *Women Scientists in America: Struggles and Strategies to 1940* (Baltimore: Johns Hopkins University Press), pp. 72–4. On domestic sites considered among a range of non-academic sites in the gendering of knowledge, see C. von Oertzen, M. Rentetzi and E.S. Watkins (eds) (2013) *Beyond the Academy: Histories of Gender and Knowledge*, special issue of *Centaurus, 55* (2).
5. Advanced by political scientist James C. Scott in his analysis of Malaysian peasant resistance in the late 1970s, his categories of 'onstage' and 'offstage' can have similar applicability in scientific households: J.C. Scott (1985) *Weapons of the Weak: Everyday Forms of Peasant Resistance* (New Haven: Yale University Press), p. 25. The idea of the domestic 'threshold' separating 'private' experimental and 'public' knowledge spaces was introduced by Shapin, 'The House of Experiment', pp. 374–6. On science as a family business in the

early modern period, see L. Schiebinger (1989) *The Mind Has No Sex? Women in the Origins of Modern Science* (Cambridge, MA: Harvard University Press).

6. On historical research studying the boundary between private and public, see for instance L. Davidoff and C. Hall (1987) *Family Fortunes: Men and Women of the English Middle Class 1750–1850* (Chicago: University of Chicago Press); J.B. Landes (ed.) (1998) *Feminism, the Public and the Private* (Oxford: Oxford University Press).
7. On the dual ambition of righting some historical records and exploring gender as a relational category, see D.L. Opitz, A. Lykknes and B. Van Tiggelen (2012) 'Introduction', in Lykknes, Opitz, and Van Tiggelen, *For Better or for Worse*, pp. 1–15: 3.
8. Claire G. Jones's chapter, for instance, highlights the differential valuation of 'homemade science' performed by men and women of science, and Katy Price's chapter analyses the gendering of bodies in narratives about domestic wireless technology. An exceptional focus on the relationship between masculinity and domesticity is J. Tosh (1999) *A Man's Place: Masculinity and the Middle-Class Home in Victorian England* (New Haven: Yale University Press). Masculinity in the sciences, however, is an understudied area, promisingly redressed by the forthcoming volume of *Osiris*: E.L. Milam and R.A. Nye (eds) (2015) *Scientific Masculinities*, *Osiris, 15*.
9. See for instance S. Shapin and A. Ophir, (1991) 'The Place of Knowledge: A Methodological Survey', *Science in Context, 4*, 3–22; P. Galison and E. Thompson (eds) (1999) *The Architecture of Science* (Cambridge, MA: MIT press); D.A. Finnegan (2008) 'The Spatial Turn: Geographical Approaches in the History of Science', *Journal of the History of Biology, 41*, 369–88.
10. Finnegan, 'The Spatial Turn', p. 372; see also D.N. Livingstone and C.W.J. Withers (eds) (2011) *Geographies of Nineteenth-Century Science* (Chicago: University of Chicago Press).
11. For a fuller overview of the historiographical developments, see D.L. Opitz (2016) 'Domestic Space', in B. Lightman (ed.) *Blackwell Companion to the History of Science* (Oxford: Wiley-Blackwell), forthcoming.
12. For a broad presentation of network approaches in the history of science, see J. Golinski (1998) *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge: Cambridge University Press).
13. Among the networks examined are informal ones that radiated from such households as Mary Somerset's, Marie Dupiéry's, Jérôme Lalande's, and Charles Darwin's, as well as national ones like the COL and international ones like the Women's Agricultural and Horticultural International Union.
14. Particularly on the enduring importance of familial affections, see D.R. Coen (2014) 'The Common World: Histories of Science and Domestic Intimacy', *Modern Intellectual History, 11*, 417–38.
15. For an elaboration of the 'Big Science, Little Science' ideology shaping meanings of 'homemade' science, see D.L. Opitz (2012) '"Not merely wifely devotion": Collaborating in the Construction of Science at Terling Place', in Lykknes, Opitz and Van Tiggelen, *For Better or For Worse*, pp. 33–56: 34–5.
16. On the category of 'invisible technician', see S. Shapin (1989) 'The Invisible Technician', *American Scientist, 77*, 554–63.

17. M. Terrall (2014) *Catching Nature in the Act: Réaumur and the Practice of Natural History in the Eighteenth Century* (Chicago: University of Chicago Press).
18. On the Sachs–Darwin controversy, see S. De Chadarevian (1996) 'Laboratory Science versus Country-House Experiments: The Controversy between Julius Sachs and Charles Darwin', *British Journal for the History of Science, 29*, 17–41.
19. On Ayrton's nomination and denial, see J. Mason (1995) 'Hertha Ayrton and the Admission of Women to the Royal Society of London', *Notes and Records of the Royal Society of London, 49*, 125–40.
20. P. Abir-Am and D. Outram (1987) 'Introduction', in Abir-Am and Outram, *Uneasy Careers and Intimate Lives*, pp. 1–16: 4.
21. B. Van Tiggelen (2013) 'Agnes Pockels: The Shaping of a "*forschende Hausfrau*" ', paper presented at the 24th International Congress of History of Science, Technology, and Medicine, Manchester. For more on the gendering of the imagery surrounding Agnes Pockels and her work, see S.G. Kohlstedt and D.L. Opitz (2002) 'Re-Imag(in)ing Women in Science: Crafting Identity and Negotiating Gender in Science', in I.H. Stamhuis, T. Koetsier, C. De Pater and A. Van Helden (eds) *The Changing Image of the Sciences* (Amsterdam: Kluwer), pp. 105–139: 120–3.
22. For a review of the historiography and a revisionist perspective on domestic science, see S. Stage and V.B. Vincenti (eds) (1997) *Rethinking Home Economics: Women and the History of a Profession* (Ithaca: Cornell University Press). For the American context, particularly useful is S.A. Leavitt (2002) *From Catharine Beecher to Martha Stewart: A Cultural History of Domestic Advice* (Chapel Hill: University of North Carolina Press).
23. On the clerical tradition in science, see D. Noble (1993) *A World without Women* (New York: Alfred A. Knopf). On the interface between biomedical and cultural definitions of family and kinship, see L. Jordanova (1999) *Nature Displayed: Gender, Science and Medicine, 1760–1820* (London: Longman), pp. 161–227: 'Part III: Family Values'. On the idealization of the scientific family in eugenics, of which Francis Galton was a key proponent, see D. Kevles (1985) *In the Name of Eugenics: Genetics and the Uses of Human Heredity* (Berkeley: University of California Press), esp. pp. 3–40.
24. P. Ariès and G. Duby (eds) (1992–1998) *A History of Private Life*, 5 Vols. (Cambridge: Harvard University Press).
25. G. Gooday (2008) 'Placing or Replacing the Laboratory in the History of Science?', *Isis*, 99, 783–95: 783.

Part I

The Estate of Knowledge: Domestic Sites and Scientific Authority

1

Botanizing at Badminton House: The Botanical Pursuits of Mary Somerset, First Duchess of Beaufort

Julie Davies

In the last decades of the seventeenth century, Mary Somerset, the third Marchioness of Worcester and first Duchess of Beaufort, actively collected, identified, and classified thousands of plants from around the world. She worked with her gardener, George Adams, and several famous botanists to grow, study, catalogue, distribute, dry, and paint her specimens. Friends, family, and colleagues from both Oxford and the Royal Society of London contributed to her collection. Yet she also obtained many plants and seeds through conventional garden suppliers, and she commissioned agents to hunt down and collect specimens within the British Isles and abroad. The report of just one such shipment, received in 1696, indicates that she had hundreds of seeds, leaves, cuttings, saplings, and even several large trees shipped to her from Barbados. This particular consignment was so large that the first 11 tubs were split between five ships, with eight more promised in the next fleet. Each tub was large enough to contain, in one instance, one fern tree, seven water common trees, and one white mangrove tree, and, in another, one great bay tree and 50 saplings.[1] In this way, Somerset amassed an exceptionally large and diverse collection of plants at the family estate of Badminton House in Gloucestershire, which provided the foundation for her botanical pursuits.

Somerset's contributions to botanical knowledge have drawn limited attention until very recent years. Having lived to the impressive age of 84, Somerset passed away in January 1715, still some 20 years before the seminal works of Carl Linnaeus solidified the commonly recognized foundations of modern botanical science.[2] This chronological misfortune has contributed to the tendency to characterize Somerset as a gardener or collector of plants rather than giving her the recognition she deserves as pre-Linnaean botanist.

In her choice of discipline, Somerset foreshadows the fervour of the eighteenth century, which saw women encouraged to return to their 'natural' area of study.[3] It was thought that, by engaging herself in botanizing, a lady would become more 'favourable to reflection' as 'dispassionate reflection will turn anger into pity, and lend to sorrow itself a patience from which it may extract some portion of sweetness'.[4] Indeed, such a sentiment appears to hold some truth in this case, for it seems that Somerset's botanical pursuits were motivated, at least in part, by Joseph Glanvill. Glanvill recommended study of the natural world and, especially, training in the experimental methodologies of the Royal Society as a remedy for debilitating bouts of melancholy, which Somerset suffered from throughout the 1660s and 1670s.

The tendency to overlook Somerset's contribution to early botanical history was seemingly supported by the limitations placed on her as a seventeenth-century woman: her options as a scientific figure were limited by her gender in many typical ways. Challenged by several severe bouts of melancholy and poor health, Somerset was not of the temperament to openly challenge many of the traditional limitations placed on women in this period. Not sharing Margaret Cavendish's fiery personality and assertiveness, Somerset does not seem to have sought opportunities to publish works or teach, and she was excluded from membership of scientific organizations such as the Royal Society of London.

Even among those women hailed as important patrons and contributors to experimental science, these gendered limitations prevailed. Foreshadowing the norm which would emerge in the eighteenth century, Cavendish suggests that women are particularly suited to the role of assistant when she writes in her *Observations on Experimental Philosophy* (1666) that: 'Woman was given to Man not only to delight, but to help and assist him; and I am confident, Women would labour as much with Fire and Furnace as Men.'[5] Meanwhile, her contemporary Mary Evelyn turned her back on the philosophical engagements which inspired her friendship with Ralph Bohun, writing in 1674 that:

> Women were not born to read authors, and censure the learned, to compare lives and judge of virtues, to give rules of morality, and sacrifice to the muses. We are willing to acknowledge all time borrowed

> from family duties is misspent; the care of children's education, observing a husband's commands, assisting the sick, relieving the poor, and being serviceable to our friends, are of sufficient weight to employ the most improved capacities amongst us; and if sometimes it happens by accident that one of a thousand aspires a little higher, her fate commonly exposes her to wonder, but adds little of esteem . . . [6]

Thus, despite their different lifestyles and opinions of the new science, it appears that Cavendish and Evelyn both agreed that women had only a secondary role to play in intellectual pursuits.

By basing her work in a sphere where she did have considerable control, the family estate that she managed during her husband's frequent absences, Somerset was able to overcome these emerging beliefs about women's capacities and actively contribute to the collaborative advancement of knowledge of the natural world as advocated by the Royal Society. She not only produced copious catalogues and records for personal use, but regularly collaborated with colleagues and friends to grow, understand, identify, and classify plant specimens. She had working relationships with several significant fellows of the Royal Society including Robert Southwell, Samuel Doody, James Petiver, John Ray, William Sherard, and Hans Sloane, and she was involved in botanical projects that were reported in the Royal Society's *Philosophical Transactions*.[7] The tangible culmination of her work, which survives still in the Sloane collection in the British Natural History Museum, is her skilfully produced 12-volume herbarium.

However, in execution, the domestic setting of Somerset's operation enabled her to overcome many of the obstacles posed by the emerging gendered norms faced by women at the turn of the eighteenth century and evidently expounded by Cavendish and Evelyn. For example, while it became relatively common for women to work as assistants throughout the eighteenth century, such women typically remained spinsters or stopped working once they wed.[8] In contrast, the many extant papers, correspondences, notes, and diaries documenting her contributions clearly demonstrate that Somerset was the driving force behind this work.[9] Somerset was actively working with, overseeing, and often training the male workers in her self-funded operation, all with the full cooperation of her family.

Interestingly, Somerset's gardening became a serious botanical pursuit while the children from her second marriage, born in 1660 and 1684, were still young. Nevertheless, Somerset proceeded with the family's involvement. She conferred with her husband, the Duke of Beaufort, on designs for the garden, and she received plants, cuttings, and seeds from friends and family.[10] For a time, she shared her passion with her children, particularly her eldest son, Charles. Charles held a particular interest in his mother's pursuits and in 1673, at the tender age of 13, was the youngest nominee to be elected a Fellow of the Royal Society, a distinction he still holds.[11]

This familial cooperation seems to be the key factor that enabled Somerset to overcome any stereotypical gender restrictions and take charge of her botanical programme. Somerset's botanical endeavours also depended on both the networks and influence that accompanied a titled family and its country estate. Badminton provided many resources, including money, staff, and space necessary to house such a collection, with the Beauforts spending some £29,760 on the house and gardens by 1690.[12] In this chapter, I will analyse Somerset's botanizing at Badminton as a case in which a gentlewoman leveraged her class privilege in defiance of the emerging gender norms that typically circumscribed women's independent scientific pursuits, and how the household, including the family and the estate, played a critical role as a resource in the production of botanical knowledge.

A little family history

Mary was the second of six children born to Arthur Capel, first Baron Capel of Hadham, and Elizabeth Morrison, in 1630. Cornelius Johnson painted the couple and five of their children in 1640 (Figure 1.1). A large formal garden provides the backdrop for the portrait, reflecting the family's interests in gardening. The young Mary draws the viewer's attention by being the only figure in the painting who is provided with a prop, handing a rose from a small basket to the young child on her mother's lap.[13] This passion for plants was not, however, limited to the female line. Indeed, Mary's brother Henry, first (and last) Baron Capel of Tewkesbury, has been most widely acknowledged for his horticultural skill, having been first to cultivate a garden at a particular location in Kew, a garden which received much praise in his time and which would eventually develop into the Royal Botanic Garden.[14]

In 1648 Mary married Henry Seymour, Lord Beauchamp, and they had two children together. However, their reportedly happy and affectionate marriage ended with Seymour's unexpected death in 1654. There is little indication of Somerset's interest in gardening in this period; however,

Figure 1.1 The Capel Family, oil painting on canvas by Cornelius Johnson, *c*.1640. From left to right: Arthur Capel, Earl of Essex; Charles Capel; Arthur Capel, 1st Baron Capel; Elizabeth, Lady Capel; Henry Capel, 2nd Baron Capel; Mary Capel, Duchess of Beaufort; Elizabeth, Countess of Carnarvon.

three years later, in 1657, Mary married into another family renowned for, among other things, their gardening prowess. Mary's new husband was Henry Somerset, then Marquess of Worcester, who would, in 1682, be named the first Duke of Beaufort. The famous Somerset estate garden at Raglan Castle had been abandoned after the castle was severely damaged while under siege by the Parliamentarians in 1646, prompting the family to move to Badminton House.[15] Then, in 1664, Mary and Henry embarked upon a programme to revitalize the house and expand the gardens, a project which would help induce Mary to expand the scale of her horticultural interests.[16]

Nevertheless, the association of both families with exceptional gardening in no way guaranteed the level of support for botanical endeavour that Mary received. Henry and Mary had taken great measures to protect the Badminton Estate from Henry's parents. His father Edward, the second Marquess of Worcester had a passion for mechanical invention which brought the family near to bankruptcy in pursuit of a perpetual motion machine.[17] In contrast to Edward's money-making schemes, Mary Somerset's botany seems to have grown from a deeply emotional place, and this is likely the reason why her botanizing was embraced by her family and friends, despite the financial burden.[18] Furthermore, Somerset's personal motivations seem to have shaped her botany in several ways, and offer a viable explanation for the freedom she enjoyed to undertake her pursuits.

Melancholy

After the death of Lord Beauchamp, and during the first decades of her marriage to Henry Somerset, Mary suffered from melancholy. During the 1660s and 1670s she endured several severe bouts of a depression-like illness, with her diaries and letters giving a touching insight into her internal struggles. Indeed, the 1670s were a particularly challenging decade. Somerset's final significant bout of melancholy seems to have taken hold over her at some point in 1674. By 1675, Somerset relinquished several key aspects of the household management, including the keeping of household accounts, and she produced very little correspondence. In her biography of the couple, Molly McClain makes a convincing case that this seems to be more than an accident of survival, noting that Somerset writes in a letter from this time, that 'truly my head and stomach are so strangely disordered at all times that when I write . . . I often lose a meal for a letter'.[19] Indeed, her condition was such that Henry and several of her friends have left us records of their concern for her health.[20] To characterize Somerset as something of a paranoid melancholic with a touch of agoraphobia seems to be an extreme interpretation of her condition and resulting reluctance to stray far from the estate; this was an undeniably difficult period for the young family.[21] In an attempt to overcome her melancholy Somerset capitalized on her childhood fascination with plants and began collecting specimens for exotic botanical remedies, and she often grew plants for medicinal recipes from seeds and cuttings.[22] Then, towards the end of this period, between 1675 and 1680, Somerset's interest in plants developed into something more.[23] Under the guidance of her correspondent and client Joseph Glanvill, Somerset's search for a botanical remedy for her condition inspired an undertaking that would soon produce one of the finest living botanical collections in England.

Glanvill, then Rector of the Abbey Church at Bath, was a Fellow of the Royal Society and an active proponent of its experimental philosophy. Between 1676 and 1678, Glanvill dedicated three works to the Somerset family: *Essays on Several Important Subjects in Philosophy and Religion* (1676) to Henry; *Seasonable Reflections and Discourses in Order to the Conviction & Cure of the Scoffing, & Infidelity of a Degenerate Age*

(1676) to Somerset; and, *The Way of Happiness and Salvation Rescued from Vulgar Errours* (1677) to the couple's son, Charles.[24] As adaptations or condensed versions of Glanvill's existing publications, all three volumes shared a common theme of particular relevance to Somerset's situation. Glanvill not only defended both science and the Anglican religion in these works; he repeatedly argued that excessive melancholy leaves one vulnerable to spiritual attack and allows a variety of demonically inspired delusions to take hold. These delusions could then prompt the weak-willed to engage in any number of destructive behaviours, including enthusiasm, fanaticism, atheism, and witchcraft.[25] Glanvill also sought to demonstrate that scientific training and enquiry into the natural world, specifically using the methods advocated by the Royal Society, could help overcome such conditions. Training the mind in rational analysis, collaboration, and evidence-based interpretation of the natural world, could develop skills that would enable the melancholic to resist or break the hold of such delusions. In short, according to Glanvill, scientific training could provide an effective remedy for the melancholic state.[26] The family's high regard for Glanvill is reflected in the three appointments granted to Glanvill through the Duke's influence. Glanvill received a position as Chaplain in Ordinary in 1675, a Prebendary at Worcester Cathedral in 1678, and was nominated as Chaplain in Waiting to Charles II in 1680, though he died before he could accept this last post.[27]

Glanvill's teaching resonated with Somerset, who had concluded during this period that her malady was spiritual in nature. In the few documents that survive from this time, Somerset describes herself as feeling emotionally 'dead' and prays for God to come to her as '[her] soul thirsteth for thee as ground [for] water'.[28] Indeed, the increasingly academic nature of Somerset's interest in plants during this same period suggests that Somerset not only supported Glanvill as an Anglican apologist, but acted upon his advice. A letter from the Duchess to her husband from 1678 described a report given to her by Glanvill regarding some rumours about the investigation into Henry and the Popish Plot of that year. Though brief, the exchange confirms that Mary was in direct contact with Glanvill and that she did consider him an advisor of some regard.[29]

Overview of Somerset's botanical work and networks

The records for the Duchess's botanical collections are vast and scattered across several public and private collections in the United Kingdom, making a comprehensive count, as yet, untenable.[30] However, the draft catalogues and receipts in the British Library, upon which this analysis is primarily based, demonstrate that Somerset had hundreds of specimens in her garden and collection by the 1680s, and that by the 1690s she had well-established seed-collecting networks and several large custom-built greenhouses in which to propagate, grow, and observe her specimens.[31] Somerset had plants in her collection from all corners of the globe, and there are records of plants, cuttings, and seeds being transported from across Europe, the Americas, Africa, and the far reaches of Asia.[32] Indeed, she boasts to Sloane in a letter dated *c*.1699 that her collection had grown to well over two thousand varieties.[33]

Somerset employed several people to help her with the practicalities of expanding her collection over the years. Her gardener, George Adams, was indispensable. Her most famous employee was William Sherard, employed at Badminton for some 18 months ostensibly as tutor to Somerset's grandson.[34] She hired Sherard, once a candidate for the role of Queen's Botanist, with Sloane's assistance; she prevailed upon Sloane to convince Sherard that he would be 'contented wth a quiet life in the country'.[35] It is clear that she sought more than a tutor and impressed upon Sherard to help in her supervision of the botanical collecting and cataloguing work.[36] Sherard wrote to a colleague that he had sent 'requests to all my Botanick friends for seads . . . for her Graces garden', and that he sought connections to source more plants from Virginia on Somerset's behalf. He also commented that he planned to use one of the gardeners' skills in botanical painting for documenting the additions to the collection.[37]

Jacob Bobart, superintendent of the Physic Garden and professor of Botany at Oxford University, was in regular correspondence with Somerset and her staff. Not only did he view her collection personally and contribute many plants and seeds to it, he also facilitated the employment of Edward Lhwyd, keeper of the Ashmolean Museum at Oxford.[38] Lhwyd, whom Bobart recommends as 'a Person of great integritie & abilitie perhaps the best Naturallist in England', contributed several rare alpine specimens from Wales to Somerset's collection in 1696 and again in 1698.[39]

Despite the involvement of such iconic horticultural and botanical figures, Somerset, without a doubt, directly guided the collecting, growing, drying, describing, and identifying of the plants, and thereby orchestrated the production of botanical knowledge at Badminton.

Somerset herself drove both the creative research, which shaped the collection, and the practical work, which transformed the greenhouses and grounds at Badminton into a site for knowledge production.

Somerset's skill is often conveyed to us in the form of praise from her colleagues and peers. Among them, James Petiver described the garden as 'a Paradise' and credited Somerset with a skill for nursing plants which induce any specimen, even 'tho' from the most distant Climates', to thrive.[40] He later dedicated Table III of his *Gazophylacium* to the lady who shared with him 'many New, Rare and very curious Plants, most of them raised to that Perfection I never saw before'.[41] Her skill was also similarly acknowledged by Leonard Plukenet in his *Amaltheum Botanicum*, and by the Society of Gardeners, a Chelsea-based group of horticulturalists active from the late 1720s.[42] Although such praise may have been nominal, her correspondence and notes document Somerset's direct involvement in the activities of the garden. Bobart, for example, attested to Somerset's daily supervisions in the gardens and acknowledged the requests for plants that she sent to him 'from Her owne hands'.[43] Somerset's own words conveyed the depth of her passion for this work. In writing to Sloane, she described how she distracted herself from illness keeping 'busy w^th^ my dry'd plants', and how when finding herself 'into storys of plants' she 'know[s] not how to get out'.[44] This passion culminated in her production of the 12-volume herbarium in which she immortalized her beloved plants.

The herbarium

Somerset oversaw the production of this compendious 12-volume herbarium, now housed in the British Natural History Museum, having already provided Sloane with material for two additional volumes that form part of his own herbarium.[45] Somerset's health was deteriorating by this time and the herbarium may well be seen as an attempt to immortalize her collection before her own passing.[46] However, given the circumstances under which she turned to botany, it is interesting to note that Somerset began the compilation of the herbarium within a year of her husband's death in 1700, a loss which so quickly followed that of her son Charles, who died suddenly in a coach accident in 1698.[47] One wonders whether the herbarium was equally a memorial and way of coping with these losses. Nevertheless, her friend and mentor Hans Sloane accepted the volumes after Somerset's death in 1715, and the herbarium remains in near pristine condition – a surviving testimony of the Duchess's range of botanical skills.

The herbarium itself is not particularly well ordered. While specimens are usually dated, the order is not chronological, nor are the specimens categorized consistently by some other method. Volume I, for example, is subtitled, 'in which amongst others are the Ficus [*Mesembryanthemum*], Aloes Opu[n]tia Various Tulips, Anemones, Ranunculuses, Auriculas, Mimosas, Acacias, etc.'. Other volumes, such as volume V, are simply labelled as 'containing mostly plants from Chelsea . . . 1714'.[48] Nevertheless, many of the samples have been annotated with species identifications and references to authorities like Plukenet and John Ray. Also often included are details about the plants' native origins and dates of acclimatization.[49] The herbarium was not left idle after coming to Sloane either. Not only are many of the notations to Ray added in Sloane's own hand, indicating his attention to the volumes, but William Aiton consulted the work when compiling his *Hortus Kewensis*, in which he listed some 62 plants from the herbarium as being introduced into cultivation in England by the Duchess.[50]

The incorporation of tropical and exotic plants into the collection was enabled by the installation of a series of greenhouses and a tropical hothouse or 'orringere' at great expense in 1698–1699.[51] The hothouse appears in a painting of the estate commissioned between 1708 and 1710, which is thought to have been completed by Thomas Smith. The painting remains under the care of the family estate at Badminton House.[52] So enabled, the herbarium contains a large variety of plants which were not only difficult to cultivate in England's climate, but many expertly preserved specimens, including various sedums and other succulents, which were notoriously difficult to dry successfully, let alone with such preservation of colour and care for the aesthetic of the final result. The sheer expense of the undertaking is embodied in each detail, in particular the amount of paper involved. It is rare to find each specimen so carefully pressed between an individual cut-to-size fold of paper, then glued, sewed, or pinned onto yet another stiffer mounting sheet.[53] It is evident that much of the pressing, drying, and mounting was delegated by Somerset personally. For example, the Duchess informed Sloane that her gardener had acted as scribe in the production of the small herbarium volume she sent him (now known as HS 235 in Sloane's herbarium), but commented further that any mistakes which had been made were both hers and his together for 'neither hee nor I understande latine so that I feare wee have commited many faults'.[54] Other letters demonstrate the seriousness with which her staff received such instructions. A letter from William Orem to George Adams details the great lengths to which this agent went so that he might secure a worthy order of new plants for Somerset's collection.[55] This correspondence reveals the level of Somerset's managerial instruction.

Knowledge production

Somerset's papers, correspondence, catalogues, and herbarium demonstrate the fact that the activities at Badminton went well beyond both collection and gardening challenges. These sources show Somerset and her staff actively engaged in the compilation, analysis, and discussion of botanical and horticultural references. In addition to the numerous annotated lists of plants, her catalogues are accompanied by legends that explain her system of abbreviating the titles of her references.[56] Somerset referred to a wide range of significant contemporary texts, including many that Carl Linnaeus referred to when developing his new taxonomical system, including Johann Bauhin's *Historia plantarum universalis* (1650–1651), Caspar Bauhin's *Theatri Botanici* (1671), Charles Plumier's *Description des plantes de l'Amérique avec leurs figures* (1693), and Joseph Pitton de Tournefort's *Elemens de Botanique, ou method pour connoître les Plantes* (1694).[57] The impressive list of resources Somerset referenced also included works by several other botanists of note, including multiple works by Robert Morison (1620–1683), Leonard Plukenet (1641–1706), Paul Hermann (1646–1695), and of course Sloane and Ray.

The Duchess often independently consulted, compared, and analysed the botanical sources, having the Latin translated for her when her basic comprehension fell short. Historian Douglas Chambers identified lists of plants from Rivinus and Tournefort as items translated for Somerset, likely by Sloane, who is noted as the translator of one of the many lists recording which seeds had been sown that year.[58] However, Somerset has added the Latin names to several list of seeds, originally identified only by common names, indicating that she did have at least some basic level of ability with the language.[59] Sloane's papers also contain lists of Latin vocabulary pertinent to describing characteristics of plants and summary tables of botanical terminology.[60] One such item is a four-columned table of plants from, it is noted, Scottish botanist Robert Morison's alphabetical table of plants. This list of Latin plant names is not in Somerset's hand, but she did add the common names beside many of the items.[61] Not only do such notes demonstrate her familiarity with many Latin terms, but they also show her engagements with the chief tasks of the botanist: the collection, identification, classification, and description of plant specimens, and the recording of their native habitats and conditions of growth.[62] Far from a mere consumer of traditional botanical sources and knowledge, Somerset, as with her collection, used her family's wealth and influence to carry out her research and share her resources and findings.

Somerset's regular receipt of the Royal Society's journal, the *Philosophical Transactions*, was quite unusual for a woman, and a testament to the respect and favour with which the fellows accorded her.[63] She often consulted the volumes, which she had bound with the assistance of John Beale, FRS, Somerset clergyman and colleague of Joseph Glanvill. References from the *Transactions* appear numerous times in her notes. Her correspondence informs us that she received the volumes from Sloane during the 1690s, and that she continued to receive them well into the next decade, having arranged binding for another batch in 1706.[64]

Somerset's receipt of the volumes likely came through her son Charles. Other than his early botanical interests, which earned him election to the Society's fellowship, Charles did not show much further interest in scientific study. Though he corresponded with the Society's secretary, Henry Oldenburg, in the years after his election, it does not seem that Charles attended meetings or made any other contributions to the Society. His letters with Oldenburg were essentially conversational, consisting of reports of curiosities and goings-on at the Society meetings.[65] His sole scientific contribution seems to have occurred through his mother. Evidently he lent Somerset one of his travel books, so that she could research the plants of Tobago described therein.[66] Following Charles's sudden death, Mary thanked Sloane for continuing to send her copies of the *Transactions*.[67] According to the Royal Society's Journal Book (26 November 1701), Charles's son Henry (1684–1714) was then proposed as candidate by Robert Southwell. However, Henry was not awarded Charles's fellowship.[68] Henry had come into Mary's care after elected to the and it was Henry's need for a tutor that had enabled the employment of William Sherard. Yet evidently, Mary, Sloane, or some as yet unknown agent, had been able to facilitate Mary's unusual, yet continued subscription to the *Transactions*, despite her ineligibility for membership and despite her grandson's failed candidacy. These circumstances reflect the importance of the connections made through family members and colleagues for sustaining her independent botanical pursuits.

Mary Somerset was not the only woman to have some interest or involvement in the Society. Samuel Pepys famously reported on Margaret Cavendish's visit there in 1667.[69] Indeed, Cavendish, Katherine Jones, Mary Evelyn, and Margaret Flamsteed, like Somerset, participated within intellectual circles that included several Royal Society fellows.[70] Although it is unknown whether any of these women shared Somerset's interest in the Society's journal, Flamsteed and Evelyn would most certainly have had access to volumes of the *Transactions* through their husbands. However, Somerset stands out among these contemporary women in both the pride she took in her ownership of the journals and in the direct evidence of her academic engagement with them. Not only are there no females listed as authors in the *Transactions* prior to the twentieth century, but it is also noteworthy to have evidence of a woman from this period working directly from the journal in the manner seen in Somerset's notes.[71]

Cavendish and Jones were both involved in correspondence with those savants who were members of the Society (and its predecessor at Gresham College) in the 1650s and 1660s, much earlier than Somerset. Cavendish's relationship with the Society was far from congenial, which was the result of well-recognized disagreements over fundamental philosophical principles.[72] However, Jones and, later, Flamsteed both made some contributions to the scientific output of the Society. Several of Jones's recipes were published in Thomas Willis's *Pharmaceutice Rationalis (Part 1)* (1684) and Robert Boyle's *Medicinal Experiments* (1692).[73] Flamsteed is credited with the making of several observations and calculations throughout her husband John Flamsteed's astronomical notebooks.[74] However, in each case, the contributions of these women had been subordinated to the interests of their male colleagues, and they were much more limited in scope when compared to Somerset's output.[75] In contrast, various associates and Fellows of the Society actively sought Somerset's skill and resources, and she herself actively sought to contribute new knowledge to the botanical corpus.

Unimpeded by a lack of resources or a partner's research agenda, Somerset trawled through travel books and descriptions of foreign lands, searching for descriptions of plants that she then requested from her contacts. Some of these books can be identified, for example, Simon de La Loubère's *A New Historical Relation of the Kingdom of Siam* (1693), the first book of Charles de Rochefort's *The History of the Caribby-Islands* (1666), Garcilaso de la Vega's *Royal Commentaries of Peru* (1688), and François Froger's *A Relation of a Voyage Made in the Years 1695, 1696, 1697, on the Coasts of Africa* (1698).[76] For this project she produced lists of 'Things I would have', and she later reported on the unsuccessful search for an alternative variety of bay tree that she believed would be found on Barbados.[77] A letter was also sent attempting to procure a whole nut from the Cacao tree, as Somerset evidently had 'a great desire to try whether it be possible to raise [one] in England'.[78] However, the identification of new specimens with which to expand her collection was only part of this ongoing process of comparison. Not only are Somerset's lists and catalogues filled with references noting when a plant in her collection is included in a work, she also made regular notes when specimens could not be found in any of her books.

The analysis that Somerset, and at times her staff, undertook when comparing items from her collection to descriptions in reference works was detailed and productive. A sugar apple and a bixa were just two specimens included on one of Somerset's lists of 'plants I can find no figures of in any of my books . . . therefore to be described as they grow now at Badminton 1693'.[79] Lists such as this demonstrate that Somerset was engaging in the discipline of phytographia, or plant description and taxonomy, still one of the main branches of botany today. Not only had Somerset made some brief notes about the history of this discipline, but it seems to have been one of her chief botanical interests.[80] Indeed, an unsigned letter draft (not in Somerset's hand) records Somerset's complaints about the difficulties identifying plants by name, given the numerous systems and conventions then in use.[81]

To identify her specimens, and when her books failed her, Somerset consulted with her correspondents, most notably Sloane and Bobart.[82] When she sent Sloane one of the early volumes of specimens, she did so with the request that he send her any corrections identified by figure number so that she might correct her catalogues.[83] A further list, dated 1702, gave a series of plant descriptions of newly identified plants in Somerset's collection which had been 'sent to Dr Sher[ard]', indicating that they continued to correspond after his departure from her service sometime after 1700.[84] However, Somerset remained an independent thinker, and while accepting others' guidance and advice, she sometimes argued her case when she found a particular classification, identification, or description to have been incorrect.[85] She noted when she disagreed with an identification made by her gardener Adams.[86] She also noted errors that she identified in her books, on one occasion judging John Parkinson's *Theatrum Botanicum* (1660) as outright 'false'.[87] Even the information provided by botanical heavyweight Plukenet underwent careful cross-checking and verification, with Somerset noting that, while he described a particular variety of acacia well, his description 'wants the number of prickles that mine has'.[88] Although Somerset did not actively publish material of this nature, her analyses suggest that she otherwise contributed to the communal body of botanical knowledge through her correspondence and by allowing visits to the estate gardens.

Badminton House and estate

Badminton House itself provided an important focal point for the botanical pursuits of Mary Somerset and her colleagues. Though she rarely left the estate's familiar surroundings, she was often sought out for her expertise.[89] Southwell, Sloane, and Bobart are all known to have sent Somerset unidentified seeds for her assistance in growing and identifying the specimens.[90] In 1694, Bobart sent her one such packet of seeds that the East India Company had given to the Royal Society.[91] Sloane also recruited Somerset to raise a crop of medicinal plants on behalf of 'the College', or the Royal College of Physicians.[92] In this way, she lent the space and resources of Badminton for the benefit of the Royal Society and the College, for example, the hothouses that some of the plants required for their growth. Badminton House also drew all manner of botanical expertise to its doors.[93] Ray, Bobart, and Petiver all visited the site to access specimens, both living and dried, in the extensive collection.[94] Somerset hosted a number of noted botanical artists as well, including Daniel Frankcom and Everard Kickius, both of whom painted several specimens from the collection.[95] Leonard Knyff and Thomas Smith also immortalized the gardens and grounds in their depictions.[96]

Somerset's botanical endeavours were literally built into the extensive grounds surrounding her home at Badminton House in the form of both gardens and glasshouses. Utilizing her family's wealth and influence, she was able to fill these structures with exotic plants bought from local merchants or specially transported from around the world. Her husband's estate supplied her with the gardeners and assistants crucial to the pursuit of both practical and intellectual aspects of her botanical endeavours. The estate also enabled Somerset to fill her library with reference works which ensured that her investigations were both valuable and current. The family's willingness to grant Somerset such extensive use of their resources, despite the misfortunes of the previous generation's endeavours, speaks to the Somersets' passion for the work and the pleasure they drew from it.

Somerset provides us with a valuable case study, giving us insight into both personal and intellectual aspects of her life. Her very personal motivations and her use of botany to overcome emotional challenges foreshadow the future characterization of botanizing as an ideal, healthful pursuit for women. Yet, simultaneously, her correspondence with her suppliers and academic contacts gives us another perspective on the practices, interests, and pursuits of several of the most notable figures associated with immediately pre-Linnean botany. While Somerset's gender undoubtedly shaped the nature of her contributions to botanical knowledge and limited her ability to engage directly with the premier institutions, her case demonstrates how the academy still benefited from the vast resources and goodwill of aristocratic homes in the pursuit of activities aimed directly at the production of botanical knowledge. Somerset's gender and social status has also influenced the attention she has been given in the history of botany: her home-based, horticultural experiments and research being largely overlooked. However, as interest in the early history of the Royal Society, the role of women in scientific development, and scientific activity outside the academy all continue to increase, Somerset's most excellently preserved herbarium and extensive archive will no doubt prove an invaluable resource for improving our understanding of all these aspects of the emerging botanical sciences.

Notes

1. Letter from J. Weir, 26 July 1696, British Library, London, MS Sloane (hereafter MS Sloane) 3343, fol.270.
2. The two works often credited with solidifying the taxonomical systems and procedures of plant naming which prompted the solidification of botanical science were C. Linnaeus (1737) *Critica botanica* and C. Linnaeus (1753) *Species Plantarum*; see W. Stearn (1971) 'Sources of Information about Botanic Gardens and Herbaria', *Biological Journal of the Linnaean Society, 3*, 225–33: 229.
3. E. Kent (1829) 'Considerations on Botany, as a Study for Young People . . . ', *The Magazine of Natural History and Journal of Zoology, Botany, Mineralogy, Geology, and Meteorology, 1*, 124–35: 132.
4. William Withering, Jr. (1830) *An Arrangement of British Plants* (Birmingham), pp. xxxviii–ix, as quoted in E. Dolan (2008) *Seeing Suffering in Women's Literature of the Romantic Era* (Aldershot: Ashgate), pp. 107–8.
5. M. Cavendish (1666) *Observations on Experimental Philosophy* (London) pp. 102–3; F. Harris (1997) 'Living in the Neighbourhood of Science: Mary Evelyn, Margaret Cavendish and the Greshamites', in L. Hunter and S. Hutton (eds) *Women, Science and Medicine, 1500–1700: Mothers and Sisters of the Royal Society* (Stroud: Sutton Publishing), p. 210.
6. M. Evelyn to R. Bohun, 4 January [1674], in W. Bray (1859) *Diary and Correspondence of John Evelyn*, 4 Vols. (London: Bohn), Vol. 4, pp. 31–2, as quoted in Harris, 'Living in the Neighbourhood', p. 213.
7. Somerset was related to both William Brereton, the first president of the Royal Society, and Robert Boyle, through her marriages.
8. Indeed, very much a family affair, botanical training came to be seen as a useful means through which to teach the skills of motherhood: A. Shteir (1996) *Cultivating Women, Cultivating Science: Flora's Daughters and Botany in England, 1760 to 1860* (Baltimore: Johns Hopkins University Press), pp. 4, 76–7. However, into the nineteenth century, the majority of contributions by

women were made in their capacity as assistants or subordinated to institutional projects: M. Creese (1998) *Ladies in the Laboratory? American and British Women in Science, 1800–1900* (Lanham, MD: The Scarecrow Press), p. 367. See also E.B. Keeney (1992) *The Botanizers Amateur Scientists in Nineteenth-Century America* (Chapel Hill: University of North Carolina Press), pp. 69–82.

9. The two significant collections are housed at Badminton House and the British Library. The British Library catalogues still attribute many of her items to the Duke: D. Chambers (1997) ' "Storys of Plants": The Assembling of Mary Capel Somerset's Botanical Collection at Badminton', *Journal of the History of Collections, 9*, 49–60: 59 no. 15. I have confirmed this by comparing the handwriting of documents in the British Library with a document obtained from Badminton estate: M. Somerset to H. Somerset [1678], Badminton Muniments, Badminton House, Gloucester (hereafter Bad. Mun.), FmE 4/1/6.
10. M. McClain (2001) *Beaufort: The Duke and his Duchess, 1657–1715* (New Haven: Yale University Press), pp. 116, 121.
11. Though formally nominated by John Hoskins, Charles's fellowship was evidently the result of negotiations undertaken by his tutor, Edward Chamberlayne: A.R. Hall and M.B. Hall (eds) (1965) *The Correspondence of Henry Oldenburg*, 13 Vols. (Madison: University of Wisconsin Press), Vol. 10, pp. 16, 85.
12. J. Munroe (2011) ' "My innocent diversion of gardening": Mary Somerset's Plants', *Renaissance Studies, 25*, 111–23: 112. For examples of the accounts which reflect Mary's ongoing expenditure on plants see the unpublished list of tulips bought from Mr Piereson, September 1692, MS Sloane 4070, fol.75; M. Gillythrow, unpublished account for garden supplies, [n.d.], MS Sloane 4071, fol.108; unpublished account for garden supplies, 1696, MS Sloane 4071, fol.234.
13. C. Horwood (2007) *Potted History: The Story of Plants in the Home* (London: Frances Lincoln), p. 37.
14. B.D. Henning (1983) 'Capel, Hon. Henry (1638–96), of Kew, Surr.', in B.D. Henning (ed.) *The History of Parliament: the House of Commons 1660–1690* (London: The History of Parliament Trust), http://www.historyofparliament online.org/volume/1660-1690/member/capel-hon-henry-1638-96, date accessed 17 September 2014; H. Durant (1973) *Henry 1st Duke of Beaufort and his Duchess, Mary* (Pontypool: The Griffin Press), p. 35.
15. E.H. Whittle (1989) 'The Renaissance Gardens of Raglan Castle', *Garden History, 17*, 83–94: 85.
16. Munroe, 'Innocent Diversion', p. 112; McClain, *Beaufort,* pp. 92–3; Chambers, 'Storys', p. 51.
17. Edward had some successes with a new water pump, but ultimately he put the family fortune at great risk, and Henry was forced to seek legal rejoinders to prevent his father selling off lands. On the water pump see A.P. Usher (1929) *A History of Mechanical Inventions* (New York: Dover Publications), pp. 343–7. On the range of family disputes see: McClain, *Beaufort*, pp. 13–5, 37, 94, 132. The basic design for the Marquess's perpetual motion machine can be found in: G. Hiscox (1904) *Mechanical Appliances: Mechanical Movements and Novelties of Construction* (New York: Norman W. Henley), p. 366.

18. Despite being valued at over £40,000, the 99-year monopoly awarded over the 'water-commanding' engine seems to have come to naught: Usher, *History*, p. 344.
19. McClain, *Beaufort*, p. 118, n. 33.
20. McClain, *Beaufort*, pp. 118–19.
21. For an example of this stronger interpretation see: McClain, *Beaufort*, p. 89.
22. McClain, *Beaufort*, pp. 118–20.
23. According to Chambers, she started collecting in the 1690s: Chambers, 'Storys', p. 49. She began growing herbs and plants in her garden to make homeopathic medicines, her recipes for which have also survived: McClain, *Beaufort*, p. 118.
24. This work was published in three versions: J. Glanvill (1670) *The Way of Happiness Represented in its Difficulties and Incouragements, and Cleared from Many Popular and Dangerous Mistakes* (London: James Collins/London: Gedeon Schaw). Glanvill (1671) *The Way to Happiness Represented in its Difficulties and Incouragements, and Cleared from Many Popular and Dangerous Mistakes* (London: Gedeon Shaw); and J. Glanvill (1677) *Way of Happiness and Salvation Rescued from Vulgar Errours* (London: James Collins).
25. J. Davies (2012) 'Preaching Science: The Influences of Science and Philosophy on Joseph Glanvill's Sermons and Pastoral Care', in M.K. Harmes, L. Henderson, B. Harmes, and A. Antonio (eds) *The British World: Religion, Memory, Society, Culture* (Toowoomba: University of Southern Queensland), pp. 375–88: 382–5.
26. For a more extensive discussion of these arguments, see Davies, 'Preaching Science', pp. 375–88.
27. Glanvill's name appears on the list of Chaplains in Waiting for 1681. However, his name was crossed out, presumably after his unexpected death from fever in November 1680: National Archives, Kew, Records of the Lord Chamberlain LC3/24, fol.14.
28. M. Somerset, unpublished diary, Bad. Mun. FmF 1/6/1/ f.10v, as quoted in McClain, *Beaufort*, pp. 119–20.
29. M. Somerset to H. Somerset, undated [1678], Bad. Mun. FmE 4/1/6.
30. There is a significant amount of correspondence supplemented by many accounts, receipts, orders, and draft versions of Mary Somerset's various catalogues of her collection in the Sloane Manuscripts at the British Library. A detailed summary can be found in McClain, *Beaufort*, pp. 219–21.
31. Horwood, *Potted History*, p. 36.
32. MS Sloan 3343 and 4071 alone contain references to plants received from Yorkshire, Wales, Oxford, and Camden (British Isles); Nuremburg (Free Imperial City); Leiden and Amsterdam (Dutch Republic); Rome and Sicily (Italy); Paris and Montpellier (France); Spain; Madeira and the Portugal mainland; Candia (Crete); Persia; China; India; Surinam; both the East and West Indies; the Straits of Magellan; the Cape of Good Hope; Barbados (Jamaica); and the British Colony of Virginia
33. M. Somerset to H. Sloane, 19 February [no year], MS Sloane 4061, fol.1.
34. The exact dates of Sherard's employment are not given, but he is clearly in Mary Somerset's employ on 21 September 1700 when he writes to a colleague on her behalf: W. Sherard, 21 September 1700, MS Sloane 4063, fol.44. See

also J. Dandy (1958) *The Sloane Herbarium* (London: Trustees of the British Museum), p. 210.

35. McClain, *Beaufort*, p. 211; Series of letters from M. Somerset to H. Sloane, [*c*.1699–1700], MS Sloane 4061, fol.3, 5, 7, and 9.
36. M. Somerset to H. Sloane, 19 February [no year], MS Sloane 4061, fol.1.
37. W. Sherard, 21 September 1700, MS Sloane 4063, fol.44. The correspondent was likely James Petiver, FRS, a London apothecary. The list of contributors to the garden includes George London, gardener to William III, Robert Southwell, Richard Bradley, Samuel Doody, Henry Hyde, second Earl of Clarendon, and Mary's brother-in-law, Captain Robert Knox. For details see the unpublished papers of the first Duke and Duchess of Beaufort, MS Sloane 3343 and MS Sloane 4071.
38. J. Bobart to G. Adams, 4 February 1696, MS Sloane 3343, fol.142.
39. Unpublished list of plants, June 1696, MS Sloane 3343, fol.117; unpublished list of plants, July 1698, MS Sloane 3343, fol.119.
40. J. Petiver (1692–1703) *Museum Petiverianum* (London) no. 890 and J. Petiver (1710–1712) 'An Account of Divers Rare Plants', *Philosophical Transactions, 27*, 375–94: 392; Dandy, *Sloane Herbarium*, p. 210.
41. Petiver (1702) *Gazophylacium Naturæ & Artis* (London), Vol. 1, p. 7; and Petiver, *Museum Petiverianum* (London), no. 94, as quoted in Dandy, *Sloane Herbarium*, p. 210.
42. Leonard Plukenet (1705) *Amaltheum Botanicum* (London); Society of Gardeners (1730) *Catalogus Plantarum* (London), p. vii; Dandy, *Sloane Herbarium*, p. 210.
43. J. Bobart to G. Adams, 28 March 1694, MS Sloane 3343, fol.37; J. Bobart to G. Adams, 4 February 1696, MS Sloane 3343, fol.142.
44. M. Somerset to H. Sloane, 19 February [no year], MS Sloane 4061, fol.1, 15.
45. Mary Somerset gifted two volumes to Sloan for his herbarium: Natural History Museum, Botany Library, HS 66 and HS 235. The specimens therein are dated 1701–1714. Dandy suggests that much of the compilation happened after the Duchess's death on 7 January 1714; however, more recent sources place her death in January 1715: Dandy, *Sloane Herbarium*, pp. 210–1. See also Sloane 4061, fol.19 for a letter from Mary Somerset to Sloane regarding the volume of pressed plants she gave to him, which is now part of the Sloane Herbarium: HS 235.
46. Somerset was herself, by 1700, suffering from deteriorating health and struggling 'to master the weakness of old age': M. Somerset to H. Sloane, 19 February [no year], MS Sloane 4061, fol.1.
47. McClain, *Beaufort*, p. 198.
48. Dandy, *Sloane Herbarium*, p. 211.
49. Dandy, *Sloane Herbarium*, p. 211.
50. For a convenient list of the plants from Mary's herbarium that appear in this work see Dandy, *Sloane Herbarium*, pp. 212–14.
51. One account indicates that the orangery and stable at Chelsea were constructed together and costed £140 for the carpentry alone, giving an indication of the expense involved in their construction; see MS Sloane 4071, fol.197.

52. M. Laird (2006) '"Perpetual Spring" or Tempestuous Fall: The Greenhouse and the Great Storm of 1703 in the Life of John Evelyn and His Contemporaries', *Garden History, 34*, 153–73: 164–5.
53. I am here indebted to Mark Spencer, curator of the Botany Library at the British Natural History Museum, London, who generously guided me through several volumes of the herbarium.
54. M. Beaufort to H. Sloane, 19 December [no year], MS Sloane 4061, fol.19.
55. W. Orem to G. Adams, 6 August 1695, MS Sloane 4071, fol.242.
56. For examples see M. Somerset, List of books referred to in accompanying catalogue, unpublished, 1699, MS Sloane 4070, fol.79; Unpublished lists of books of plants referred to in accompanying catalogue, 1699, MS Sloane 4072, fol.210.
57. For a summary of the relationship of these people and their works to Linnaeus, see W. Stearn (1958) 'Botanical Exploration to the Time of Linnaeus', *Proceedings of the Linnaean Society of London, 169*, 173–96.
58. Unpublished list of figures from *Philosophical Transactions*, [n.d.], MS Sloane 4071, fol.243–6; Chambers, 'Storys', p. 57.
59. Unpublished list of seeds sent by H. Sloane [24 November 1699], MS Sloane 3343, fol.97; Chambers, 'Storys', p. 57. For a further example see: unpublished notes in multiple hands, [n.d.], MS Sloane 4072, fol.27–31.
60. The undated vocabulary list at MS Sloane 4070, fol. 199 is in Somerset's own hand, while the undated table of Classes of different Species of Plants found at MS Sloane 4072, fol.177–8, seems to have been drawn up for her.
61. Unpublished notes in multiple hands, [n.d.], MS Sloane 4072, fol.27–31.
62. Stearn, 'Botanical Exploration', pp. 192–4; Stearn, 'Sources', esp. pp. 228, 230.
63. Munroe, 'Innocent Diversion', pp. 114–5; Chambers, 'Storys', p. 50.
64. For examples see: unpublished list of figures from *Philosophical Transactions*, [n.d.], MS Sloane 4071, fol.79; unpublished notes on the *Philosophical Transactions*, 1694, MS Sloane 4072, fol.188–9; draft of letter from Badminton to Mr. Gosline regarding Beale and the binding of the *Transactions*, 18 July 1706, MS Sloane 3343, fol.115. Dated only 10 July, one letter mentions the orangery, which was built at Badminton 1698–1699, and the health of her husband in 1700. The letter must therefore have been written in either 1669 or 1700; M. Somerset to H. Sloane, 10 July [*c.*1700], MS Sloane 4061, fol.26r.
65. For the correspondence between Charles Somerset and Oldenburg, exchanged during Somerset's travels on the Continent from 1673–1675, and before his military career, see Hall and Hall, *The Correspondence of Henry Oldenburg*, Vols. 10 and 11.
66. M. Somerset, unpublished list of plants wanted, [n.d.], MS Sloane 4071, fol.163–4.
67. M. Somerset to H. Sloane, 10 July [1699/1700], MS Sloane 4061, fol.26.
68. The Royal Society (2014) 'Somerset; Charles (1660–1698); Marquess of Worcester', *The Royal Society Archive of Past Fellows*, <https://royalsociety.org/library/collections/biographical-records/> (home page), date accessed 17 September 2014; The Royal Society (1701) *Journal Book* 1696–1702, entry dated 26 November 1701, JBC/9 as quoted in The Royal Society (2014) 'Somerset, Henry (1684–1714), 2nd Duke of Beaufort', *The Royal*

Society Archive of Past Fellows, <https://royalsociety.org/library/collections/biographical-records/> (home page), date accessed 17 September 2014.

69. S.I. Mintz (1952) 'The Duchess of Newcastle's Visit to the Royal Society', *The Journal of English and Germanic Philology, 51*, 168–76.
70. All these women are the subject of contributions to chapters in Hunter and Hutton, *Women, Science and Medicine*.
71. D. Atkinson (1996) 'The "Philosophical Transactions of the Royal Society of London," 1675–1975: A Sociohistorical Discourse Analysis', *Language in Society, 25*, 333–71: 368, n. 7.
72. S. Hutton (1997) 'Anne Conway, Margaret Cavendish and Seventeenth-Century Scientific Thought', in Hunter and Hutton, *Women, Science and Medicine*, p. 223; E. Keller (1997) 'Producing Petty Gods: Margaret Cavendish's Critique of Experimental Science', *ELH*, 64, 447–71: 447–8.
73. L. Hunter (1997) 'Sisters of the Royal Society: The Circle of Katherine Jones, Lady Ranelagh', in Hunter and Hutton *Women, Science and Medicine*, p. 191.
74. R. Iliffe and F. Willmoth (1997) 'Astronomy and the Domestic Sphere: Margaret Flamsteed and Caroline Herschel as Assistant-Astronomers', in Hunter and Hutton, *Women, Science and Medicine*, p. 249.
75. Hunter suggested that several women who were involved in the scientific activities of the Royal Society in the years surrounding its formation were increasingly and actively excluded from the proceedings and studies as it strove to establish its legitimacy. However, Hunter based this on a misquoted disparaging of 'Ladies' Chemistry' in a letter by John Beale, which, in the original, actually reads 'the vulgar Art of Lady-Chymistry'. As such, this letter represents a disparaging of an anthropomorphized representation of chemistry and bears no relation to chemistry as practised by ladies: Hunter, 'Sisters of the Royal Society', p. 188.
76. M. Somerset, unpublished notes, [n.d.], MS Sloane 3343, fol.33; [Author unknown], unpublished notes on roots and plants taken from the Royal Commentaries of Peru, [n.d.], MS Sloane 4072, fol.179–80, 229. Other lists of 'Bookes that give an accounte of plants but have no figures' can be found in Sloane 4071, fol.310–11.
77. Mary Somerset's contact, Mr Weir, writes to her from Barbados, 26 July 1696: 'you writ for 2 sorts of bay trees, the bay tree with the round leafe and the bay tree with the long leafe but I can find noe such thing in this Island': Sloane 3343, fol.270.
78. Unpublished notes on plants wanted by the Duchess of Beaufort, [n.d.], MS Sloane 4071, fol.110.
79. M. Somerset, unpublished descriptions of plants that grow at Badminton where no figures have been found in books, [1693], MS Sloane 4070, fol.74.
80. M. Somerset, unpublished research notes, [n.d.], MS Sloane 4071, fol.111v.
81. Unpublished notes on plants wanted by the Duchess of Beaufort, [n.d.], MS Sloane 4071, fol.110. This issue was only resolved in the mid-eighteenth century by Linnaeus: Stearn, 'Sources', p. 229.
82. For examples see Munroe, 'Innocent Diversion', p. 119, citing Sloane Herbarium, HS 235; Chambers, 'Storys', p. 57; M. Beaufort to H. Sloane, 23 September [no year], 4061, fol.17. See also M. Somerset, unpublished

descriptions of plants, [after April 1693], MS Sloane 4071, fol.139, for the discussion of the 'Amba-paja' and 'Phisick Nut' of Surinam, thought by Bobart to be a 'Rinnus' plant.

83. M. Somerset to H. Sloane, 19 December [no year], MS Sloane 4061, fol.19.
84. M. Somerset, Unpublished notes on plants sent to W. Sherard, 1702, Sloane 4071, fol.236–9.
85. Munroe, 'Innocent Diversion', pp. 120–1.
86. Munroe, 'Innocent Diversion', p. 166; M. Somerset, unpublished descriptions of plants, [n.d.], MS Sloane 4071, fol.142.
87. For an example a list of errors, see M. Somerset, Unpublished research notes, MS Sloane 4070, fol.38. For a reproduction of MS Sloane 3349, fol.1, which refers to an error in Parkinson, see the figure in Chambers, 'Storys', p. 51.
88. M. Somerset, Unpublished research notes, MS Sloane 4070, fol.42.
89. On Mary's reclusive tendencies, see McClain, *Beaufort*, p. 118.
90. S. Brown and J. Petiver (1701) 'An Account of Part of a Collection of Curious Plants and Drugs, Lately Given to the Royal Society by the East India Company', *Philosophical Transactions, 22*, 579–94: 579; M. Somerset, list of seeds received from Mrs. London, August 1694, MS Sloane 3343, fol.58; unpublished notes in multiple hands, [n.d.], MS Sloane 3343, fol.130–1; M. Somerset, unpublished notes, [n.d.], MS Sloane 3343, fol.273; M. Somerset to H. Sloane, [n.d.], MS Sloane 4061, fol.23.
91. J. Bobart to M. Somerset, 28 March 1694, MS Sloane 3343, fol.37. Some of the results of these activities are listed in M. Somerset, unpublished notes, [n.d.], MS Sloane 3343, fol.120–1. The findings of this experiment are then reported in Brown and Petiver, 'An Account', p. 579.
92. Somerset delayed the delivery of the plants on the grounds that too few have 'blown', indicating that she was expected to return the plants to the College: M. Somerset to H. Sloane, 13 December [1699], MS Sloane 4061, fol.21. She then sent him samples of the leaves as she waited for the plants to mature and flower: M. Beaufort to H. Sloane, 10 July [1700] Sloane 4061, fol.25–6. A letter to Sloane from Edward Strother, a physician and member and licentiate of the Royal College of Physicians, referred to that institution as 'the College', supporting this identification: H. Sloane to E. Strother, [n.d.], MS Sloane 4061, fol.136.
93. Stearn, 'Sources', pp. 225, 231–2.
94. Dandy, *Sloane Herbarium*, pp. 214–5; J. Petiver (1713) 'Botanicum Hortense III', *Philosophical Transactions, 28*, 177–221: 204; J. Bobart to M. Somerset, 28 March 1694, MS Sloane 3343, fol.37.
95. Dandy, *Sloane Herbarium*, p. 212; McClain, *Beaufort*, p. 213. For a discussion of the importance of botanical art to the development of the botanical sciences see G. Saunders (1995) *Picturing Plants: An Analytical History of Botanical Illustration* (Los Angeles: University of California Press).
96. See J. Kip and L. Knyff (1720) *Britannia Illustrata* (London), Figures 9–12; Chambers, 'Storys', pp. 53–4; McClain, *Beaufort*, p. 196.

2
Gender and Space in Enlightenment Science: Madame Dupiéry's Scientific Work and Network

Isabelle Lémonon

Translated by Laurent Damesin

'Dear fellow chemist . . . I picture thee surrounded by papers and work', Antoine-François Fourcroy wrote in 1799 to Mme Dupiéry.[1] Who was this woman addressed by the well-known academician as a fellow chemist? What was she working on? And where did she work? So many questions raised by a single sentence by an eighteenth-century male savant, addressed to a woman of whom we know very little. How does this specific case fit the distinction between professional/institutional and amateur/domestic typical of how some modern historiography interprets the gendering of scientific knowledge? According to this dichotomized interpretation, women who took part in scientific endeavours are not considered producers of knowledge, but mere auxiliaries, supporting male savants from the domestic space where they seem confined, without entitlements to affiliations with learned, scientific institutions – these being the preserve of men of science. This assumed emphasis on exclusion from the institutional and professional sphere persisted, even amid women's growing involvement in public scientific life during the Republic of Letters and the Enlightenment.[2]

Over the last 20 years, the historiography has increasingly focused on the spaces of knowledge production, particularly the household. It has highlighted women's contributions made from within domestic spaces (the household and salon) without further institutional recognition, although sometimes with financial compensation.[3] Indeed, two recent studies have pointed to cases of women who received institutional, financial compensation for the scientific work they did. Monika Mommertz has established that, in the case of the Kirch family, the production of calendars was carried out by the whole family – Gottfried, astronomer and academician, his wife Maria Margarethe, and their four children – from within their home, for the benefit of the Berlin Academy.[4] The academy made payments to Mme Kirch, and later on to her daughter Christine, after Gottfried's death. Kirch and her children carried out observations and produced the calendars distributed under the aegis of the academy. In this case, the academic institution subcontracted astronomical duties to a woman and her children, who worked for pay from home. Likewise, Mary Terrall highlighted the extent of Hélène Dumoustier's work at the Hôtel d'Uzès, Réaumur's private mansion.[5] The sketches and natural studies she did for Réaumur were remunerated by the Académie des sciences in Paris from 1736 onwards, and she received upwards of 8,750 livres over 11 years.[6] Although she claimed that her commitment to science was out of pleasure, not out of necessity, as was expected of women, her example nevertheless blurs the boundary between amateur and professional knowledge production. Are these just marginal cases in a broader context of knowledge production in eighteenth-century France? Even if the Paris Academy did not, as an institution, recognize women working from home, by making them associates or granting them membership, it did rely on their external collaborations. These women became savants by proxy, whenever the institution called upon them; as such, it is crucial to document their roles in knowledge production, and to build upon a rich historiography that challenges simplistic gendered stereotypes and advances our understanding of the dynamics of knowledge production at the interface of several spheres during the Enlightenment.[7]

Parallel roles existed in the economic and commercial spheres, such as those examined by Liliane Hilaire-Pérez and Dena Goodman, respectively in the business of tin and silk.[8] Likewise, in their study of eighteenth-century colonial Quebec, Benoît Grenier and Catherine Ferland showed that the role played by women (whether wives or sisters) in commerce typically assumed those of men in their absence.[9] As they often had to travel over prolonged periods of time, the men entrusted their wives or sisters with their household and business affairs by giving them powers of attorney. These women were therefore considered to have served as 'deputies', possessing, in most cases, the same power as their spouses or brothers.

In this chapter I will show that, when it comes to the production of scientific knowledge, a number of women in Enlightenment France worked on the margins of knowledge-producing institutions, conducting their activities from the confines of their homes, or those of their male collaborators. For their collaborative work, these women often earned an income, and they sometimes became independent managers of savant enterprises, very much like those businesswomen in Quebec who served as economic managers of their households. I examine here the case of Mme Dupiéry.[10] In my investigation, I analyse her spaces of knowledge production and the types of knowledge therein produced, so as to better understand Dupiéry's various roles. The chapter explains how she developed a scientific and institutional network that, over the long term, provided her with intellectual and financial independence. It will show to what extent a woman in eighteenth-century France could intertwine institutional and domestic production, and how the dynamics of knowledge production operated between these two spheres.

Jérôme Lalande and his human computers

Mme Marie Louise Elisabeth Félicité Dupiéry (1746–1830) is one of the female astronomers known to us thanks to the astronomer Jérôme Lalande (1732–1807). In his works, he refers to her, mentioning his admiration for the 'best-educated woman' he knew, and he dedicated his book, *Astronomie des Dames*, to her.[11] Other than these fleeting mentions and the short biography he wrote about her, very little is known about this 'savant sister' of Lalande.[12] Even standard dictionaries of female scientists have based their sketches on the information provided by Lalande.[13] However, hitherto neglected, unpublished archival sources reveal Dupiéry's personal history, her role alongside Lalande, and the scientific network that she developed as a result of her association with him.

In 1759, as a member of the Académie des sciences, Lalande was put in charge of compiling the *Connaissance des Tems*, among the oldest published astronomical ephemerides, having been in publication every year under the aegis of the Paris Academy since 1679.[14] Lalande wished to include tables for the moon's distances, useful to navigators for calculating their longitude when at sea. In order to create these tables on a tight, recurring publication schedule, Lalande surrounded himself with many human computers, as Simone Dumont described:

> In June 1775, Lalande settled in an apartment in the new building of the Collège Royal. He was happy to live in this vast edifice where

> he could provide accommodations for his assistants, live alongside them, and accelerate their progress. According to Delambre, Lalande picked the brightest students and gave them room and board for a modest sum, and his household became a kind of seminary from which a great many disciples graduated.[15]

The French astronomers Jean-Baptiste Delambre, Pierre Méchain, and Michel Lefrançois de Lalande are among those who started their careers working as computers for Lalande. These well-known students worked alongside lesser-known computers, some of whom corresponded with Lalande, either in France (Honoré Flaugergues, Anne Jean Pascal Duc-Lachapelle) or from abroad (Baron von Zach, the Duchess of Gotha). Others still were valued by Lalande because of their mathematical disposition, including Mmes Dupiéry, Nicole-Reine Lepaute, and Marie Jeanne Lefrançois de Lalande, his niece-in-law.[16] The space where the computing took place was, in this case, not gender-specific, as both men and (a few) women took part in the practice. His household thus became a place for learning the sciences and producing knowledge. For the purpose of this chapter, I focus only on Dupiéry, whose work in the calculus workshop marks her entry into a savant life. This computing household was active from 1763, when Lalande was put in charge of the *Ephémérides des mouvemens célestes*, until at least 1793.

The issue of sources

There is no shortage of primary sources concerning the scientific life of Lalande's more famous students, such as Méchain or Delambre. However, the same cannot be said for lesser-known computers like Julien Rivet or Dupiéry. Rivet, practically unheard of nowadays, was trained as a geographical engineer and, as such, his scientific career did leave a paper trail in the archives.[17] Dupiéry, on the other hand, had no access to institutions of learning. A gender effect, differentially shaping how men's and women's astronomical knowledge was transmitted and used, has ensured any trace of Dupiéry's education and work is rather faint. In order to recover her activities, I have conducted a systematic investigation of Lalande's primary sources, and his correspondence proved quite crucial. Thirty-six of his letters have provided clues for tracking vital records about Dupiéry, such as real estate and financial transactions, notary public records, her holographic will, and a post-mortem inventory, unfortunately incomplete. There are also five autographed letters by Fourcroy, and a letter from François-Jean Baudouin, publisher at the Institut de France, focusing on the financial agreement she made during her collaboration with Fourcroy in chemistry. This close study of Lalande's archives provides us with an in-depth accounting of Dupiéry's productions.

The spaces of knowledge production of Lalande and Dupiéry

Jérôme Lalande frequented several intellectual circles: he was part of the institutional scientific community, due to the positions he occupied at the Académie des sciences, then the Institut de France, the Collège Royal, the Paris Observatory, and the Bureau of Longitudes. He played a major part in freemasonry circles where he created the Loge des Neuf Sœurs in Paris, and he helped found the Grand Orient de France, of which he was a Grand Master.[18] He developed a wide correspondence network with foreign academies in Berlin, London, and St Petersburg of which he was a member, as well as with local academies in Béziers, Montauban, and Dijon.[19] He regularly frequented places of political power, including the English court, where he was granted an audience with the King on 19 May 1788, the court of the Duke and the Duchess of Gotha, to whom he was close, the French court (mainly during the 1760s and 1770s), and the court of Bonaparte, around 1797. He moved in high society circles and was a noted visitor at Mme Geoffrin's salon and the Paris Opera.[20]

Lalande's personal spaces of scientific knowledge production, which were accessible to Dupiéry while the two were associates, included the observatories where he worked (especially the one at the Collège Royal between 1779 and 1790) and his household (at the Collège Royal).[21] We know that observatories were institutional places where families also resided: the domestic and institutional spheres intermingled, and women often carried out observations. Thus, in his observation diary, Philippe de La Hire mentions that, between 19 August and 21 September 1683, his daughter (most probably Catherine Geneviève), then aged 13, had already made observations of the moon at the Paris Observatory, while he was away in Flanders.[22] Likewise, a century later on 11 June 1794, Jérôme Lalande mentioned in his journal: 'This observation was made by Cnne Lefrançois', his niece-in-law.[23] It is therefore possible that Dupiéry developed her skills as a computer at the beginning of her 'career' at any of Lalande's workplaces – the Collège Royal, his household, his observatory – or her own home.

Letters indicate that, from 1780 and at least until 1791, Dupiéry lived in Paris at 8 Rue Thévenot, about a half an hour's walk from the Collège

Royal in Place Cambrai. Her home, already likely the site of her astronomical computations for Lalande, also served as a public classroom, as she taught astronomy there from 1789 to 1790. By 1793, she was living at 3 Place Cambrai, right next to the Collège Royal, and during that year she acquired a two-storey house in Mareil-en-France, outside of Paris. She moved into the house during the months of revolutionary violence known as 'The Terror', her most likely motivation for relocating.[24] Judging from the floor plan of the house, she could situate her computing work in adequate, dedicated space. In the ensuing years, Dupiéry's 'astronomical' ties to Lalande seemed to have weakened, and she gave up astronomical calculations for the sake of pursuing chemistry and entomology. (Meanwhile, Amélie Lalande assumed a larger role in assisting with her uncle's and husband's observations and calculations.)[25] Beset with financial difficulties, Dupiéry was forced into obtaining employment in Eaubonne as tutor to the Gohier family, with whom she temporarily lived.[26] In 1806, she returned to Mareil-en-France, and then, from 1811 onwards, she settled permanently in Luzarches, in a two-storey house with an attic, that she bought.[27] The property, consisting of four rooms on the ground floor and three more on the first floor, held a library of 486 volumes, 'most of which are scientific books, especially astronomy, chemistry, botany, and the rest is literature'.[28] Dupiéry also had two globes (one celestial and one terrestrial), world maps, drawing and painting sets, a herbarium, and an insect collection.

Even when Dupiéry's activities were confined to the domestic sphere, her contributions to knowledge production were translated, through a male savant (Lalande or Fourcroy, as detailed further below), into the institutional sphere. Dupiéry thus collaborated in a dynamical system of knowledge production that lay within, and moved between, domestic and institutional spheres.

Types of knowledge produced

We know nothing of Dupiéry's early education. She was the daughter of Marie Angélique Félicité d'Hostel du Perron and André Pourrat de la Magdeleine, head of aides at the Ferté Bernard by 1746.[29] (Aides in eighteenth-century France were indirect royal taxes on beverages, handled by the Ferme générale, or corporation of tax farmers.) She then married Alexandre Colin Dupiéry in 1770; he also worked in the tax farming system.[30] Thus, Dupiéry may have spent part of her childhood and her married life around accounting books. It would be interesting to know if she had a tutor or attended school, but unfortunately the extant records are silent about her early education.[31] When she became a widow in 1780, according to the state records she did not own any technical device or books about astronomy.[32] Nevertheless, she studied astronomical calculus in the autumn of 1779 under Jérôme Lalande's 'guidance'; he wrote her in October from the countryside town of Bourg-en-Bresse: 'It is unfortunate that your studies in astronomy were cut short: however, you probably know Orion and Sirius, which rise before you set.'[33] Not only did Dupiéry study astronomy and the related mathematics, but she also carried out astronomical observations.

Unknown in Parisian scientific circles a few years before, she became involved in producing knowledge by collaborating with Parisian men of science. Only very few sources document Dupiéry's scientific work, but they are testimonies of her considerable endeavours. In 1782, Lottin published her astronomical tables, along with a brochure, entitled *Explication des tables de la durée du jour et de la nuit, pour la latitude de Paris, à chaque jour de l'année, calculées par Madame Du Pierry*.[34] The same tables were also published in the *Ephémérides des mouvemens célestes* (1785–1794), edited by Lalande. Dupiéry, 'as keen as she is knowledgeable and witty', as Lalande observed, produced work that was 'the result of rigorous computations which she undertook so as to achieve greater precision'.[35] Contemporary reviews in the *Journal des sçavans* and the *Mercure de France* pointed out that Dupiéry was one of the 'expert computers, much appreciated by astronomers' who took part in Lalande's work.[36] She was also known for her gift for drawing. She sketched a portrait of Leonhard Euler in 1785, based on a medal sent to the Paris Academy by the St Petersburg Academy. Her portrait was reproduced in the 1786 French edition of Euler's *Introduction à l'analyse des infiniments petits*. She also drew portraits of William Herschel and French astronomer Alexandre-Gui Pingré. Lalande also used a refraction table in *Connaissance des Temps* for 1791, based on schematics completely designed by Dupiéry.[37]

During this period, Dupiéry became active in chemistry. In 1786, Fourcroy published the second edition of his *Eléments d'histoire naturelle et de chimie*, for which Dupiéry designed the table of contents. According to Fourcroy, she did this with 'such care, such precision and patience, the likes of which I am not capable'.[38] He also used his female friend's competencies in chemistry for at least the two further editions.[39] Significantly, she produced the *Table alphabétique et analytique* for Fourcroy's five-volume *Système des connaissances chimiques*, published in 1801. This table differs from *Eléments d'histoire naturelle et de chimie* as it sorted chemical matters alphabetically, in accordance with the new nomenclature. Its production required Dupiéry's familiarity with all five volumes of Fourcroy's work, and a solid grasp of the modern nomenclature established by Messrs Louis Bernard Guyton de Morveau, Antoine Lavoisier, Claude Louis Berthollet, and, of course, Fourcroy.[40]

These scientific contributions are just a few of Dupiéry's works. Others include her assistance with a table of sunrises and sunsets at Bourg-in-Bresse for 1785; a study in 1791 of the moon's movements over more than a century, extrapolated from Pingré's manuscript of *Annales célestes du dix-septième siècle*; and *Une table du nonagésime* sent to the Academy in Béziers.[41] In 1801, she also worked with Baudouin, on a study of insects, which likely included mounting and drawing specimens, as a letter from Lalande suggests: 'I got your receipt for Baudouin, but he told me he sent you the creatures I tasked myself to get from him, so I could not give him your receipt without further instructions from you.' In addition, Dupiéry's post-mortem inventory lists an 'insect or butterfly collection', and 'four cartons containing unclaimed drawings, supposed to be the work of the deceased'.[42] Pierre-André Latreille, in his *Encyclopédie méthodique des insectes*, referred to one of her drawings of a butterfly, the Piéride du réséda (Bath White, or Pontia daplidice): 'Mme Dupiéry has painted one that is even more remarkable than the two previous ones, found in Luzarches, department of Seine et Oise.'[43] She also wrote several hitherto unknown manuscripts, for example, 'a dictionary of astronomy commented by the late Delambre'.[44]

Mme Dupiéry's roles in the production of scientific knowledge

If Dupiéry is at all known nowadays, it is for her astronomical computations for Lalande, providing data for the *Ephémérides des mouvemens célestes*. Nevertheless, her role in Lalande's endeavours cannot be reduced to her position as a computer, which was the task of many of Lalande's students. She would also check other students' computations as well as keep a close eye on their pace of work whenever Lalande was absent, just as Mme Lepaute did before her.[45] Dupiéry could therefore be considered a trusted astronomical aide in the employ of Lalande – all the more so, as he used her skills to check and proofread his own work, before sending it off to the print shop.[46] While he was away on business, Lalande put her in charge of his affairs, domestic and scientific, including his correspondence with fellow astronomers. She had one of Lalande's keys, granting her access to all of his documents.[47] She was an observer who carried out astronomical observations, though in an unofficial capacity. My portrait of Dupiéry is not that of a skilled computer only in charge of carrying out long and tedious computations – as Jérôme Lamy or Peggy Kidwell described this role in the nineteenth century – but rather of a technician to whom Lalande 'devolved the whole responsibility for managing and recording experiments' as defined by Steven Shapin.[48] More than this, she was an associate, or as Lalande suggested, a 'savant fellow sister', in charge of his day-to-day astronomical workshop, based in his lodgings.[49]

Thanks to her knowledge and skills in astronomy, she taught a course 'aimed mostly at women . . . whom a lack of education and some leftover backwardness have prevented from studying the exact sciences', which was made up of 24 sessions: 18 of these for lessons, and the rest spent on astronomical observations.[50] Unfortunately, there is no information regarding the number and characteristics of the students, but the persistence of the classes until 1790 suggests it attracted significant enrolments.[51] The advertisement for the course in the *Journal de Paris* clearly stated, in keeping with gender conventions, that 'it is in no way a Savante attempting to teach a thorough course in astronomy' as Dupiéry 'knows how important still it is for people of her gender to avoid the ridicule of claiming to be able to do so . . . . These are edifying conferences which she offers.'[52] The course's purpose was clear: to alleviate women's ignorance of astronomy, in order to do away with 'preconceptions and mistakes which bring dishonour to even the conversation of people in society'. The content of the sessions covered diurnal and annual movements, latitude and longitude, Kepler's laws, interplanetary distances, calendars, drawings of the planets, the plurality of worlds, the universal law of attraction, and the occurrence of tides. Such a record of the programme of an astronomy course by a woman in eighteenth-century Paris is extremely rare; it provides us with much information regarding her knowledge and competencies. Unfortunately, we do not have all the course material, which would have enabled us to establish a precise comparison with an astronomy course open to a male audience, and taught by a male savant.[53] This latter sort of public course was commonplace in the eighteenth century, and famous savants such as Jean Antoine Nollet (in physics) or Guillaume François Rouelle (in chemistry) taught them over several years.[54] At around the same time, Mme Sophie Grandchamp also taught such a course in Paris.[55] As I have already pointed out (see the section, 'The spaces of knowledge production of Lalande and Dupiéry'), Dupiéry herself worked as tutor and scientific writer. Such callings provide testimony of women's roles as savants, as carried out in their households. They also demonstrate women were well aware of the gendered constraints and difficulties they had to overcome in order to play a role in knowledge production.

By 1785, as mentioned, Dupiéry worked intensively with Fourcroy. She worked at home, then would, from time to time, go over to Fourcroy's home to discuss the problems that she encountered when drawing the tables, as indicated in this letter: 'I know that you write down your problems in your little notebook and that you will show up one of these mornings [*letter torn*] of these notes .... You will always find me glad to see you, to [*letter torn*] your doubts ... grateful to hear your thoughts.' He also entrusted his 'dear associate, Mme Du Piéry, the author of an analytical table for a great chemistry book' and 'fellow female chemist' with getting this table printed with Baudouin. Baudouin sent her the necessary leaflets for her to complete and return, so her work could be printed.[56] The homes of Dupiéry and Fourcroy thus served as spaces for producing knowledge in chemistry, as was the case with Lalande's in astronomy before. This knowledge would then be translated into institutional space, by means of presentations at the academies, for instance. The same can be said of Dupiéry's complementary activities when, for instance, she collected specimens for herbariums, including two for Lamarck.[57] She also drew plants and insects, as mentioned by Latreille and her will.[58]

Mme Dupiéry's income as a knowledge producer

Did Dupiéry's home-based knowledge receive any recognition from scientific institutions? One indicator of institutional recognition would be receipt of financial compensation. Dupiéry became a widow in 1780, and at that time she was financially independent thanks to her dower and several annuities.[59] For the period between 1746 and 1780, she led a comfortable life at home. Later, a mention by Lalande suggests that part of her resources did come from her scientific work. Thus, in May 1793, he wrote to her: 'the sunnier it is, the more fun it will be, and the ants and wildlife will increase your resources'.[60] The exchanged correspondences with the publisher, Baudouin, through Lalande, suggests she may have been commissioned to illustrate further insects and plants for publication, beyond the butterfly for Latreille, as discussed.[61] However, the lack of archival records leaves open to speculation the full range and nature of her income during this period.

Extant manuscripts are more informative about the subsequent period. In 1793, she took out a loan to buy her house in Mareil-en-France, which she paid back over 16 years, but she afterwards bought more land in Mareil-en-France in 1806. Where did she obtain her income? Guy Boistel, writing about Jérôme Lalande, provided clues: 'By giving his students the possibility of carrying out paid computations for Antoine Darquier, the Parisian astronomer made it possible for the more modest of his students to overcome the financial obstacle to studying.'[62] Likewise, the money given by the Académie des sciences to Lalande towards the completion of *Connaissance des Tems*, that is, around 1,600 francs, was split between the various computers, and it is likely that Dupiéry also received her share.[63] In 1801, Fourcroy wrote to her regarding the financial agreement with Baudouin for the analytical chemistry table she designed: 'I remember well our verbal agreement according to which you would receive the sum of 50 French Louis for the book, and that the work it represents is worth at least that.'[64] Therefore, her chemical work did result in some form of financial compensation. During this period she also endured financial hardship, which pushed her to work as a tutor and shun astronomy. Economic and financial archives show that, prior to 1806, she invested money on several occasions in the public debt.[65] Her investment generated, in 1811 for instance, over 500 francs per annum, to which should be added an extra 550 francs in life annuities for the sale of her house in Mareil-en-France, and the return on 10 shares in the tontine Lafarge invested in her name.[66] Of course, part of that income went towards paying back the existing loan and further loans she took out; in 1813, she bought two houses in Luzarches, north of Paris.[67] Four years before she passed away, she had finished paying back these loans and would receive, in total, a yearly pension of over 800 francs in life annuities and investments.

The only document concerning a financial agreement that I have uncovered in the case of Dupiéry was the one made with Baudouin, though such agreements were probably widespread in the eighteenth century. I have been fortunate to document two further cases, that of Mme Tigny, widow of Martin Grostête of Tigny, the naturalist, and that of Amélie Lalande, niece of Jérôme Lalande and wife of astronomer Lefrançois de Lalande. Tigny drew up an analytical table of contents for the first 30 volumes of *Annales de chimie* for, according to a contract, 1,350 francs, spread out over two years, extended by the editorial committee.[68] As for Amélie Lalande and her husband, they were promised, by their uncle, an annual pension of 5,000 francs for work they jointly performed in astronomy.[69] In all of these cases, the production of scientific work in the domestic space was subject to a financial 'contract' with one or more representatives of the institutional sphere, constituting a form of outsourcing. The case of Miss Dumoustier and Réaumur, as laid out by Mary Terrall, presents a similar configuration. Their examples strongly demarcate roles for the institutional and domestic spheres in the dynamics of science in the eighteenth century: the institutions of knowledge outsourced production to the domestic sphere, with the products returned to the institutional sphere. Knowledge production arose from a back-and-forth exchange between these two spheres.

Mme Dupiéry's savant network

All these women who worked primarily within the domestic sphere but produced knowledge for scientific institutions were 'funded' by members of the Paris Académie des sciences. How did these women develop and conduct their relationships with such institutions? To which networks did they connect and belong? In this section, I will address these issues in the case of Dupiéry.

Before meeting Jérôme Lalande in 1779, Dupiéry was totally absent from the Parisian scientific sphere; it would therefore seem that Lalande introduced her to it. As discussed in the section 'Mme Dupiéry's roles in the production of scientific knowledge', he commended, acknowledged, and honoured her in a variety of his published works. By 1784, she was also named as an astronomy computer in both the *Journal des sçavans* and the *Mercure de France*.[70] Lalande presented her to colleagues such as Delambre, Méchain, Lefrançois, and he spoke of her during his visits abroad to colleagues such as the Baron von Zach and Caroline and William Herschel.[71] But such commentary was not simply mere social flattery by Lalande, for it provided long-standing social and 'scientific' connections for Dupiéry.[72] For instance, Delambre, after Lalande's death, corrected a manuscript in astronomy that she penned. Around the 1790s, Dupiéry's initial network of savants, focusing on astronomy, and grafted on Lalande's, subsequently shifted to chemistry, centred on Fourcroy. The list of savants who knew her, paid her visits, and sent her gifts grew considerably. In addition to the names mentioned, there were also two female savants: Mme Lalande, a computer and Jérôme Lalande's niece-in-law, and Mme Tigny, working in botany and chemistry.[73]

As was the tradition in the eighteenth century, this savant network was intertwined with wider intellectual circles. Dupiéry enjoyed associations with prestigious members of Parisian salons, including, for example, Mme Dubocage, writer, member of several academies, and hostess of her own Paris salon.[74] Clearly, Dupiéry was fully integrated into the savant world of her time but within the limits laid down for women: she had no institutional position.[75] Despite this exclusion, savants regularly paid her visits, corresponded with her, and appreciated her contributions.

Although lacking institutional affiliation in Paris, she was nevertheless elected to other regional and foreign learned societies. Lalande mentioned in his correspondence and books that she was a member of the scientific academies in Béziers, Montauban, and Richmond.[76] A precedent to this was Mme Lepaute's associate membership in the Béziers academy, as documented in the membership list for 1766 (which also listed Lalande as an associate member). Within the Academy of Montauban, Dupiéry was sponsored to become a corresponding associate by Duc de la Chapelle, a former student of Lalande, in April 1799 (less than a year after Lalande's own nomination).[77] Finally, the Academy of Virginia (in Richmond) in 1788 asked the Paris Académie des sciences, via Alexandre Marie Quesnay de Beaurepaire, to serve as its patron.[78] A corresponding committee, of which Lalande and Fourcroy were members, was formed to oversee the recruitment of foreign associates on the Continent. In September 1788, a list was established, and the statutes of the academy were presented to its members. The Paris academy supported the project but, unfortunately, it was swept away by the French Revolution. The list presented to the academy does not contain Dupiéry's name. There is no doubt, however, as to Dupiéry's institutional recognition by provincial academies as a savant in her own right, despite her being 'seemingly absent' from the Paris Académie des sciences, the Collège Royal, and the Paris Observatory.

Dupiéry also received recognition for her domestic production of scientific knowledge by a different type of institution: freemasonry. In 1785 and in 1787, Lalande invited her to take part in meetings at the Société d'Emulation at Bourg-en-Bresse, with a presentation of her astronomical computations for that town. He was one of the founders of this secret, freemasonry society.[79] At the time, quite a few savants were members of lodges, and women could meet within adoptive lodges. Was Dupiéry part of one of these? Although the sources document the Société d'Emulation's acknowledgement of her computational skill, they are otherwise silent on the question of her membership.

Conclusion

The case of Mme Dupiéry enables us to reveal another example of the strong demarcation between the domestic and institutional spheres in the production of knowledge in eighteenth-century France. I have shown that these two spheres enjoyed a dynamic interaction that contributed to the knowledge typically attributed to those formally affiliated with institutions. It was an integrated system. The spatial localization of knowledge production has always been diverse, and among these diverse places, households are essential in the study of the geography of knowledge. The back and forth between these spaces, furthermore, renders visible the 'technicians' who took part in this savant enterprise, and yet who are not recognized as savants. Understanding this dynamic establishes the significant and too often invisible role of women.

As far as the eighteenth century is concerned, domestic production was under the authority of the paterfamilias, and the hierarchy within the household was not always mapped according to gender. Indeed, most of male savants, such as Lavoisier, Réaumur, or Lalande, spent a great part of their time producing knowledge at home. They also occupied institutional spaces where they could share, publicize, and develop science. Although one cannot find women in such institutional roles, domestic spaces were used both by men and women to produce knowledge, under the authority of a male patron. Moreover, as the case of some of Lalande's male students (for example, the little-known 'Faro') shows, 'obscure' computers who were never well known outside of the astronomer's household shared women's lack of recognition in the institutional sphere. It is thus not gender here that made a difference in being acknowledged, but the confinement of one's activity within the domestic sphere. Preventing women from more institutional involvement was principally their lack of education – typically a gendered issue, even though many men were also confronted with this challenge. Despite this obstacle, Dupiéry took on, from her own home or the home of her protector Lalande, the roles of astronomical computer, scientific manager, critic, teacher, tutor, writer, specimen collector, and illustrator. All the while, she also carried out the duties of a middle-class widow in the eighteenth century: managing her household and finances, and participating in social calls. She even maintained both her private and intellectual life from within her home through politically and financially troubled times.

Despite her academic expertise and intellectual acumen, she nevertheless achieved little institutional recognition. Savants around her may have expressed their admiration of her abilities and achievements, and she may have been well known to a great many of them, yet the historiography has remembered her simply as a human computer, applying an algorithm without having command of its demonstration, and as among the first female astronomy teachers in Paris. By situating Dupiéry within a broad, integrated system of domestic and institutional knowledge production, this chapter demonstrates how savants limited to the domestic sphere, including women, were able to contribute in significant ways to the production of knowledge managed by formal institutions. Analysis of the relationships between, and knowledge making within, these intertwined spheres, which themselves cannot be simply reduced to households vis-à-vis institutions, reveals female savants working within domestic spheres to be far from marginal in the production of knowledge during the French Enlightenment.

Notes

1. A.F. Fourcroy to M. Dupiéry [n.d.], 1799, Memorial Library Special Collections, University of Wisconsin-Madison, Cole Collection of Chemistry [hereafter 'Cole Coll.'], MS 34. On Dupiéry's vital statistics, see Etat civil, Archives Départementales du Val D'Oise [hereafter 'ADVO'], 5Mi 223. All translations from French sources are by Laurent Damesin.
2. On these themes, see, for example, M. Terrall (1995) 'Gendered Spaces, Gendered Audiences: Inside and Outside the Paris Academy of Sciences', *Configurations, 3*, 207–32; D. Noble (1993) *A World without Women* (New York: Alfred A. Knopf); A. Cooper (2006) 'Homes and Households', in K. Park and L. Daston (eds) *The Cambridge History of Science*, Vol. 3: *Early Modern Science* (Cambridge: Cambridge University Press), pp. 224–37. One should note the Italian exceptions whereby several women did achieve institutional recognition by Italian universities and academies, such as Laura Bassi, Mme du Châtelet, and Maria Gaetana Agnesi in the seventeenth and eighteenth centuries; see P. Findlen (1993) 'Science as a Career in Enlightenment Italy: The Strategies of Laura Bassi', *Isis, 84*, 441–69; M. Cavazza (1997) 'Minerva e Pigmalione: Carriere femminili nell'Italia del Settecento', *The Italianist, 17*, 5–17; and M. Mazotti (2007) *The World of Maria Gaetana Agnesi, Mathematician of God* (Baltimore: The John Hopkins University Press).
3. About the role of women in the salon, see A. Lilti (2005) *Le monde des salons: Sociabilité et mondanité à Paris au XVIIIe siècle* (Paris: Fayard).
4. M. Mommertz (2005) 'The Invisible Economy of Science: A New Approach to the History of Gender and Astronomy at the Eighteenth-Century Berlin Academy of Sciences', in J.P. Zinsser (ed.) *Men, Women, and the Birthing of Modern Science* (DeKalb: Northern Illinois Press), pp. 159–78.
5. M. Terrall (2014) *Catching Nature in the Act: Réaumur and the Practice of Natural History in the Eighteenth Century* (Chicago: University of Chicago Press).
6. At the time, the average wage of a factory worker was less than 1 livre per day.
7. Particularly for the Enlightenment period, see especially P. Bret and B. Van Tiggelen (eds) (2011) *Madame d'Arconville, Une femme de lettres et de sciences au siècle des Lumières* (Paris: Hermann); Zinsser, *Men, Women, and the Birthing of Modern Science*; and P. Fara (2004) *Pandora's Breeches: Women, Science & Power in the Enlightenment* (London: Pimlico).
8. L. Hilaire-Pérez (2008) 'Steel and Toy Trade between England and France: The Huntsmans' Correspondence with the Blakeys (Sheffield-Paris, 1765–1769)', *Historical Metallurgy, 42*, 127–47; D. Goodman (2009) 'Marriage Choice and

Marital Success', in D.I. Kertzer and M. Barbagli (eds) *Family and State in Early Modern Times, 1500–1789* (New Haven: Yale University Press), pp. 26–61.

9. B. Ferland and C. Grenier (2013) '"Quelque longue que soit l'absence": procurations et pouvoir féminin à Québec au XVIIIe siècle', *Clio*, no. 37, 197–225.
10. For further examples, see I. Lémonon (2016) 'Les femmes et la Philosophie Naturelle dans l'Europe des Lumières: architectes, ouvrières ou passeuses du savoir?' PhD thesis, École des hautes études en sciences sociales, Centre Alexandre Koyré, Paris, forthcoming.
11. J. Lalande (1786/1817) *Bibliothèque universelle des dames Astronomie* (Paris: Ménard et Desenne); J. Lalande (1803) *Bibliographie astronomique* (Paris: Imprimerie de la République), p. 937; and J. Lalande (1785/1820) A*stronomie des dames* (Paris: Ménard et Desenne).
12. Lalande to Dupiéry, 3 July 1794, in J.C. Pecker and S. Dumont (eds) (2007) *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, Vol. 1: *Lalandiana* (Paris Vrin), UR 17.
13. F. Briquet (1804) *Dictionnaire historique, littéraire et bibliographique des françaises et des étrangères naturalisées en France* (Paris: Treutel and Wurtz), p. 397; L. Alquié de Rieupeyroux (1893) *Anthologie des femmes écrivains poètes et prosateurs depuis l'origine de la langue française jusqu'à nos jours* (Paris: Bureau des causeries familiales); A. Rébière (1897) *Les femmes dans la science: Notes recueillies par* (Paris: Nonie and Cie); M. Ogilvie and J. Harvey (eds) (2000) *The Biographical Dictionary of Women in Science: Pioneering Lives from Ancient Times to the Mid-20th Century*, 2 Vols (London: Routledge); J.P. Poirier (2002) *Histoire des femmes de science en France* (Paris: Pygmalion); G. Chazal (2006) *Les femmes de sciences* (Paris: Ellipses).
14. For recent works on Jérôme Lalande, see especially S. Dumont (2007) *Un astronome des Lumières: Jérôme Lalande* (Paris: Vuibert); and G. Boistel, J. Lamy, and C. Le Lay (eds) (2010) *Jérôme Lalande (1732–1807): Une trajectoire scientifique* (Rennes: Presses universitaires de Rennes).
15. Dumont, *Un astronome des Lumières*, p. 120.
16. See the correspondence between Baron Von Zach and Jérôme Lalande, Archives de l'Observatoire de Paris, MS 1090.
17. Biographical notice of Julien Rivet, Archives de l'Académie des Sciences, inscriptions et belles-lettres de Toulouse (AA), 80015, VIII-1(M); J. Lamy (2005) 'L'observatoire de Toulouse de 1733 à 1908: entre savoir et pouvoir', *Cahiers d'histoire et de philosophie des sciences*, no. 54, 135–52.
18. L. Amiable (1897) *Une loge maçonnique d'avant 1789: les Neuf Sœurs* (Paris: F. Alcan).
19. Regarding Béziers, Lalande became a member of the academy before 1766; see Louis XV, *Etat des personnes que le Roi a nommées pour composer l'Académie Royale des Sciences et Belles Lettres dont sa Majesté a autorisé l'établissement dans la ville de Béziers par ses lettres patentes du présent mois*, July 1766, Archives de l'Académie de Béziers, Archives départementales de l'Hérault, D232. In the case of Montauban, registers indicate that he became a member in 1800: Duc La Chapelle, *Registre des assemblées ordinaires de la section des sciences et arts mécaniques*, session on thermidor 15th year VI (2 August 1798), Collection of the Academy of Montauban, Archives départementales du Tarn-et-Garonne [hereafter 'ADTG'], 2J1 14.

20. Lalande to Dupiéry, 3 July 1794, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 17; Dumont, *Un astronome des Lumières*, p. 325.
21. Lalande to Dupiéry, 3 July 1794, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 17; Dumont, *Un astronome des Lumières*, pp. 64–5, 325.
22. P. de La Hire, Observation Diary, Observatoire de Paris, D2-1. I thank Guy Picolet for bringing this diary to my attention.
23. J. Lalande, Observation Diary, Observatoire de Paris, C5:12.
24. Anon. (1789) 'Cours d'astronomie', *Journal de Paris*, 30 April 1789, 549–50; anon. (1789) 'Cours', *Journal de Paris*, 2 May 1789, 556; Mortgage forms of M. Dupiéry, ADVO, 4Q3 106. On 'The Terror', see S. Loomis, *Paris in the Terror: June 1793 – July 1794* (New York: Lippincott).
25. Lalande to Dupiéry, 16 October 1793, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 15.
26. See Lalande to Dupiéry, 22 January 1801, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 25. Dupiéry tutored the daughter of Louis-Jérôme Gohier, the last president under the post-revolutionary Directoire.
27. Mortgage forms of M. Dupiéry, ADVO, 4Q3 126 and 4Q3 130.
28. Post-mortem inventory of M. Dupiéry, ADVO, 2E29 144. Unfortunately an inventory of the library is not extant.
29. Church records of la Ferté Bernard, 1746, Archives Départementales de la Sarthe, 1Mi 1137 R10 BMS 1741–1751, pp. 273–311.
30. About her husband's occupation, see Archives Nationales, Archives Notariales, Minutes et répertoires du notaire Nicolas Gobin, 1793/09/06, MC/ET/X/612, and about their wedding, Minutes et répertoires du notaire François Brichard [hereafter 'ANAN-FB'], 1780/05/19, MC/ET/XXIII/771. I thank Françoise Launay for indicating the year of death of Dupiéry's husband.
31. Lalande to Dupiéry, 23 May 1795, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 20.
32. Post-mortem inventory of Dupiéry's husband, 1780, ANAN-FB, MC/ET/XXIII/771.
33. Lalande to Dupiéry, 13 October 1779, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 1.
34. M. Du Pierry (1782) *Explication des Tables de la durée du jour et de la nuit pour la latitude de Paris, pour chaque jour de l'année* (Paris: Lottin).
35. J. Lalande (1783) *Ephémérides des mouvemens célestes pour le Méridien de Paris, 8* , 76–8 and iv.
36. J. Lalande (1784) '*Ephémérides des mouvemens célestes pour le Méridien de Paris*', *Journal des sçavans*, December 1784, 812–14: 813; Anon. (1784) '*Ephémérides des mouvemens célestes*', *Mercure de France*, July 1784, 186–7: 187.
37. L. Euler (1786) *Introduction à l'analyse des infiniments petits*, trans. F. Pezzi (Strasbourg: Librairie Académique); Anon. (1787) 'Portrait de M. Herschel, dessiné par Madame Dupiery', *Journal des sçavans*, February 1787, 125; Anon (1787) 'Gravures', *Journal encyclopédique universel, 2*, part 1, February 1787, 159; J. Lalande (1789) 'Tables des satellites de Saturne', in P. Méchain (ed.)

Connaissance des Tems . . . pour l'année commune 1791 (Paris: L'Imprimerie Royale), pp. 288–94.

38. A.F. Fourcroy (1786) *Eléments d'histoire naturelle et de chimie* (Paris: Cuchet), p. 369; Anon. (1787) 'Nouvelles littéraires', *Journal des sçavans*, March 1787, 176–91: 183.
39. Lalande to Dupiéry, 16 September 1791, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 8.
40. M. Dupiéry (1801) *Table alphabétique et analytique des matières contenues dans les cinq tomes du Système des connaissances chimiques* (Paris: Baudouin); A.F. Fourcroy (1801) *Système des connaissances chimiques et de leurs applications aux phénomènes de la nature et de l'art*, 5 Vols. (Paris: Baudouin).
41. For the table of the sun's movements, see Société d'Émulation (1789) *Tableau général des ouvrages lus dans les séances de la société d'émulation de Bourg en Bresse, depuis son établissement, en Janvier 1783, jusqu'au premier Janvier 1789* (Bourg: Louis-Hyacinthe Goyffron), p. 31. For mention of her calculations based on Pingré's annales, see J. Lalande (1803) *Bibliographie astronomique*, p. 704. Her nonagésime tables are lost but cited in Anon. (1789) 'Nouvelles littéraires', *Journal des sçavans*, August 1789, 558–73: 560. 'Nonagésime' refers to the nonagesimal degree, or the ninetieth degree of the ecliptic, reckoned from the point in which it is intersected by the horizon.
42. Lalande to Dupiéry, 25 August 1801, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 27; Post-mortem inventory, ADVO, 2E29 144.
43. P.-A. Latreille and J.B. Godart (eds) (1819) *Encyclopédie méthodique: Histoire naturelle* (Paris: Agassi), Vol. 9, p. 129.
44. Although at present these manuscripts cannot be traced, they are cited in the will and post-mortem inventory of Dupiéry, 1830, ADVO, 2E29 144.
45. Lalande to Dupiéry, 23 July 1788, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 2. For the role of Nicole-Reine Lepaute in coordinating Lalande's computing team, see Boistel, Lamy, and Le Lay, *Jérôme Lalande*, p. 19.
46. He acknowledged her proofreading abilities, for example, in his expansion of Dominique-François Rivard's treatise: F. Rivard (1797) *Traité de la sphère et du calendrier*, ed. J. Lalande (Paris: Guillaume); see Anon. (1798) 'Livres nouveaux', *Journal Typographique et Bibliographique*, 24 March 1798, 176–83: 179.
47. See Lalande to Dupiéry, 23 July 1788, 12 August 1788, and 16 September 1791, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR2, UR5, and UR8.
48. Lamy, 'L'observatoire de Toulouse de 1733 à 1908'; P.A. Kidwell (1984) 'Women Astronomers in Britain 1780–1930', *Isis, 75*, 534–46, S. Shapin (1989) 'The Invisible Technician', *American Scientist, 77*, 554–63.
49. See Lalande to Dupiéry, 23 May 1795, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 20.
50. Anon., 'Cours d'astronomie'; Anon., 'Cours'; and Anon. (1790), 'Astronomie', *Gazette nationale*, 12 March 1790, 586.
51. Anon., 'Astronomie'.
52. Anon., 'Cours d'astronomie', p. 549.

53. Such as François Arago's weekly course, held since 1812, at the Paris Observatory, then at the Collège de France.
54. Anon. (1737) [Advertisement], *Mercure de France*, September 1737, 2032–3; Anon. (1738) [Advertisement], *Mercure de France*, December 1738, 2912.
55. Briquet, *Dictionnaire historique, littéraire et bibliographique des françaises*, p. 161.
56. Fourcroy, unfinished note and letter to Dupiéry, messidor 6th year 7 (24 June 1799), and Beaudouin, letter to Dupiéry, germinal 17th year 7 (6 April 1799), Cole Coll. MS 34. See also Lalande to Dupiéry, 16 May 1802, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 28.
57. For an example, see P. Corsi (ed.) (2008) *L'herbier de Jean-Baptiste Lamarck*, Liasse no. 8, p. 8, http://www.lamarck.cnrs.fr/ (home page), date accessed 20 January 2015; G. Aymonin (1981) 'L'herbier de Lamarck', *Revue d'histoire des sciences, 34*, 25–58.
58. Will and post-mortem inventory of Dupiéry.
59. Minutes et répertoires du notaire François Brichard, 1780, ANAN-FB, MC/ET/XXIII/771. After her husband passed away, she received a dower of 1,200 livres in annuity, 5,500 livres-worth of furniture, jewels, garments, and several other annuities.
60. Lalande to Dupiéry, 6 May 1793, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 11.
61. Lalande to Dupiéry, 15 July 1797, 25 August 1801, and 16 May 1802, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR22, UR27, and UR 28.
62. Boistel, Lamy, and Le Lay, *Jérôme Lalande*, pp. 33–49.
63. Manuscripts of the Comité de Trésorerie 1764–1766, Archives de l'Académie des sciences, P. Bret (ed.) (2012), *Oeuvres de Lavoisier: Correspondance*, Vol. VII: *1792–1794* (Paris: Académie des sciences), p. 491.
64. Fourcroy to Dupiéry, thermidor 16th year 9 (4 August 1801), Cole Coll. MS 34. The amount corresponds to about 1,200 francs over two years.
65. Archives économiques et financières, Registre Journal des versements des copies d'inscriptions au grand livre de la dette publique (5 pour cent consolidés), DGLP 16/24–17/24.
66. Will and post-mortem inventory of Dupiéry.
67. M. Dupiéry, Mortgage Forms, 23 January 1813 and 26 April 1813, ADVO, 4Q3 126 and 4Q3 130.
68. Manuscrit des séances des *Annales de chimie*, session on floréal 17th year 9 (8 May 1801), Archives de la bibliothèque de l'Ecole Polytechnique. This journal was, at first, created in 1789 under the auspices of the Académie des sciences by Lavoisier and his colleagues. Fourcroy recommended Tigny to the editorial committee of the journal.
69. Lalande, draft to prepare a notarial record, n.d., Archives de la Bibliothèque Inguimbertine, Fonds Raspail, Ms 2762, fol.62. The annual budget of the Paris Académie des sciences amounted to about 72,000 francs, to be divided up between the different savants: P. Bret, *Oeuvres de Lavoisier*, Vol. VII, p. 472.
70. Lalande, Observation Diary.
71. Lalande to Dupiéry, 29 July 1788 and 7 August 1788, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 3 and UR 4.
72. Dumont, *Un astronome des Lumières*, p. 4.

73. Further members of her network included André Thouin, Charles Augustin Coulomb, Antony Shepherd, Roger Barry, Bertholet de Bordeaux, Guiseppe Piazzi, and Faro.
74. Others included Mme D'Isjonval, wife of the physicist and academician, Quatremère d'Isjonval, Mme Joliveau, wife of the playwright and permanent secretary of the Royal Music Academy, and Mr Grangeret, a painter.
75. K. Kawashima (2013) *Emilie du Châtelet et Marie-Anne Lavoisier: Science et genre au XVIIIe siècle*, trans. A. Lécaille-Okamura (Paris: Champion), pp. 288–9.
76. Lalande to Dupiéry, 28 April 1793 and 2 January 1801, in Pecker and Dumont, *Lettres à Madame Du Pierry et au juge Honoré Flaugergues*, UR 10 and UR 24.
77. ['Citoyen Robert'], *Registre des assemblées ordinaires de la section des sciences et arts mécaniques*, session on germinal 15th year VII (15 April 1799), Collection of the Academy of Montauban, ADTG, 2J1 14; for the Béziers membership list, see Louis XV, *Etat des personnes que la Roi nominées pour composer l'Académie Royale des Sciences et Belles Lettres*.
78. A.M. Quesnay de Beaurepaire (1788) *Mémoires, statuts et prospectus concernant l'académie des sciences et beaux arts des Etats-Unis de l'Amérique, établie à Richmond capitale de la Virginie* (Paris: Cailleau).
79. Anon. (1787) 'France', *Journal politique de Bruxelles*, Supplement to *Mercure de France*, December 1787, 172–82: 179; M. Riboux (1785) *Eloge d'Agnès Sorel surnommée la Belle Agnès* (Lyon: Faucheux). I thank Jérôme Croyet for pointing out to me the freemasonry connection with the Société d'Emulation.

3
Darwin's Home of Science and the Nature of Domesticity

Paul White

After his famous voyage around the world on the *Beagle* and a brief period in London, Charles Darwin acquired a large country house in the quiet village of Down in Kent and worked all of his remaining life from home. There he walked through orchid fields, traced the paths of honey bees, dissected pigeons, wrote his books, and was nursed in sickness by his devoted wife, Emma. Darwin the naturalist and country squire has come to epitomize the long tradition of gentlemanly science, using his house and its environs as a site of observation and makeshift experiment, reliant upon family members for assistance, and personal networks of exchange, especially letter writing.[1] He seems part of a genteel, bygone age before the production of knowledge in university departments and national institutes with their factory-like laboratories, standardized training, and bureaucratic chains of command. Yet Darwin's working life was contemporary with these institutional developments. Many of his closest friends and supporters were based in university or state institutions and presided over their expansion. Darwin's career shows the enduring importance of the home in the making of elite science, and the extent to which household and newly professionalized science were interwoven, drawing authority from each other, sharing identity and ethos. Owing in part to his considerable celebrity, Darwin came to possess some of the characteristics of an institution, occupying a stable centre of authority, directing the research agendas of others, and authoring a stream of publications based upon work by remote observers, collectors, and collaborators. This Darwinian community was not bound, however, by bureaucratic allegiance or professional obligation, but by more emotional and familial ties. A whole series of affective relations were forged within Darwin's household and beyond, structuring scientific production in new institutions of research alongside more impersonal and mechanical forms of discipline.[2]

For Darwin, domesticity was both a setting for scientific work and an object of enquiry. His home and garden, his pet dogs, even his own children were part of a series of studies on the effects of domestication, its power to modify organic structure and behaviour, to improve wild nature and civilize savage man. Darwin's research on animals and plants addressed the origin of domestic bonds, the division of labour between the sexes, and the crucial role of the family in evolution and human culture. Darwin's theories of sexual selection and the development of moral and intellectual powers were deeply embedded in Victorian patriarchal society; but conventions of masculinity and femininity, of work and home, were not continuous with domesticity in practice.[3] Darwin's experimental approach to the household encouraged a certain liberality in his own family affairs that did not translate into reform in the public sphere. The home for Darwin was a breeding ground for tender feelings, especially the sympathy and love that were the foundation of his moral theory. These feelings would play an important role in the production of knowledge in Darwin's household and wider social circle; when violated, they would trigger the bitterest of scientific controversies.

Making space

Darwin is often portrayed as a creature of solitude, avoiding public appearances and controversies, preferring the company of dogs, and loving plants best of all. It might be assumed that he moved from London to the small parish of Down because he sought seclusion. Many of his letters, however, suggest that he greatly enjoyed life in the city, attending meetings, sitting on committees, entertaining friends and colleagues, participating in club life. During his London years, Darwin was an active member of various learned societies. His favourite was the Athenaeum, established in the 1820s for men of letters, science, and the fine arts to mingle with wealthy patrons.[4] Darwin joined through the support of Charles Lyell, and used it as his principal place of work. What Darwin found most to recommend about the club was not its library or its provision for scholarly retreat, but its conviviality and food: 'I go & dine at the Athenaeum like a gentleman, or rather like a Lord, for I am sure the first evening I sat in that great drawing room . . . I felt just like a duke.'[5]

Private clubs, an established feature of metropolitan life in the Georgian period, greatly expanded in the early nineteenth century. They extended some of the comforts traditionally associated with upper-class hospitality to 'self-made' men: a large library, spacious sitting and dining rooms for entertaining, billiards and brandy, private baths and lodging, servants available at all hours. In the Victorian period, these halls of homosocial domesticity came into potential conflict with the home proper, newly sanctified by the evangelical revival as a distinctly middle-class space of purity and retreat from other masculine domains.[6] To husbands and fathers, clubs might offer a temporary reprieve from ordinary family responsibilities, but they were mostly frequented by single men. Lyell had remarked on the welcome presence of ladies on Wednesday evenings at the Athenaeum, though some members complained: 'They all say it is too good for bachelors, and makes married men keep away from home.'[7] The appeal of London society to Darwin as a rival to familial duties and affections is evident in his 'notes on marriage', a series of calculations weighing the pros and cons of bachelor life for a future career in science. 'If *not* marry . . . Live in London . . . near Regents Park – keep horse – take Summer tours Collect specimens . . . Systematiz. – Study affinities.' On another page he added the advantage: 'Conversation of clever men at clubs.'[8] Darwin wrote these notes during a period of intense scientific activity. He was engaged in a number of publishing projects, including the five-volume edition of the *Beagle Zoology*, the revision of his *Beagle Journal*, and several large-scale geological books. He was also in the middle of his famous 'notebook period', filling pages with observations of species variation and distribution, raising questions about transmutation, the origins of language, moral sensibility, and emotional expression.[9] Imagining a space that would best nourish such ambitious theorizing and fact-finding, he fixed on a house in the heart of scientific London, with the freedom to travel and collect. Marriage at first seemed only a hindrance: 'If marry – means limited, Feel duty to work for money . . . no country, no tours, no large Zoolog. Collect. no books.' On another page he underlined: 'terrible loss of time'.

As one of two sons, his father a wealthy physician and landowner, Darwin could reasonably expect a steady income to support himself as an independent gentleman. His elder brother, unmarried and unemployed, was already settled in London, ensconced in literary society. There Darwin could enjoy the proximity of family without the burdens of domestic life. These he continued to enumerate: 'the expense & anxiety of children . . . obliged to go every day walking with my wife. – Eheu!! . . . banishment & degradation into indolent, idle fool.' Among the men of science whom Darwin admired, some were unmarried professors. He pictured himself as a Cambridge don, but this came with other obligations (students, colleges, chapel). On the other hand, Lyell, his closest friend and mentor in this period, lived comfortably as a married man in London. Darwin compared his aspirations as a naturalist with those of Lyell, much of whose scientific life was spent revising a single (albeit long) book: 'I have so much more pleasure in direct observation, that I could not go on as Lyell does, correcting & adding up new information to old train.' As a compromise, he imagined a country house near London. Here scientific research, evidently more satisfying than clubs and conversation, could thrive: 'In country, experiment & observations on lower animals, – more space.' In another set of notes, he began to find advantages in married life rather than mere obstacles to science.

> Marry
> Children – (if it Please God) – Constant companion,
> (& friend in old age) who will feel interested in one, –
> object to be beloved & played with. –– better than a
> dog anyhow. – Home, & someone to take care of
> house – Charms of music & female chit-chat...
> My God, it is intolerable to think of spending ones
> whole life, like a neuter bee, working, working, &
> nothing after all.... Only picture to yourself a nice soft
> wife on a sofa with
> good fire, & books & music perhaps – Compare this
> vision with the dingy reality of Grt. Marlbro' St.
> Marry – Mary – Marry Q.E.D.

Darwin's oft-quoted remarks, especially regarding the charms of his wife-object on a sofa, are easy to dismiss as by-products of Victorian patriarchy. They echo a pervasive ideology of domesticity that, as historians have shown, cannot be taken as indicative of actual practice.[10] It is surprising then to see these familiar tropes of home and hearth structuring Darwin's decision making almost completely. Though nominally middle class, he was cushioned by wealth from many of the difficulties faced by men of humbler birth who could barely contemplate marriage unless they had established themselves in a trade or profession, men for whom a house and family were the measure of success and the seal of manliness. Had he needed to earn a living from science, his situation would have been precarious. Darwin was instead caught between two conflicting models of manhood: the (independent) gentleman, free to invest his wealth and time in the pursuit of science; and the family man, dividing his resources between 'work' and 'home'. Here, the Victorian ideology of separate spheres pressed remarkably hard upon him. The ideal of home as a sanctuary from work rendered his vocation 'nothing', even if his scientific work issued for the most part from the home. Though a man of science, he was effectively emasculated (neutered) without the complement of wife and family. Darwin shared his marital concerns with his father, who imparted sound physiological advice:

> [O]ne's character is more flexible – one's feelings more lively & if one does not marry soon, one misses so much good pure happiness . . . Never mind my boy – Cheer up – One cannot live this solitary life, with groggy old age, friendless & cold, & childless staring one in ones face, already beginning to wrinkle.[11]

Within three months of this consult, Darwin was engaged to his first cousin, Emma Wedgwood; two months later the couple were married. 'I think you will humanize me', he wrote to her, '& soon teach me there is greater happiness, than building theories, & accumulating facts in silence & solitude.'[12]

The families of Darwin and Wedgwood had crossed paths the generation before, and Emma had been a friend since childhood. This conjunction of kinship and friendship had become a pattern among the European gentry from the middle of the eighteenth century, when laws of primogeniture and the inheritance of offices were reformed. Families began to invest in every child, not just the eldest, and marriages within families, as well as marital alliances between families already bound by friendship and mutual interests, became common.[13] Such intercrossing often occurred over several generations, making a dense web of alliances. Darwin's paternal grandfather, Erasmus, and his maternal grandfather, Josiah Wedgwood, had been close friends and members of the famous learned fraternity, the Lunar Society of Birmingham. One of Darwin's sisters, Caroline, had married Josiah Wedgwood III in August 1837, just a few months before Darwin's own engagement. The Darwins and Wedgwoods were part of larger family circle that would evolve over the course of nineteenth century, the heyday of first-cousin marriage.

Such links between families helped to secure positions and influence in a more mobile, commercial society. But cousin marriage was not just about blood and property. It was a matter of personal choice, closeness, and affection. Through this system of marital bonds, a new and powerful form of sentiment was rooted in families. They became the most 'natural' bases of love, marked by deep loyalty and adoration.[14] That Emma Wedgwood was not only close to Charles Darwin's family, especially his sisters, but already part of the family, strengthened their feelings of sympathy and attachment considerably. The letters exchanged between the newly engaged couple attested to a shared ideal of companionate marriage: 'everything that concerns you concerns me', Emma wrote.[15] There was a lightness and loquacity only seen in Charles's correspondence with his sisters, but also graver discussions, especially of religious belief and doubt. His notebooks in this period expressed considerable heterodoxy on matters of Christian revelation, bordering on materialism. Emma was devoutly Unitarian, her faith resting largely upon inner feeling and moral duty rather than Church doctrine, though she remained strongly wedded to belief in the afterlife.[16] How were such differences to be resolved, so that their household could become a centre of religious devotion and of scientific work?

In their brief period of engagement and first months of marriage, the couple negotiated the place of science and religion in their home and hearts. Emma cast her respect for Charles's science in light of matters dear to her that could not be thrust aside just to make more room for his investigations: 'your mind & time are full of the most interesting subjects & thoughts of the most absorbing kind . . . which make it very difficult for you to avoid casting out as interruptions other sorts of thoughts'. She warned that his 'habit in scientific pursuits of believing nothing till it is proved' would open 'a painful void between [them]'. She then pressed him to read some of her favourite Bible verses, while closing off potentially divisive discussion, trusting that their differences of belief would be bridged by stronger affections: 'I do not wish for any answer to all this – it is a satisfaction to me to write it . . . I know you will have patience . . . we may sympathize a good deal in our feelings.' Charles's side of the correspondence has not survived, only a note added to the end of this letter: 'when I am dead, know that many times, I have kissed & cryed over this'.[17]

The implications of Darwin's evolutionary theory for religion would, of course, be the most controversial of debates in the public sphere, with direct bearing on institutional reforms in education that would create space for science to develop as a profession.[18] Between the young couple, however, the topic was discussed in relation to the private sphere, in conjunction with setting up a household. Matters of science and religion were literally interspersed with descriptions of London flats, kitchen equipment, and the interviewing of servants. In mapping their future together, they drew upon conventional divisions of work and home, of the considerate husband and devoted wife, imposing these upon the practice of science and religion. Crucial to their marriage agreement was another piece of emotional and social geography: the boundary of public and private. With rare exceptions, Darwin would avoid any discussion of religion in print, convinced that it did no good, and only caused pain. He would also present his scientific theories in a manner that allowed for their incorporation into a variety of religious viewpoints.[19] The same strategy was signalled by Emma in her allocation of space within the home for religious and scientific devotion, sustained by a sense of privacy and interiority, by a language of feeling – tenderness, love, sympathy, and perhaps sorrow – and by the absence of discussion.

Labour conditions and familial affections

Shortly after marriage, Darwin started to work from home. He rose early, spending several hours in the study before breakfast. Emma would often join him later, doing quiet needlework until lunchtime. In the afternoon, Charles would attend to scientific business in town, returning for dinner by six, followed by light reading and music (Emma on piano). This routine was refined when the Darwins moved to Down, their London house too small for a growing family.[20] He typically spent three periods a day in the study, reading, writing, doing correspondence, microscopy, or dissection, and occasionally petting the dog or being sick in a screened-off corner (Figure 3.1). Intervals were passed in the drawing room, lying on the sofa and being read to: novels, histories, family letters. He enjoyed listening to music and playing backgammon. He also took several walks a day, sometimes sat in the garden, or did a bit of riding.

When we think of science in the home, it is usually in a circumscribed place: the study, a basement laboratory, or more elaborate schemes with multiple rooms or floors devoted to collections, medical teaching, or dissection. In such arrangements, the familiar separation of spheres – work and home, science and domestic life – is reasserted, as it were, within the house itself.[21] Darwin's case shows, however, that these boundaries could be highly permeable, and might even dissolve altogether. Though he had originally envisioned domestic life as a distraction, he came to use the entire home as a site of scientific discipline. Its different rooms, activities, and rhythms, were part of a regime of intellectual labour. While still a bachelor, Darwin had been mentored in how to

Figure 3.1 Darwin's study from *The Century Magazine*, January 1883. From the author's collection.

regulate his scientific life by Lyell: the importance of diverse reading matter, balancing periods of reading with writing, conversation, and walking.[22] Such activity renewed mental energy, channelling excitement and avoiding exhaustion. At Down, Darwin had a precise timetable for these activities. Interruptions and irregularities were upsetting, for the main point of all this movement about the home was to maximize productivity. Even what might seem to be leisure activity was incorporated into a work regimen. Unable to enjoy leisure unless it could be harnessed to scientific activity, Darwin was at his most miserable when on holiday, wrenched from this routine and forced to be idle.

In his letters and journals, Darwin always gave the impression of being under tremendous pressure of work. He accounted for every day's output, recording the time spent on articles and books, as well as time lost to family visits and illness.[23] This intensity pervaded his gentleman's study. It was not a place of polite conversation or learned display. The desk was packed with scientific instruments and specimens, sometimes the remains of dissections. The library was extensive, but shoddy. The books, soiled by use, were never re-covered: no fine leather bindings or gilt edges such as a wealthy gentleman might own. The only comfortable chair was converted as if for industrial use, with metal legs and wheels for ease of movement about the room. It looked like it belonged in a workshop or factory, and lent a sense of ruthless efficiency to the space.

Darwin embraced the work discipline of industrial capitalism, the time-keeping, the regularity, the precise accounting of production and expenditure. Such a routine is usually associated with the factory system or middle-class professions. His grandfather had pioneered the monitoring of factory labourers at his pottery works at Etruria.[24] Other managerial systems were being implemented for scientific observation, for example, at the Royal Observatory at Greenwich.[25] By contrast, Darwin's regime was entirely self-imposed and curiously situated in a country house. Indeed, it positively required an expensive library, drawing room and spacious garden. Darwin could only work himself to the bone in this manner because of his considerable wealth. He did eventually earn tidy sums for his books, and he recorded every shilling gained and spent on science, alongside his investment income, servants' wages, farm animals, beer, and snuff, as if it were a department in the household economy.[26] But he prided himself on not having to write for a living, on being answerable to no one but his scientific peers. Darwin adopted an ethos of 'hard labour' with relative ease because his manhood never depended on having to work for others or earn a living. Without a trace of irony, he would later praise the twin virtues of hard work and gentlemanly independence as the driving forces of human progress in *Descent of Man*.[27]

If the different rooms and activities in the home contributed to scientific knowledge, so too did its many occupants. Nearly all the members of the large household participated: Emma, the children, the governesses, and the servants. An array of social hierarchies structured their contributions, and the modes in which these were acknowledged. As we have seen, Darwin at first did not conceive of his family as an aide to work, but as an expense and anxiety. Soon, however, Emma came to play the role of amanuensis, especially during her husband's many bouts of illness. This was a well-established tradition in science and the learned professions that were similarly situated in the home. Though he could have afforded it, Charles never employed a private secretary, preferring to keep this in the family, while paying others for occasional work such as translating from German, or copying long manuscripts. Some of the Darwin children also fulfilled this role. Their son Francis even left a career path in medicine to work at his father's side, and pursue his own interest in botany.

The children became extensively involved in observation and experiment. This may have developed as part of other activities, such as drawing and music, which were appropriate to the home as a place of instruction and accomplishment. Reminiscences from the children describe the ease of movement in and out of their father's study, the pleasure in turning the pages of an illustrated zoology. While still young, they followed the honeybees that flitted from flower to flower in the garden, assisting Darwin's work on the agency of insects in pollination. As they grew older, the children were encouraged to become independent observers and critics. Having set up his eldest son William as a banker in Southampton (a source of great anxiety indeed), Darwin encouraged his botanical activities, drawing him into work on the comparative fertility and sexual dimorphism of plants. While on holiday on the Isle of Wight, the dutiful son measured pollen grains and pistils in different forms of flowers. Father and son worked closely together on heterostyly in buckthorn (*Rhamnus cathartica*), William observing what appeared to be four sexual forms of flower. 'If your case turns out true (wh. it probably won't)', Darwin wrote, 'it will be a most interesting discovery & I vow you shall write a paper & publish it . . . Do not be discouraged if the whole case blows up – I am well accustomed to such explosions.'[28] The elder Darwin expressed fatherly pride through such mentoring in science, sharing his patience in observation and enthusiasm for discovery, holding out the promise of authorship. William did not in fact publish independently, but his observations were reported and acknowledged in a number of Darwin's own works.

A differential treatment was accorded his daughter Henrietta, who became a valued critic of her father's manuscripts. The role developed out of her being asked, at the age of 19, to read the proofs of *Orchids* (1862) as a test of the book's accessibility to general readers.[29] In 1870 Darwin asked her to read the draft of his controversial chapters on mind and morals in *Descent of Man*: 'the more time you can give up for deep criticism or corrections of style, the more grateful I shall be'.[30] Her editorial comments have not survived, but Darwin wrote to her after *Descent* was published, boasting of its sales and favourable reviews, and addressing her as his 'coadjutor & fellow-labourer': 'I know how much I owe to you in this respect.' He also rewarded her time and effort with a gift: 'I wish to give you some little memorial costing about £25 or £50, to keep in memory of the book, over which you took such immense trouble.'[31] The monetary sum, generous for the time, tacitly credited her for work that a professional might perform, but was immediately converted into sentimental currency, a memento of her father's love and a token of respect for her valuable contributions that were not acknowledged publicly.[32]

It was not uncommon for children to assist or collaborate in household science. Perhaps more exceptional was the close interweaving of scientific observation and authorship with the experience of fatherhood for Darwin. He took great pleasure in sharing his lifelong passion with those whom he most loved. He took pride in watching his children grow in participation. The children too seemed to find filial affection and duty sealed through scientific work. As they grew older and left home, their letters helped sustain this fellowship, mingling mundane facts and editorial corrections with accounts of Cambridge dinners, Italian excursions, or married life. As new families were formed, Darwin did not lose, but gained more partners in science. No sooner was Henrietta engaged than her fiancé, a music teacher in London, was asked to comment on a draft chapter in the *Expression of Emotions* that discussed the feelings evoked by different tones of voice.[33] Darwin's son Francis and his newly wedded wife Amy spent their honeymoon in Wales observing bladderworts and gathering worm castings, contributing to Darwin's work on insectivorous plants and the formation of vegetable mould by earthworms.[34]

The extension of Darwin's home of science beyond the borders of his immediate household might be taken further through the medium of correspondence. The role of letters in scientific production is now well known. It was particularly important for Darwin because of his homebound existence, combined with the global scope of his theorizing. How was this network established and maintained? In contrast to the early modern 'republic of letters', large correspondence networks in the nineteenth century were more often formed around institutions. It is possible to characterize Darwin's correspondence in institutional terms: his study as a centre of administration, a place for exercising control over information through letter writing, negotiating with publishers, wielding influence over readers, even shaping the scientific practice of experts.[35] Botanical specimens flowed from the British colonies to Down House through Kew Gardens, its staff running experiments according to Darwin's designs. In his research on emotional expression, Darwin recruited specialists in hospitals and institutes with their array of precision instruments for recording bodily movements. His work on carnivorous plants reached from his greenhouse to chemical and physiological laboratories in Manchester and London.

Yet if we look at the manner in which Darwin engaged his correspondents, a more gentlemanly model seems appropriate, rooted in codes of politeness, deference, and gift exchange. Great care was taken in forms of address, appropriate to gender and social station.[36] Requests were always marked by apology, the expression of gratitude, with compliments (in advance) for the kindness received. Later in life Darwin could trade on celebrity, information occasionally coming to him unsolicited in exchange for an autograph, or a mention in one of his publications. Darwin certainly capitalized on institutional networks and forms of authority, but he did so through the medium of friendship. In the early years he relied upon Cambridge connections established through the close relationship he enjoyed with his botany professor and mentor, John Henslow. New links came from his friendships with Charles Lyell, Joseph Dalton Hooker, Thomas Henry Huxley, and Asa Gray, all of whom occupied positions of influence in leading institutions, and possessed extensive networks of their own.

Darwin's correspondence shows how the dichotomy between home and institutional modes of scientific production can be broken down, as it were, from both sides. Gentlemanly forms of address and affective bonds of friendship remained vital; large institutions might be quite personal domains. Even a centralizing administrator like Hooker could not rely solely on the authority of his institutional position to engage colleagues and secure useful observers and collectors. Indeed, the director of Kew presided over the imperial institution as if it were his private estate.[37] He extended the resources of his garden and staff to Darwin because he was a close friend. Their friendship had been built largely through letters exchanged over several years, especially lengthy esoteric discussions on the geographic distribution of plants, means of seed dispersal, the effects of climate on variation – discussions that drew on their complementary interests and expertise, discussions that neither of them could have with anyone else. Darwin's friendships and working relations with Huxley, Gray, and a number of other institution-based practitioners were established in the same way.

Such close friendships were often familial. After moving to Down, Darwin did not frequent scientific societies or clubs, and so his gentlemen friends did not compete with companionate marriage. Rather, the familiarity cultivated through letter writing was strengthened through household visits and bonds between couples and their children. For those outside Darwin's circle of 'blood' relations, such visits could be crucial in establishing loyalty and support despite marked theoretical differences. Crossing the threshold of the home carried with it an enduring intimacy. Scientific correspondence thereafter mingled with domestic life in the form of inquiries after health, regards to family members, a sharing of achievements, frustrations, or personal loss. Home visits sometimes included whole families, the Hookers, the Huxleys, the Grays, prompting concerns about bedding and playmates for the children, and affording opportunities for joint observation (visits to the greenhouse, photographs of emotional expression viewed after dinner). Darwin's innermost network was thus a web of households, forged by bonds between couples and their offspring. 'You talk of being allowed to treat us as relatives', wrote Henrietta Huxley after receiving a gift on moving house:

> You are like the man – who had been all his life talking prose without knowing it and in this more than brotherly kindness . . . make poetry of your life.
>
> With our united love to your two selves
>
> [signed] one of the family.[38]

Darwin's bitterest disputes arose when the intimacy and loyalty of scientific friendship and family were violated. Of course, from 1859 onwards Darwin faced extensive public criticism and occasional ridicule, but only two men ever aroused such antipathy that all relations with them were severed: Richard Owen and St George Mivart. Their controversies have been variously explained on social, religious, or personal grounds; but from Darwin's point of view, both followed a similar pattern.[39] Darwin had worked closely with Owen in the early years and sought his frank opinion of *Origin of Species* in a private meeting. He was abashed by Owen's 'arrogance' and 'sneering tone', but left puzzled, not knowing where Owen really stood: 'we parted on high terms of consideration; which on reflexion I am almost sorry for'. Then a few weeks later came Owen's long and highly critical review.[40] Darwin regarded it as unfair, as distorting, and so forth; but he received many such notices. The review in itself would not have been enough to stir such deep animosity if he had not regarded its author as a scientific friend, someone with whom he had collaborated and had round to dinner with his wife, someone whose expertise he valued and whose honest opinion he had sought in person.

The Mivart affair was far more protracted. A promising zoologist and protégé of Huxley, Mivart became an outspoken critic of Darwinian evolution as extended to 'man'. His relations with Darwin remained cordial for several years, owing in part to a personal meeting in which Darwin warmed to his adversary. Relations grew strained, however, as

Mivart continued to write hostile reviews at the same time as sending friendly letters, asking after Darwin's health and pleading admiration for the elder naturalist. According to Darwin's gentlemanly code of science, friends and colleagues did not write hostile reviews. They aired their differences in private, whether face to face or in correspondence, and were respectful and supportive (if critical) in public. Darwin's correspondence with Lyell, Hooker, and Gray was full of heated debate and unresolved differences. Mivart was the reverse. Almost reverential in private, he defended his scathing reviews on the grounds of a disinterested pursuit of truth. Finally, an unforgivable blow was struck when Mivart insinuated that Darwin's son, George, had sanctioned licentious behaviour (prostitution!) in an article on population control. Concerned about the moral decay wrought by Darwinism, Mivart effectively accused the scientific productions of the Darwin family of undermining the purity of marital bonds and threatening the sanctity of the home.[41]

The nature of domesticity

As many have noted, Darwin's work on evolutionary theory relied heavily on information about domestic animals and plants. He turned early to breeders and their practices for knowledge about generation, variation, and divergence. Drawing on family experiences in Shropshire and Staffordshire, he raised poultry, pigeons, rabbits, and different varieties of peas and beans. He gathered information from neighbouring farmers, attended agricultural shows, joined pigeon fanciers' clubs, sent queries to the *Gardeners' Chronicle* and *The Field*, and corresponded with nurserymen, beekeepers, and livestock breeders.[42] Such a profound interest in 'man-made' productions was unusual for a naturalist, but it was central to Darwin's household science, effectively converting the practical and recreational features of rural life into an intensive research programme. The production of domestic varieties provided compelling evidence for the plasticity of nature and the power of selection, as embodied in the breeder, to modify structure and behaviour. *Origin of Species* began with the famous case of pigeon varieties so divergent that they would be regarded as separate species if found in the wild, yet all had been produced within a short span of time from a single ancestral form.

In horticulture and animal husbandry, the process of domestication was closely linked with 'improvement'. Scales of progress underpinned breeders' claims about prize animals or vegetables, more vigorous crops, sweeter fruit, larger, stronger horses. This ability to improve upon nature, to render wild, barren terrain more fertile and productive was also central to discourses of civilization and colonial expansion that were pervasive and largely unquestioned in Darwin's lifetime.[43] Travel writers, naturalists, and anthropologists described the crucial role of domestication in the development of the human race from a savage condition: the herding of animals and the cultivation of the soil, the steady provision of food, warmth, and shelter – all contributed to the formation of manners, the refining of temperament, and the advances in intellectual and material culture that made Europeans the master civilization or race.[44] Darwin's evolutionary theory was ambiguously positioned here. Darwinian improvement, couched in terms of fitness, was relative and non-linear. There was no fixed ideal towards which species progressed, or against which their adaptations might be evaluated. Contrary to Victorian conventions about the centrality and superiority of 'man', Darwin presented a history of the natural world in which humans were largely absent and, when they finally emerged on the scene, unexceptional, sharing every characteristic with some animal progenitor.

But when Darwin came to write about human races, and the evolution of the moral and intellectual faculties, the relativism of fitness receded, and more conventional hierarchies came to the fore. In the struggle between human tribes, he argued, victory went to those who excelled not merely in physical strength, but in sagacity and social instincts. Intellect enabled them to make better weapons, better traps for food, and so forth; while sympathy, fidelity, and courage allowed them to become disciplined soldiers, foregoing selfishness and sacrificing themselves for the community good. With their superior mental and moral traits, Europeans thus spread across the globe, driving other peoples to extinction: 'at the present day civilized nations are everywhere supplanting barbarous nations'.[45] For Darwin, domestication in the form of private property, fixed abode, and family structure, were fundamental to the civilizing process. His study of human domestication began on the *Beagle*, when he observed the effects of Fitzroy's experiment in taming the savage 'Fuegians', collected from their native Tierra del Fuego on a previous voyage and now returned. Darwin's extended description of the encounter with this savage people was almost completely derogatory: 'hideous . . . filthy . . . greasy . . . discordant . . . violent and without dignity'.[46] They revealed what human nature was like before domestication. Living for the most part without dwellings, uncovered, clinging to rocks, they seemed not even to desire what the Brazilian slaves most longed for, the comforts and affections of home. Returned to their native land, the *Beagle* passengers quickly reverted, leaving Darwin in a state of revulsion.

In his notebooks, Darwin wrote: 'Show a savage a dog, & ask him, how wolf was so changed'.[47] Dogs were animals that not only hunted with man, but also became his protector and friend, suggesting how vicious and violent characteristics, once useful in the wild, could be refined through domestication. In *Descent of Man*, Darwin gave the example of the English pointer who bonded with his master and was trained to resist the impulse to give chase, replacing wild instincts with those befitting a companion.[48] Darwin described the same process in his children's development. His first-born child, William, emerged in a wild state, crying for food like nestling birds, trying to slap his nurse's face when she took his cake, 'like just-born crocodile from egg, learns to snap'. The father pinched, poked, and tickled the boy, waved objects about and grimaced. A loud snoring noise induced a fear response. Hiding toys and scolding provoked aggression. 'I repeated the experiment', Darwin wrote. Over the course of several years, Darwin watched William develop powers of sympathy and affection, gradually manifesting a concern for others, his fear and aggression retreating behind softer impulses and expressions. He observed the boy on the verge of punching his sister with a wooden candlestick, 'when I called sharply to him & he wheeled round & instantly sent the candlestick whirling over my head. – He then stood resolute . . . as if ready to oppose the whole world. – but . . . when I said "Doddy wont throw a candlestick at Papas head" . . . he said "no wont – kiss papa".' Later, instead of snapping like a reptile, he gave his sister his last bit of gingerbread, declaring 'kind Doddy'.[49] Crucial to the evolution of social feeling in children was the custodial environment of the well-mannered home, including the affection and discipline meted out to the young ones as they sucked and squalled, pawed and snapped. Darwin's notebook, including entries in Emma's hand, moved between these structures of animal feeling, parental devotion, and command showing the process of domestication at work.

In the course of his discussion of human races and civilization in *Descent*, Darwin shifted from the term 'mankind' to 'men', suggesting that traits once common to both sexes were later apportioned between them, resulting in a division of roles in human society that required men to be the exclusive aggressors and defenders, while women raised children and provided moral support.[50] For decades, Darwin had studied the separation of the sexes, and the evolution of distinct male and female characteristics, eventually exhausting the subject in his survey of sexual selection from molluscs to man. The picture Darwin drew was of males of every species fighting, cavorting, and exhibiting their prowess: strength, size, courage, pugnacity, and beauty. Darwin called it a battle 'for possession of the females', especially those who were most vigorous and well nourished. Females either waited until the weakest males expired, or acted like breeders of game-cocks, shaping male nature according to their tastes.[51] But Darwin's animals also displayed a rich and varied courtship behaviour. He dwelt on the more peaceful allurements of smell, sound, and colour. Lamellicorn beetles lived in pairs and seemed much attached to each other. The male excited the female to roll balls of dung in which ova were deposited and, if she were removed, became much agitated. Other insects established long-term relations and mutual care. Rats lived in peace and love.

1In humans, the divide between combat and conjugal devotion was manifest in the separation of work and home. The law of battle still prevailed, according to Darwin, assisting in the evolution of higher mental powers. Intellect, imagination, invention, and observation enabled men to succeed against their rivals, and better defend and provide for their mates. Having become bigger, stronger, and smarter, men then seized the power of selection, turning it upon women who were valued primarily for their beauty and nurturing qualities. Civilized men embraced companionate marriage in contrast to savages, who captured their wives from rival tribes, dragging them, stunned by blows, through the woods. Perhaps unsurprisingly, the evolution of domesticity culminated in features that bore a strong resemblance to the Victorian home, in which women were the improvers of men, further softening their savage instincts. Tough men needed tender wives on a sofa to humanize them: a process enacted each day upon husbands who returned from the wilderness of work, where the same characteristics beneficial to animals in the wild – jealous self-regard, assertiveness, rugged endurance – served men in their struggles against each other, struggles that were essential to the support of the home.

The setting and ethos of Darwin's scientific work, rooted in the home and sustained by sympathy and affection, seem out of place in this natural history of hard labour and soft domesticity. Darwin was virtually housebound, experiencing periods of crippling sickness punctuated by an almost chronic invalidism. He relied upon his wife's daily assistance and a wealth of contributions from family and friends as fellow observers, astute editors, and critics. He rarely entered into the public controversies that some of his writings provoked, preferring to engage critics in private correspondence, build mutual respect, and draw upon their expertise for future research. That his own work resided in and rested upon the home and its many comforts seems not to have diminished his sense of manly endeavour as a battleground. His own achievements, he insisted, were won by the same hard work, determination, and endurance that prevailed in most of life's struggles. In answer to Francis Galton's queries for *English Men of Science: Their Nature and Nurture* (1874), he wrote of himself: 'special talents none, except for business . . . An early riser . . . Energy of mind shown by vigorous and long-continued work on same subject.'[52] He added to the list of character strengths in an autobiographical memoir for his children. Patient observation, cautious reasoning, and a steady and ardent love for science were the virtues he extolled to those closest to him who had shared his enthusiasm for nature, and contributed so much to his work in the home.[53]

Conclusion

Five years after his death, Darwin's memoir was made public in the *Life and Letters* edited by his son Francis, who added a lengthy account of his father's manner of work, emphasizing his painstaking attention to detail, his sense of urgency, and enthusiasm:

> [W]hen he was making an experiment on the roots of beans which required some care of manipulation . . . fastening the little bits of card upon the roots was done carefully and . . . slowly, but the intermediate movements were all quick; taking a fresh bean, seeing that its root was healthy, impaling it on a pin, fixing it on a cork . . . all these processes were performed with a kind of restrained eagerness.[54]

A graduate in natural sciences at Cambridge, then a medical student in London, Francis had served as a go-between for his father, operating within new institutional laboratories and his childhood home, eventually becoming his father's full-time secretary and assistant. He helped initiate working relations with leading experimental physiologists, John Burdon Sanderson and Emanuel Klein, who advised and assisted his father in research on insectivorous plants. At intervals in 1878 and 1879, he worked under Julius Sachs in the botanical laboratory in Würzburg. Sachs and Darwin shared an interest in the power of movement in plants, plotting the directional motions of tendrils and roots. Sachs encouraged Francis to stay on, offering him a whole greenhouse of plants for experiments: 'It is Sachs idea', Francis wrote, 'so that if it is to be any good it ought to be done here.'[55]

Sachs had reached different conclusions from Charles Darwin about the directionality and locus of movement in the roots, and in later publications he anchored this dispute in the geography of knowledge.[56] He criticized Darwin's homely experiments with cork and card for lacking the control available only in a research laboratory, equipped with specialized instruments like the self-recording auxanometer, designed to measure the size and direction of plant growth at the tip to a tenth of a millimetre. Able to run automatically for days, such a device would never grow tired, be sick, or get enthusiastic. Here in the modern laboratory were forms of discipline and expertise that had no need for drawing rooms or country walks, for personal contacts or bonds of affection and loyalty. Through appeals to an impersonal, highly technical, and standardized space of knowledge, Sachs tried to pry apart the domains of scientific work and home that Darwin had woven together. As we know, such workspaces were increasingly the model for knowledge production in the nineteenth century, and the envy of many British researchers in the life sciences and medicine. In accounts of the controversy, Sachs is ultimately proved wrong, but his laboratory is the winner. Darwin's theory of movement only gained credence because it was eventually verified in a laboratory setting. The old gentleman of Down House, it seems, was no match for the new machinery of scientific production.

Yet the juxtaposition that Sachs constructed was by no means a natural or obvious one. In Britain, where systematic science training and the reorientation of medicine around laboratory methods and procedures were just beginning, the authority of science was rarely located so exclusively in laboratories or precision instruments. Darwin had corresponded with Sachs and always referred respectfully to his expertise. For Darwin, the home and laboratory were continuous and co-productive. He routinely called upon leading chemists and physiologists to run experiments in their university laboratories, often according to his own design and methods. Though he made frequent use of ready-made materials, he also availed himself of specialist equipment. Indeed, even this originated within the family. His youngest son Horace, who would found the Cambridge Scientific Instrument Company, began building equipment in the late 1870s to assist his father's research.

Francis's reverent tribute to his father, the *Life and Letters*, was among a series of publications that opened Darwin's house and garden to the public. A life revealed in letters could resolve the tension between work and home into a literary device: correspondence was a space in which science and domesticity, professional and personal, could meet and contend. Letters were a means of institution building, of sustaining learned society, of exchanging highly technical information in impersonal language. Yet they also served to inscribe scientific endeavours with personal achievement, emotional engagement, and friendship, in other words, those very features that the process of professionalization often masked. Here, and in other celebrated portraits of the period, those characteristics that Sachs tried to erase were preserved: the personal face and familiar place of knowledge in the household, the man of science as an embattled mind, the harmonious relationship between scientific work and home, with its tireless workers, its loving husbands and fathers.

Notes

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4

The Tensions of Homemade Science in the Work of Henderina Scott and Hertha Ayrton

Claire G. Jones

On 22 June 1904, Burlington House was the setting for an illustrious event that crossed the boundaries of science and society; the occasion was the second Royal Society of London conversazione of the summer, commonly known as 'ladies' night'. As *The Times* explained in its regular reporting of the event:

> The first of these, held in May, is confined to men, and, for obvious reasons, is known as the 'Black *Soirée*', whereas the June reception is graced by the presence of the other sex, whose variegated adornments impart an unwonted gaiety to the severe environment of the headquarters of British science.[1]

That evening, the scientific and social elite of London gathered, with their wives, to view exhibits and demonstrations of the latest developments in science – and also to partake of lavish hospitality in the specially decorated halls adorned with flowers and plants to mark the occasion. Two of the scientific exhibiters that night were women: botanist, palaeobotanist, and filmmaker, Henderina (Rina) Scott (1862–1929), and physicist and electrical engineer, Hertha Ayrton (1854–1923). Scott displayed her novel animated photographs, which used pioneering time-lapse techniques to illustrate the movements of plants, while Ayrton exhibited her experiments with sand and water in glass troughs to demonstrate the origin of ripple marks. Ayrton's display was connected to the paper she had read to the Royal Society a couple of weeks earlier and which would later be published in its *Proceedings*; this work would contribute to Ayrton being awarded the Royal Society's Hughes Medal for original research in 1906.[2]

It was unusual for women to exhibit at Royal Society conversaziones, but not without precedent. Ayrton had demonstrated her dramatic experiments on the hissing of the electric arc in 1899, and, although she was the only female exhibitor on that occasion, the following year astronomer Annie Maunder displayed her photographs of the Milky Way.[3] Women were not entirely absent – as exhibiters at least – from the more severe Black *Soirée* either; in 1903, in the first of the two Royal Society conversaziones that year, biologist Edith Saunders had demonstrated experiments on the structure of cells, and palaeontologist Dorothea Bate had displayed the remains of pygmy elephant and hippopotamus originating from her recent excavations in Cyprus.[4] Despite their participation as specialists at Royal Society conversaziones, these women worked, to a large extent, only at the periphery of elite science at this time. Denied fellowship, due to their sex, of the learned society that nonetheless was happy to display their work, both Scott and Ayrton pursued their research in domestic settings: their science was homemade. This is a trivial description in one sense, but in another the adjective *homemade* attaches a meaning to the women's work that contrasts it explicitly to professional science produced in an institution or laboratory. The latter spaces of knowledge production were increasingly using purpose-built spaces and equipment which gave their findings a credibility that experimentation in the home, using improvised equipment, mostly lacked. Because of this homemade setting, Scott and Ayrton were limited, to an extent, in the kinds of research they could undertake, and this reinforced their marginal position in contemporary scientific hierarchies and influenced the reception and legacy of their work.

Women's role in science: Explanatory frameworks

The problem of women being left behind to operate in the domestic sphere as science moved increasingly to a mainly institutional setting in the later part of the nineteenth century has been well documented.[5] As a result, women were typically cast as amateurs, with all the connotations of triviality and marginality to serious science that accompanied that status. Also relevant here is women's frequent exclusion from elite scientific institutions and, to a large part, from academic positions. As will be illustrated further in this chapter, the interpretations attached to homemade science were often different for men who produced their science in domestic settings but had positions and post-nominal letters endorsing their work. Here the home, and the knowledge produced in it, is coloured according to gender. This is hardly surprising – after all, the home is a space that implies social relationships and hierarchies, and these have always been strongly gendered. Men are not defined by the home in the same way as women, even when we allow that all work takes on a special character according to its frame or context.[6] It will be argued here that even though Scott's husband, like her, pursued his science at home and had no institutional base for a number of years, contemporary understandings positioned his science as more significant and primary to his identity. This was not the case for his wife: women were defined by the home in a way that men were not – and so was their homemade science.

Recent scholarship has uncovered the often ignored contributions of technicians and assistants. These roles are indispensable to the production of scientific knowledge yet are commonly rendered invisible by the narrative of the lone, heroic scientific worker.[7] This latter configuration of scientific endeavour has obscured the work of less privileged men as well as that of women of all classes. Female scientists who collaborated in the home have been typically assigned the role of assistant, regardless of the nature of their participation, and so have been rendered peripheral in histories of science. This was something identified by Margaret Rossiter in 1993, and included in a process leading to the systematic underrepresentation of women that she coined 'the Matilda effect'.[8] This effect also operates when women contribute in the early days of a new science or technology, but get wiped from its history once it becomes successful and gendered.[9]

Woman as assistant and secondary to man was an ideology in keeping with the middle-class gender prescriptions of late Victorian and Edwardian Britain, especially those governing marital relationships. A woman was helpmeet to her husband and, in the sanctity of the home and marriage, absorbed her interests and identity into his.[10] This ideal relationship was taught to middle-class girls from a young age, through stories such as 'An Admirable Arrangement', which appeared in an 1897 edition of *Lady's Realm*. Here, a Cambridge don is dismayed that the Girton graduate who is a fellow guest at a house party has done original research into the primitive tribe which is his specialist area and produced a new theory to rival his own, jeopardising his academic reputation. The narrative is resolved by the two falling in love, with the Girton girl promising to marry the don on condition that he include her work in his next book, putting only his name on the cover.[11] These role prescriptions helped to preserve gender hierarchies in science as well as in marriage, and rendered women's homemade knowledge particularly vulnerable to being rendered invisible.

Due to dynamics such as these, wives, sisters, and daughters have been omitted from or relegated as unimportant in accounts of the development of science, especially when that science was the result of collaboration in a domestic setting. Building on this perspective, it has been argued that, nonetheless, marriage and other familial relations between the sexes gave scientific women a route into science through the support of a male mentor with access to professional networks denied to ordinary women.[12] Certainly, this interpretation can be applied, to an extent, to Scott and Ayrton – yet just as important are issues of class and participation in more general social–scientific networks, often based around the home. The male mentor explanatory framework, used in isolation, can sometimes hide a more complex picture and so conspire to relegate women to a secondary role. Both Scott and Ayrton were affected by these issues; they were married to eminent men of science who researched in the same field; however, after being widowed, Ayrton still managed to be scientifically productive for some 15 years. Marriage and collaboration was an important thread for both and, although each woman negotiated this differently, it still affected the reception and interpretation of their homemade science.

What makes it interesting to compare these women, too, is that one was a botanist and the other a physicist: Did the domestic setting of their science impact the women differently because of their contrasting disciplines? Botany and physics developed very different cultures and traditions. Physics, a self-consciously virile activity which emphasized experimentation in the laboratory and a mathematical representation of the world, developed a culture that excluded women right from the start of modern science. This can be traced back to the seventeenth century in Britain, when femininity became the antithesis of a new, active experimental science which sought to break from the contemplative, investigative style of the past.[13] This distancing of women and femininity from experimental physics in particular was exacerbated by the tradition of Nature being personified in only female form. Male experimenters made Mother Nature the object of their investigations and characterized her as a female muse who could seduce and trick them, but, if tamed, would also allow them to penetrate her secrets. This representation cast woman as the passive subject of enquiry and man as the virile, active investigator in a duality which only added to the dissonance between femininity and science.[14]

Botany, in contrast, did not move wholly into the laboratory and continued, to an extent at least, to seek phenomena as they occurred in nature. Indeed, botany had a tradition of including women in what was seen as a morally uplifting Enlightenment science. Until the early nineteenth century, as Ann Shteir summarized:

> [W]omen had more culturally sanctioned access to botany than to any other science: they collected plants, drew them, studied them, and named them, taught their children about plants, and wrote popularizing books on botany. Botany came to be widely associated with women and widely gender coded as feminine.[15]

One may have anticipated that homemade science would not have been so problematic for a woman botanist as for a woman physicist/engineer; however, this does not follow from a case study of Scott and Ayrton. During the second half of the nineteenth century, the study of plants was transformed into botanical science and moved away from describing the natural world after the Linnaean system and instead focused on investigating the structure of plants. According to Shteir, this involved the defeminization and professionalization of the discipline, including strategies to set women's botanical activities apart.[16] More generally, this was a time too when science specialized and fragmented, and when scientific practitioners increasingly required the credibility of academic qualifications. By the first decades of the twentieth century, the professional scientist had acquired a distinctly masculine identity. This was the culmination of a process that had begun in the first decades of the nineteenth century when scientific disciplines and institutions reorganized. At this time the term 'scientist' emerged, and organizations such as the British Association for the Advancement of Science were established, with an understanding encoded in their regulations that women would only ever play a passive role as spectators of science, if indeed they had any role at all.[17] The rise of mass media before World War I reflected this understanding of professional science; the new magazines and journals, as well as established newspapers and media, greedily covered the developments of science and technology and gave these an almost exclusively masculine character. In these reports, the professional male scientist was most often represented as a brave and heroic seeker after truth.[18] Women's homemade science was doubly suspicious in this world, where the status and credibility of knowledge was dependent on the personage of the scientist, as well as upon the location and context of the space of its production.

At home with Rina Scott

Henderina Victoria Klaassen came from an educated, middle-class background and a family life that revolved around science in the home. Her father, Hendericus M. Klaassen, had arrived in England as a 20-year-old from Hanover and, after a successful career in business, from 1874 onwards pursued his scientific interests by taking classes at University College London in chemistry, zoology, and geology. He was elected a Fellow of the Geological Society in 1877 and submitted two papers to its *Proceedings*.[19] Hendericus was fascinated by the plant and animal fossils exposed by railworks near his home in Croydon, and imparted this enthusiasm to his daughters, Henderina and Helen.[20] He was also a supporter of education for girls and was one of the movers behind the creation of a girls' secondary school in Croydon under the auspices of the Girls' Day School Trust. Helen embarked on a career in physics at Newnham College, Cambridge, but Henderina's scientific interests followed those of her father more closely; she became a student at the Royal College of Science in South Kensington in 1886 where she attended advanced classes in botany held by Dukinfield Henry Scott (known as DH Scott) at the Jodrell Laboratory at Kew. Marriage to the professor followed shortly after in 1887.

DH Scott (1854–1934) is a well-known 'father' of palaeobotany; he was elected FRS in 1894, was president of the Linnean Society in 1908–1912, and received various honorary degrees and prizes. DH was known for his support of female botanists; his obituary in *The Times* quotes a former student who suggested, 'All women should honour the memory of Dr DH Scott, for he was the first lecturer on Botany at University College who allowed women to enter his class.'[21] In 1892, DH took up an appointment as honorary director (unpaid) of the Jodrell Laboratory at Kew, where he briefly established it as a national centre for palaeobotanical research.[22] DH was a man of independent means and, for much of his career, he enjoyed no institutional affiliation at all. In 1906 he retired from Kew and moved with Rina to East Oakley House, near Basingstoke, 'where he spent the rest of his life, seldom going farther from home than to his favourite haunts on the south coast'.[23] Here DH and his wife researched independently and together, and it was from here that they published their individual and joint papers and books. So, from 1906 to Rina's death in 1929, for more than 20 years, the couple's joint and individual research was homemade – yet the domestic/amateur taint did not affect her husband in the same way that it did Rina. Husband and wife collaborated and carried out independent research but, in obituaries and memoirs, she is invariably cast as his assistant and helper and her independent research receives secondary attention.[24] There is no doubt that they were a scientific couple. In 1904 they were both delegates to the International Botanical Congress in Vienna, where DH delivered a paper, and Rina 'was frequently with him at botanical and other scientific meetings, such as those of the Linnean Society, the British Association, and the South-Eastern Union of Scientific Societies'.[25] However, this stereotypical narrative obscures Rina's own strong scientific credentials.

In his books and papers, DH Scott typically writes of his indebtedness to his wife, 'Mrs DH Scott', for assistance and sketches, and it is clear that his science benefited enormously from her scientific expertise and service. Rina was intimately aware of her husband's research; she catalogued and indexed his collections of fossil slides and provided illustrations for DH's influential textbooks, *Introduction to Structural Botany* (1897) and *Studies in Fossil Botany* (1908).[26] However, Rina, who had pursued her own scientific interests since childhood, also made her own botanical investigations a major part of her life.

Rina's research into living and fossil plants resulted in several publications. Before marriage she collaborated with DH on the structure of algae cells, and although the paper appeared in his name only, he acknowledged her contribution.[27] Rina also submitted, in her own name, papers to *The New Phytologist* in 1906 and to the *Annals of Botany* in 1903, 1908, and 1911.[28] Earlier, she had collaborated with Ethel Sargant to research the seedlings of the wild arum, work that resulted in a joint paper published in the *Annals of Botany* in 1898.[29] Rina Scott and Ethel Sargant can be identified among a significant number of women working in palaeobotany in the first decades of the twentieth century.[30] In 1905, they were both among the first women finally admitted as Lady Fellows of the Linnean Society.[31]

Nature captured in time

Some of the most interesting – yet forgotten – outcomes of Rina Scott's homemade science were produced independently of her husband; this work made use of an early cinematograph, a film camera with a projector and developer, to record what Scott called animated photographs of the growth and movement of plants. As she explained in a lecture:

> An ordinary cinematograph picture reproduces rapid movements of living objects. The purpose of my pictures is to show at an accelerated speed slow movements that cannot be watched by the eye, such as

> the growth of the young plant from the seed, the opening of a flower and development of the fruit, the movements of a climbing plant, &c.
>
> Thus I have been able, by taking photographs at uniform intervals throughout the day during many weeks, to show these photographs in a cinematograph, so that the growth and movements of the plant made during these weeks can pass before the eyes in a few seconds. After a warm rain we often say that we can almost see our plants growing; by means of this adaptation of the cinematograph we literally can.[32]

Scott showed, in slow motion time-lapse photography, the opening of buds, pollination by a bee, the unravelling of a shoot, and other manifestations of plant activity. For this groundbreaking work, she used a Kammatograph, which was specially adapted by Leonard Kamm, who patented the instrument in 1898, two years after Auguste and Louis Lumière's first demonstration of the cinematograph in Britain.[33] This very early cinematograph was a camera and projector in one, which, in place of celluloid ribbon, used glass plates with miniature images arranged in a spiral to project movement. This technology limited Scott's work at times as she could only record phenomena over a time period that would fit into the 354 images available on each plate. This filmless camera was used with a lantern projector for showing. Scott demonstrated her animated photographs in London to the Royal Horticultural Society, Botanical Society, and Royal Society at its 1904 conversazione. She published papers detailing her findings in the *Annals of Botany* in 1903, in the popular, sixpenny *Knowledge and Scientific News* in 1904, and in the *Journal of the Royal Horticultural Society* in 1907.[34]

It should be noted that the Kammatograph would have been cumbersome and quite painstaking to use, especially for the regular, time-consuming and repetitive use to which Rina Scott put it; it also required smelly chemicals. She used as subjects plants that she had raised in her own greenhouse; she was the one who maintained the grounds and gardens at East Oakley House, and she was rumoured to have a magic touch with plants, which 'arose in obedience to her will'.[35]

Scott's filming of plant growth and insect activity was advanced for its time and in keeping with understandings of the development of slow-motion techniques as being predominantly connected to their use for science. According to cultural historian David Lavery:

> [T]ime-lapse photography was first envisioned theoretically by physicist Ernst Mach in 1888, though it was not implemented until a

> decade later. A century of real world use of time-lapse photography would begin with German botanist Wilhelm Pfeffer's documentation of the eleven-day growth of beans in 1898 . . . . In 1904, Pizon used a form of time-lapse . . . to record the growth and development of a colony of bacteria . . .
>
> In the hands of pioneers like the Russian American biologist Roman Vishniac (1897–1990) and the American inventor John Ott (1910–2000), time-lapse would be used in a variety of practical and scientific ways, simultaneously 'revealing beauty while serving as a tool for the scientist'.[36]

A key figure in the history of time-lapse photography of biological phenomena is Jean Comandon, who, from 1909, ran a micro-cinematography laboratory for Pathé in Vincennes, where he filmed phenomena including microbes and the movements of the heart.[37]

In the UK, F. Percy Smith's film *The Birth of a Flower* was issued in Kinemacolor in 1911 and is recognized as a milestone in animated film-making; Smith went on to produce over 50 films before World War I, including several utilizing microscopy.[38] There is little doubt that Scott's work was amongst the earliest in this field; yet, in keeping with the 'Matilda effect', she is not part of the history of this discipline. That her films were produced in the gardens of her home instead of in professional setting like those of Comandon and Smith, also made it difficult for her work to be recorded and appreciated as part of the developing specialism of time-lapse photography. Although Scott was elected a Fellow of the Linnean Society at around the time she was pursuing her animated photography, she did not have the institutional affiliation or qualifications to counter her science being interpreted through the prism of her status as a woman, wife, and mother, contributing to science as an amateur and hobbyist within the domestic sphere.

Rina Scott became the centre of what could be likened to an Enlightenment salon, which built on and provided an alternative to more formal and exclusive associations such as learned societies:

> As the wife and constant companion of a great botanist, Rina Scott found a position which gave full scope to her fine social gifts. The Scotts' home became a place where botanists, young and old, foregathered. Indeed, Mrs Scott's knowledge of, and sympathy with, the interests of her friends was quite remarkable.[39]

This understanding is echoed in obituaries of DH, in which appreciation is made of his and his wife's openness to all with an interest in scientific botany: at East Oakley House 'foreign botanists met with a warm welcome, and any diffidence they might have felt was soon dispelled by the joyful hospitality of their host and hostess'.[40] Financially secure, Rina could follow her scientific interests in her home, without the need to be paid, knowing that she and her work were respected by the people who mattered – the botanical scientific elite. She had social and marital position, and this facilitated her scientific status and connection to key botanical networks. This is illustrated by her nominees for election as Fellow of the Linnean Society; among the seven names signing her Form of Recommendation were some of the most influential male botanists of the day, including C Seward, Francis Darwin, FW Oliver and Arthur Lister.[41] However, unlike DH's position in these networks, Rina's status was predicated not on her science but on her identity as wife of an eminent scientist and hostess of scientific gatherings; as a result, her status as a scientific peer was easily disrupted and rendered secondary. Unlike Ayrton, there is little evidence that Rina did not identify with the wifely prescriptions of her time: she had six children, of whom four survived to adulthood, and she was involved in school and local parish politics. In a long, detailed and handwritten autobiography about his life DH mentions his wife only fleetingly at the very end:

> Marriage.
>
> I married, on Aug. 13th, 1887 Henderina Victoria Klaassen, daughter of H.M. Klaassen, F.G.S. My wife has greatly helped me in my work.[42]

His wife's expertise was, naturally, at his service, and her own homemade science was secondary – to elaborate further on her contributions would have detracted from his own, potentially jeopardizing his manly, professional scientific identity and status as head of a scientific household. These issues can be illuminated further with a consideration of the representation of the homemade science of Hertha Ayrton.

In the laboratory with Hertha Ayrton

Hertha Ayrton is significant for her researches into the electric arc in the 1890s, including her 1903 book, which became the standard text on the subject, and for her investigations into the formation of sand ripples. Ayrton received the Royal Society Hughes Medal for original research in

1906 in recognition of both these pieces of work.[43] She is also remembered as the first woman nominated for a fellowship of the Royal Society in 1902; alas, it was to be another 43 years before the nomination of a woman would be successful.[44] Like Rina Scott, Ayrton was of Continental European stock: her Jewish family had originated from Poland, and at the time she entered Girton College, Cambridge to study mathematics (with financial help from its co-founder, Barbara Bodichon, and others), her artisan family had achieved lower middle-class status. Always with a practical bent, Ayrton progressed from Girton to Finsbury Park Technical College to study electro-technics. There, after two years – just as Rina Scott – she married her professor, the electrical engineer William Ayrton. Although the Ayrtons collaborated from time to time, for the most part Hertha pursued her researches independently. Indeed, both husband and wife were fiercely protective of their individual scientific identities. An appreciation of William by his son-in-law in *The Times* noted his 'affinity for intellectual womanhood' and remarked pointedly that, unlike some men of science, he did not absorb his wife's life and work into his own: 'On the contrary he exerted himself to have her career recognized as separate and individual.'[45] Unlike Rina Scott who enjoyed a long marriage, Hertha was left a widow for some 15 years – William died in 1908 – during which time she continued with her scientific investigations; however, thereafter her science was homemade in a domestic setting.

Ayrton had undertaken her independent research into the electric arc in the laboratories of the Central Institution in London, where her husband was a professor. After her husband's death, she lost this tenuous and informal connection with the college and was transferred from his well-equipped institutional laboratory to a home laboratory in the drawing room of her London home in leafy Norfolk Square near Hyde Park. It was here that all her experimental researches were undertaken until her death in 1923. Now pursuing homemade science, Ayrton found her credibility and results questioned – challenges linked directly to the non-specialist space in which she pursued her investigations. Her home laboratory did not have the credibility of a modern, experimental space equal to those being used to standardize values in areas such as electromagnetism and electrical resistance. These institutional laboratories were built to block out vibration, sound, and other contamination from the outside world. Increasingly, the acceptance of experimental results was now dependent on the credibility of their site of production as well as on the trustworthiness of the man of science who had produced them.[46]

It is significant that the quality and efficacy of Ayrton's experimental apparatus was the focus of concern for the Royal Society on several occasions, leading to the rejection of a paper on sand ripples.[47] One referee questioned her research methods and characterized them as 'crude'.[48] In one of her papers on the subject, Ayrton describes her methods and how she made use of items found in a domestic setting. Initial experiments were executed with vessels of various shapes and sizes, from a soap dish to a pie dish, moving up the scale to a tank 44 inches in length. Rollers or cushions were put under these vessels to enable smooth rocking by hand or small electric motor which caused the water oscillations. In this way she examined varying ripple formations and, by adding finely powdered aluminium to the oscillating water, made visible the characteristics of water vortices.[49] Ayrton's experiments demonstrated that ripple marks were not formed by friction, as put forward by George Darwin at Cambridge University, but were due to the processes of varying water pressure. According to James Tattersall and Shawnee McMurran, independent experiments with ripple tanks by Ralph Bagnold (1946) and Desmond Scott (1954) confirmed Ayrton's conclusions, yet neither mentioned her pioneering results.[50]

If Royal Society referees questioned her techniques, even sympathetic contemporaries expressed mild scepticism and wrote of how hard it was to appreciate her ideas due to the 'toy-like models' used in her laboratory.[51] Another memoir describes Hertha's use of 'a morsel of feather on a single thread of silk, anchored to a hat-pin' with which to test the speed that coal gas is driven through tubes.[52] A photograph of Hertha Ayrton in her laboratory which, although undated, probably originates from 1906, the year that she received the Royal Society Medal, reflects this hesitancy about her homemade science and the domestic space of its production (Figure 4.1). Ayrton is positioned in front of a bookcase, a potted plant and vase are above each shoulder, and paintings hang on the wall above her head. She stands in front of a table upon which is a barely visible glass tank. The edge of another glass tank can just be seen, resting on top of a table covered in a velvet cloth. Ayrton herself is dressed as to receive visitors, wearing jewellery, avoiding our eyes by gazing out towards the right of the photograph. The apparent domesticity of her experimental apparatus means that there is no obvious signifier of Ayrton's profession in the portrait. The effect is ambiguous: Is this a scientist in the laboratory? Or a hostess in her drawing room? The tidy, domestic values so connected with notions of femininity can also be read from this image. The visual subtext revealed by Ayrton's portrait is that a woman's space is the home, not the laboratory.[53]

Figure 4.1 'Mrs Ayrton in her Laboratory' from *Hertha Ayrton, 1854–1923: A Memoir*, 1926.

This confusion and uncertainty over the status and robustness of a home laboratory – a woman's home laboratory at least – is also reflected in a fictional account of Ayrton's life written by her stepdaughter, Edith Ayrton Zangwill. In *The Call* (1924) Ayrton, a member of Mrs Pankhurst's Women's Social and Political Union, becomes Ursula, the heroine of a novel nominally sympathetic to scientific femininity and generally categorized as a suffrage text. Despite *The Call*'s endorsement of women's emancipation, the author reveals some ambivalence to a woman in the laboratory and uses the spectacle of this as a curiosity with which to generate humour:

> From the room within came a curious fizzling sound and a faint but still more curious odour. Some demented domestic appeared to be frying a late and unsavoury lunch in her bedroom. No servant would have condescended to a shapeless, blue-cotton overall and, still less, to hideous, dark goggles, made disfiguring by side-flaps . . . all was dominated for the moment by a hissing jet of flame that darted out between the small, dark objects held in metal clamps which stood on a table in front of the girl.[54]

Zangwill's uncertainty over a woman pursuing science in the home, or how to represent her, is also revealed by the heroine's mother, who names her daughter's home laboratory as the infernal regions of the house and feels uncomfortable visiting there. Similarly, Ursula's suitor finds himself uneasy accompanying his beloved into the laboratory, and reflects that he prefers to meet her in the park because she is less scientific and more human there.

Conclusion

The experiences of Henderina Scott and Hertha Ayrton illustrate that, in the later nineteenth and early twentieth centuries, the meanings attached to science crafted in the home were different for women, largely due to their sex and its intimate associations with the domestic. Men such as DH Scott worked in the home, but did so with the reinforcement of connection to institutions through fellowship, qualification, or position; these advantages rendered their identity as a scientist as primary and stable, unharmed by taint of dilettantism. By contrast, the scientific identity of a woman was always secondary to her identity as homemaker, wife, and mother; as a result women's homemade science was at risk of being viewed as interesting but marginal, a hobby but not a mainstream project of investigation. Despite this, female scientists – of social standing at least – were included in the polite, informal networks of science and accepted to an extent by the male scientific establishment, albeit they were kept at arm's length by elite institutions. Scott was privileged and well connected; at her home she assumed the role of hostess at the centre of gatherings including the great – and soon-to-be great – names of the London botanical world. These scientists were aware and respectful of her homemade science, but her role as companion, wife, and helpmeet to a great botanist was seen as foremost. As a result, Rina Scott's identity as a scientist, and her position as a peer in scientific networks, were both constantly unstable and subject to disruption.

At the time when Scott and Ayrton pursued their homemade science, space was gendered and there were few physical places that men and women shared on equal terms. Separate spheres placed the middle-class woman in the home and men in the great world beyond; although separate spheres can be criticized as implying too rigid a division, especially when applied to the turn of the nineteenth century, it is clear that women were defined by the home in a way that men were not. Although some notable male scientists in the late nineteenth and early twentieth centuries pursued their work in home laboratories and embraced an identity as head of a scientific household, this served to reinforce their position as scientific investigators of standing and leadership. As Hannah Gay has demonstrated with reference to chemist and president of the Royal Society in 1913–1915, William Crookes, the identity of a head of a scientific household could reinforce a man's status in science and enable him to maximize his personal scientific output with the help of a largely invisible circle of family support.[55] Although Ayrton was a widow during the time that she pursued much of her scientific investigations in her home laboratory, unlike Crookes she did not acquire the status of head of a scientific household. She worked alone for most of the time, did not have a scientific familial network to support her, and, as a woman, her management of her home did not imply the same connotations of mastery and leadership.[56]

That Ayrton's laboratory was located in the home determined to a large extent the type of research she could carry out as she did not have access to specialized equipment and so crafted her experimental science using what was available at hand. This home-crafted nature of her science led to questioning of the credibility of her experimental findings, in contrast to the positive reception of her earlier work on the electric arc carried out in the laboratories of the Central Institution. Although many male scientists had home laboratories, after the aristocratic house tradition, by the late nineteenth century they were rarely the only venues for experimental work to which these men had access.[57] For example, Nobel Prize winner Lord Rayleigh had developed large and well-known laboratories at his home, yet he also researched and held professorships at the Cavendish Laboratory and the Royal Institution, and he later played a leadership role on the executive committee of the new National Physical Laboratory. The connection of these laboratories to a wider institutional and scientific network helped preserve their credibility and integrity as viable places of experiment. Ayrton's homemade science did not benefit from these further signifiers of worth available to men of science. Working only from home, without position, implied amateur status by the closing years of the nineteenth century and conspired to isolate women from professional recognition.

Despite pursuing her researches as a widow for some 15 years, Ayrton was still described as the wife of an eminent physicist – with all the challenges to her individual scientific credentials that this entailed. Although this was Scott's fate too, it can be argued that, to a large extent, she was complicit in merging her scientific identity with that of her husband. Scott was happy with the role prescriptions of her time; a decision that can be better understood if we remember that, up until 1975, women who married were required to resign from the Geological Survey and other scientific and non-scientific civil service posts.[58] Typically for scientific women who were not teachers, both Scott and Ayrton pursued their science voluntarily for no pay. Teaching or other academic positions at women's colleges were practically the only professional roles available for scientific women at this time, and other options were generally unpaid, voluntary, and pursued at home. This narrative can be seen in the life of other female scientists, including the palaeontologist Dorothea Bate, who was connected but peripheral to the British Museum (Natural History) for most of her life.[59]

Ayrton challenged the idea that women and women's science – homemade or otherwise – was secondary or different to that produced by a man, and struggled to hold on to a scientific identity that was distinct and separate from that of her husband's. Yet, a comparison of obituaries, one of DH Scott (1934) and the other of Hertha Ayrton (1923), foregrounds the difficulties that scientific women producing homemade science faced in creating a unique persona that was not secondary to their husbands':

> [F]or rather more than forty years he [DH Scott] experienced the joys of an ideal companionship. Mrs Scott, herself the author of several botanical papers, shared as artist and secretary in the production

> of books and contributions to scientific journals. By her strong personality, characterised by qualities complementary to those of her husband, she rendered invaluable service through her constant, unobtrusive watchfulness over his happiness, and by her determination to shield his sensitive nature from soul-destroying worries and annoyances.[60]

Contrast this to the ungenerous obituary of Hertha Ayrton in *Nature* by the chemist Henry Armstrong, FRS; this references the same issues, but only to criticize Ayrton as a woman who failed in her wifely duties and who did not submit to the perceived scientific needs of her husband:

> [T]hough a capable worker, she was a complete specialist and had neither the extent or depth of knowledge, the penetrative faculty, required to give her entire grasp of her subject .... He [William Ayrton] should have had a humdrum wife ... who would have put him into carpet-slippers when he came home, fed him well and led him not to worry either himself or other people, especially other people; then he would have lived a longer and happier life and done far more effective work ... [61]

Tensions stemming from the tenuous and unstable scientific identities of Rina Scott and Hertha Ayrton form a strong subtext in these obituaries. Contemporary and later understandings, and indeed neglect, of the scientific work of these women have arguably been coloured by its homemade character, the domestic space of its production, and the sex of its producer.

Notes

1. Anon. (1899) 'Royal Society's Conversazione', *The Times*, London, 22 June 1899, p. 12.
2. H. Ayrton (1910) 'The Origin and Growth of Ripple-Mark', *Proceedings of the Royal Society of London*, Series A, *84*, 285–310.
3. For more on Annie Maunder, among the first female fellows of the Royal Astronomical Society, see M. Bailey Ogilvie (2000) 'Obligatory Amateurs: Annie Maunder (1868–1947) and British Women Astronomers at the Dawn of Professional Astronomy', *British Journal for the History of Science, 33*, 67–84.
4. M.R.S. Creese (2005) 'Saunders, Edith Rebecca (1865–1945)', *Oxford Dictionary of National Biography*, Oxford University Press, http://www.oxforddnb.com/view/article/37936, date accessed 18 August 2014. For Dorothea Bate

see K. Shindler (2005) *Discovering Dorothea: The Life of the Pioneering Fossil-Hunter Dorothea Bate* (London: HarperCollins).

5. See P.G. Abir-am and D. Outram (eds) (1987) *Uneasy Careers and Intimate Lives: Women in Science, 1789–1979* (New Brunswick: Rutgers University Press); and L. Schiebinger (1989) *The Mind Has No Sex? Women in the Origins of Modern Science* (Cambridge, MA: Harvard University Press), esp. pp. 245–64.
6. See S. Ardener (ed.) (1993) *Women and Space: Ground Rules and Social Maps* (Oxford: Berg).
7. See R. Iliffe (2008) 'Technicians', *Notes and Records of the Royal Society of London, 62*, 3–16; H. Gay (2008), 'Technical Assistance in the World of London Science, 1850–1900', *Notes and Records of the Royal Society of London, 62*, 51–75.
8. M.W. Rossiter (1993) 'The ~~Matthew~~ Matilda Effect in Science', *Social Studies of Science, 23*, 325–41.
9. For an example see M.L. Richmond (2001), 'Women in the Early History of Genetics: William Bateson and the Newnham College Mendelians, 1900–1910', *Isis, 92*, 55–90.
10. See J.N. Burstyn (1980) *Victorian Education and the Ideal of Womanhood* (London: Croom Helm); and B. Caine (1986) *Destined to be Wives: The Sisters of Beatrice Webb* (Oxford: Clarendon Press).
11. C. Smith (1897) 'An Admirable Arrangement', *Lady's Realm, 2*, 76–81; M. Beetham (1996) *A Magazine of Her Own? Domesticity and Desire in the Women's Magazine* (London: Routledge), p. 133.
12. H.M. Pycior, N.G. Slack and P.G. Abir-Am (eds) (1996) *Creative Couples in the Sciences* (New Brunswick: Rutgers University Press).
13. Schiebinger, *The Mind Has No Sex?*; M. Wertheim (1997) *Pythagoras's Trousers: God, Physics and the Gender Wars* (London: Fourth Estate).
14. L. Jordanova (1993) *Sexual Visions: Images of Gender in Science and Medicine between the Eighteenth and Twentieth Centuries* (Madison: University of Wisconsin Press).
15. A.B. Shteir, 'Gender and "Modern" Botany in Victorian England', *Osiris, 12*, 29–38: 29.
16. Shteir, 'Gender and "Modern" Botany in Victorian England'.
17. J. Golinski (1999) 'Humphry Davy's Sexual Chemistry', *Configurations, 7*, 15–41.
18. P. Broks (1996) *Media Science before the Great War* (Basingstoke: Macmillan).
19. Anon. (1910) 'Hendericus M. Klaassen, FGS (1828–1910)', *Geological Magazine*, Decade V, *7*, 191.
20. Helen Gertrude Klaassen (1865–1951) was a demonstrator and lecturer in physics at Newnham College Cambridge; see Newnham College Archives, 'Klaassen, Helen Gertrude, Roll Card'. See also P. Gould (1997) 'Women and the Culture of University Physics in Late Nineteenth-Century Cambridge', *British Journal for the History of Science, 30*, 127–49.
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22. R. Desmond (1995) *Kew: The History of the Royal Botanic Gardens* (London: Harvell Press), p. 287.
23. F.W.O. and A.C.S., 'Dukinfield Henry Scott', p. 224.

24. For example, A.B.R. (1929) 'Mrs Henderina Scott', *Journal of Botany, 67*, 57.
25. A.B.R., 'Mrs Henderina Scott'.
26. D.H. Scott (1897) *Introduction to Structural Botany* (London: Adam and Charles Black); D.H. Scott (1908) *Studies in Fossil Botany* (London: Adam and Charles Black).
27. F.W. Oliver (1929) 'Mrs Henderina Scott', *Proceedings of the Linnean Society of London, 141*, 146–7.
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59. Shindler, *Discovering Dorothea*.
60. This obituary goes on to describe Scott as 'A true Englishman of the old school, he had strong international sympathies; to him the *brotherhood* of science was a real thing'; F.W.O. and A.C.S., 'Dukinfield Henry Scott', p. 225.
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Part II

Constructions of Domestic Science and Technology

5

'My Daughters of Ceres': Domestications of Agricultural Science Education for Women

Donald L. Opitz

> The man, in his rough work in open world, must encounter all peril and trial .... But he guards the woman from all this; within his house, as ruled by her, unless she herself has sought it, need enter no danger .... This is the true nature of the home – it is the place of Peace.[1]

Ubiquitous amid Victorian prescriptions for men's and women's roles, including this excerpt from John Ruskin's famous 1864 lecture, 'The Queen's Garden', is the notion that a woman's place lay within the home in contrast to a man's 'open world' outdoors. This protocol infused a wide range of fictional and advice literature such as Coventry Patmore's popular narrative poem, *The Angel in the House* (issued in four instalments between 1854 and 1862), as well as Christian teachings about the wife's responsibility as a 'helpmate' to her husband, or, according to Samuel Smiles, as a 'staff to lean upon'.[2] As many literary critics and historians have chronicled, an entire literature mushroomed in the nineteenth and twentieth centuries, both in Great Britain and the United States, that codified a gendered division of social and physical space into 'separate spheres', one sphere domestic and private, under the occupation and preoccupation of women, the other outside the home and public, quite literally the business of men. This gendered structuring of privacy and public affairs owed much to the emergence of a bourgeoisie and, concomitantly, its public sphere, as explained by Jürgen Habermas. Although, as feminist historians have critiqued, the implications for gender roles remained largely rhetorical, as an ideology 'separate spheres' nonetheless strongly influenced practice and experience in real ways, ranging from legal curtailments of women's rights to property, suffrage, and public office, to negotiations between betrothed couples over their expectations for their marital roles and responsibilities.[3] Historians of science have noted, too, how the general social mores guided marital collaborations in scientific research, explaining, on the one hand, the buttressing of the 'man of science' and, on the other, the parallel undervaluation of women's scientific contributions.[4]

Although the home has thus often been translated as a kind of rhetorical asylum for women, restricting their access to the spaces, resources, training, and networks vital to full participation in academic and professional worlds, it has also been recognized as a context that could, alternatively, be deployed for their advancement. In science, the home earned recognition both as a valid research site in new fields relying upon amateur contributions – early twentieth-century genetics offering a case in point – as well as a target for the application of 'domestic science', a new discipline incorporating a range of natural and social sciences, and building upon and promoting women's special expertise in managing households.[5] As scholars have noted, the rise of domestic science tended to ghettoize women in science, yet as an educational movement with political potential, the field also served to strategically advance women's causes, especially in suffrage campaigns.[6] Here I will extend such a strategist perspective in analysing another arena in which an emphasis on domesticity served to promote the status of women: that being agriculture. Directly challenging the notion that women's work belonged inside the home, advocates for women's agricultural work outdoors strategically clothed that work in domestic terms, in other words, still residing within, and ultimately benefiting, a sphere considered to be 'domestic', in two senses: first, of the home in which the family resided, and secondly, of the national home of consumers situated within a global marketplace. Proponents of women's agricultural training and work effectively domesticated this field by drawing upon conservative ideas about women's roles to argue for the suitability of women for agricultural work, not in the most general sense, but rather within a quite specified, domestic sphere.

In this chapter I examine the domestication of agricultural science within the movements for women's education in agriculture and horticulture in Britain and the United States in the decades around 1900. The significant level of cross-Atlantic collaboration and exchange of ideas guides my consideration of these two otherwise distinctive national contexts as part of an international effort.[7] In my analysis, I focus on the rhetorical arguments advanced by the leading voices of the movements, the design of the educational institutions, and the intended destinations for trainees. In each of these areas, I show how the logic of 'separate spheres' infused the agendas and their outcomes. From my analysis, I conclude that, up to World War I, despite the real gains the movement achieved under the guidance of a domestic paradigm, those gains nonetheless were confined to a limited sphere of activity within agriculture – and effectively horticultural – circumscribed by the paradigm. Although the movements failed to significantly counter stereotypes of women's roles and work, and open up traditionally male occupations in agriculture to women, they did create an infrastructure and a rhetorical strategy upon which subsequent gains, like the organization and promotion of the wartime women's land armies, could be built.

'Lighter branches of agriculture' as a domesticated sphere

Historians have analysed how an ideology of separate spheres played out differently in the nineteenth century between urban and rural contexts, with women in farming communities both in the United States and Britain defying the simplistic 'Angels in the House' of urban domestic advice literature. Published agricultural guides encouraged women's participation within farming production outside of the house, though, by the mid-nineteenth century, this increasingly specified a 'domestic economy' primarily restricted to such work as raising poultry, dairying, and market gardening. Early on, writers ascribed national importance to this sphere of rural economy. The English radical William Cobbett, who spent some years living in rural America, argued that the power of a nation ultimately rested in the ability and character of its people which, in turn, relied upon families' 'economy', defined as management of 'the affairs of a house and family'.[8] As we will see, such a linking of the domestic economy of households with national strength recurred among the arguments favouring women's agricultural training later in the century.

Although commentators recognized the importance of women's productive work within rural domestic economies, as Joan Jensen observed, whereas 'rural men established public forums for educating themselves and exchanging information, women developed no parallel institutions' for much of the nineteenth century.[9] The USA and Britain shared in this situation, and, by the mid-1870s, rural and urban writers of both countries recommended the creation of formal agricultural training programmes especially designed for women. A confluence of objectives spurred their agendas into actualization by the 1890s: to promote small culture and thereby reverse the trend of big commercial farms overtaking the industry, to promote the education and economic status of middle- and upper-class women, and, particularly in the case of Britain, to increase women's potential for mitigating the effects of a massive agricultural depression on rural communities.[10] At the forefront of the arguments, proponents emphasized how trained women agriculturalists could suitably and usefully contribute to a domesticated sphere consisting of the 'lighter branches of agriculture', reincarnating and applying a form of the 'cult of True Womanhood' that had enjoyed popularity earlier in the century.[11]

Occasional uses of the phrasing 'lighter branches of agriculture' can be found in the agricultural vernacular without a gendered connotation, but throughout the nineteenth century, and particularly within the discussions on women's suitability for farm work, it carried a distinctly feminized meaning – as did the activities falling within the category of work it named. Although the popularity of its feminized form peaked at the turn of the century when repeatedly invoked to promote Lady Warwick's scheme for women's agricultural training in Britain (to which I will return later in this section), American reformers employed the language to carve out an agricultural sphere of work for women much earlier in the century.

The distinction between 'light' and 'heavy' manual agricultural labour was articulated among the writings of the French utopian reformer, Charles Fourier, and his chief American exponent, Albert Brisbane. In his column for the *New York Tribune* and his highly influential book, *Social Destiny of Man* (1840), Brisbane advocated for a sexual division of agricultural labour that assigned the 'heavier branches' to men and 'minor branches' to women and children. Whereas the former included 'Works of Irrigation', 'Care of Forests', and 'Cultivation of Grains', the latter encompassed 'the care of small domestic animals, of poultry, the gardens, etc.', as well as 'all the smaller classes of fruit trees and shrubbery'.[12] Having lived and worked on her father's 40-acre experimental farm in Waverly, New Jersey, Mary Mapes Dodge carried this view forward in her 1864 article on farm women for *Harper's New Monthly Magazine*: 'Woman, however, is especially adapted to the lighter branches of agriculture, and while her "big brother" has stronger muscles and a hardier frame than she, it is undesirable that she should devote herself to the heavy manual labors of the farm.'[13] As Deborah Fink explained, such gendered discourses instantiated an American agrarianism ideology that assigned women to supporting roles in a manual enterprise centred on the virility of the male farmer.[14] A kind of biological determinism underpinned the logic of this ideology; as Brisbane wrote, 'The true occupations of the male sex are those which require bodily strength.' In these representations, 'lighter' indeed denoted less weight, and the widespread concern for protecting women from overtaxing their bodies while performing farm work repeatedly accompanied all stages of the educational developments about to unfold.[15]

To counteract stereotypes about women's unsuitability for farm work, writers highlighted women's successes in active management and hands-on labour. A representative case was that of Marie Louise Thomas, who single-handedly managed a small farm in Tacony (near Philadelphia), Pennsylvania, as a means of sustaining her family as her aged husband, the noted Unitarian minister Abel Charles Thomas, declined in health. There she directed the cultivation of wheat, pears, and smaller fruits; the raising of cattle, poultry, and bees; and the production of butter and honey. Thomas explained her success to would-be women farmers in lectures and published testimonies that reached readers on both sides of the Atlantic.[16] In her testimonies, she directly challenged the popular sex-typing of farm work. She wrote in 1875:

> We have a farm of twenty acres. All that is done upon it is altogether and entirely under my direction and personal superintendence. I have never found any hindrances that a man might not have found.... The[re] are no sex prejudices in the natural forces of the universe. The earth yields her increase just the same to woman as to man if the conditions of cultivation are the same.[17]

Among her set of 'Women Agriculturalists', suffragist Phebe Hanaford highlighted the case of Mary Wilson, a 72-year-old proprietor of 180 acres in Ontario County, New York, who 'swings a scythe and handles a pitchfork with the ease of a man in his prime'.[18] Jeanne Smith Carr, who superintended a fruit farm of 43 acres, observed in 1884 how women's skills in domestic economy readily translated from the home to the land: 'Women who engage independently in farming, find little antagonism to overcome. So close is the relation between the land and the home that a woman who finds herself with evidences of thrift and skill commands universal respect.'[19]

Despite the dissemination of such exceptions like Thomas and Wilson, proposals for the formal training of women more often employed the logic behind Carr's view, that women's peculiar domestic skills could be successfully adapted to agriculture, and especially within those branches that were typical of domestic economy and required less physical strength. The issue received unprecedented attention in British labourers' and women's periodicals in the late 1870s, as debates ensued over female education and employment, while, in parallel, concern developed over the onset of an agricultural depression. Correspondents to *The Woman's Gazette* between 1876 and 1877 raised the question of market gardening as an area of employment for *ladies* among the distressed gentlewomanly class, and the forceful Frances Power Cobbe elaborated how the success of one 'gardeness' could serve to build a movement: '[W]hen her little establishment is in full working order, our lady market-gardener might invite one or more other ladies to board and share her work, who will thus study practical gardening as a profession.'[20] Meanwhile, building upon the ideas of horticulturalist Frederick William Burbidge, who advocated for technical instruction in small culture as a means for bolstering Britain's competitive edge internationally, Jane Chesney O'Donnell proposed the founding of a horticultural college to train women, given her assessment that 'there is no opportunity for women to learn gardening, and the art is supposed, when they practise it, to come to them by nature'. She argued for the suitability of horticultural employment for women, and, as with agriculture, she created a gendered hierarchy of its branches that accommodated women's distinctive intellectual, emotional, and physical abilities:

> We want, then, some callings for young women . . . , and several might be found in connection with the higher branches of horticulture. Indeed, if we except the roughest kinds of labour, there is scarcely a department of gardening which women could not carry out successfully, while for many operations their quick intuition, their patience, and their skilful fingers are pre-eminently suited.[21]

Her proposal came to fruition through the founding of Isabel Thorne's short-lived Ladies Association for the Promotion of Horticulture and Minor Food Production in London in 1879, followed by Arthur Harper Bond's longer-lived Horticultural College in Swanley, Kent, opened to men in 1889 and to women in 1891.[22]

The British movement primarily focused on positioning women for horticulture, that is, until the country gentlewoman, Frances Evelyn Greville, Countess of Warwick, joined the effort. She did so at the congress on 'Agricultural Education for Women in Great Britain, Ireland, and the Colonies', held in London during the summer of 1897, an event commemorating Queen Victoria's Diamond Jubilee.[23] Presenters addressed women's capacity for agricultural pursuits in the widest sense, and Lady Georgina Vernon, who kept an apiary at Hanbury Hall, Worcestershire, proposed 'activities connected with agriculture' as an answer to 'the problem of how to obtain the most profitable and suitable employment for women of the upper classes'.[24] Given her own rural and upper-class orientation with regard to the subject, Vernon emphasized the potential in small culture and estate gardening. With respect to dairying, for example, she advised against 'embarking in a large business which would entail a number of men for the care of the cows', emphasizing instead the profitability awaiting 'one or two girls joined together in a small dairy farm', perhaps one consisting of 'a small house and land for one or two cows'.[25] Present at the congress, Warwick picked up Vernon's main proposal and soon provided a full rationale for an 'Agricultural Training College for Women', which, although including 'practical work' in 'Horticulture', among other subjects, positioned 'Agriculture' as the overarching frame and leading subject for the college and its curriculum.[26] Warwick elaborated the idea that women could usefully contribute to the improvement of agriculture within a specified sphere:

> [M]en have not hitherto given the necessary time and thought to the lighter branches of agriculture, such as Poultry and Bee-keeping, Flower and Fruit growing, Jam and soft Cheese making, and such like; and it may be added that many women are gifted with more of the commercial instinct.[27]

Acutely aware of the criticisms against women's involvement in heavy farm work, Warwick embraced this traditional justification for 'women possessed of systematic training . . . in *supplementing*, not *supplanting*, the work of their husbands and brothers on the farm'.[28] Over the next decade, in publicizing her scheme, she and her collaborators singularly popularized a feminized version of the 'lighter branches of agriculture' discourse.

Housing agricultural education

Traditional collegiate education denoted residential education, and the models advanced for the agricultural and horticultural women's colleges were not exceptions. Even when provisions for commuter students existed, the manual work associated with farming and gardening demanded students' daily, early attendance, best achieved by living on the colleges' premises. Moreover, the traditional mode of agricultural and horticultural education involved apprenticeships on estates, and to the extent the new colleges – emphasizing, as they did, classroom-based, scientific instruction – could also replicate the actual conditions of the farms and gardens where trainees might work proved critically important to legitimizing these new schemes alongside the traditional system. This was already understood by the heads of all-male schools, such as the Colonial College at Hollesley Bay, in Suffolk, instituted to prepare young men for contributing to the agricultural improvement of the British colonies. Robert Johnson founded this college in 1887 on a 2,000-acre country estate within 'a thoroughly Colonial atmosphere', touting that the instructors' and students' 'habits are in themselves Colonial – including even our costumes!'[29] The establishment of the initially all-male Horticultural College at Swanley relied upon its being situated at the 43-acre country seat of a gentleman retiring to London. Its mansion, Hextable House, provided rooms for lectures; the surrounding land offered space for experimental gardens and greenhouses; and other nearby dwellings served as student hostels. Both new collegiate schemes emphasized theoretical, scientific instruction paired with practical application, introducing a new educational model that leveraged scientific principles, as encouraged by the technical instruction movement, whilst upholding the value of hands-on training.[30]

Situating the schools in such repurposed domestic sites as country houses on suburban and rural estates fed into a growing trend, both in Britain and the United States.[31] On the British side, adding to the examples of Hollesley Bay and Swanley, the British Women's Emigration Association, in 1890, opened the Colonial Training Home at the Leaton Grange country estate in Wrockwardine, Shropshire. By 1902, Lady Warwick transferred her scheme, originally located in hostels in Reading, Berkshire, to a 340-acre farming estate in Warwickshire, and specifically within the historic Studley Castle seated there. Although the quarters of the American schools were architecturally more modest, the most significant of them, the Pennsylvania School of Horticulture for Women, was founded in 1910 on a 71-acre farmstead at Ambler, outside Philadelphia, with the main farmhouse containing the school's classrooms and administrative office, and a nearby cottage the students' residence. 'A feature of life' at the school, highlighted an early prospectus, was 'its home atmosphere'.[32]

Particularly for the new women's colleges, locating the schemes within domiciles effectively reified the ideals of the domesticated agricultural paradigm that guided the programmes' curricula. Advertisements reassured prospective students that they would enjoy all of the comforts of home whilst at college, and they could rely upon matronly stewardship from the likes of a 'Lady Superintendent' living among the students. Within the Lady Warwick Hostel scheme in Reading, an alumna association was established, with the name 'Guild of Daughters of Ceres', symbolically deifying the founder, Lady Warwick, as the goddess of agricultural fertility and mother of the students. Thereafter, in her communiqués to her charges, Warwick typically opened with the salutation, 'To My Daughters of Ceres'. Expressing this same motif through artwork, the lecture hall of the Horticultural College at Swanley was 'beautifully decorated with frescoes representing Ceres at play' (Figure 5.1).[33]

Behind the literary and visual representations, the new educational schemes executed an ideology of domesticity through their curricula, which universally included subjects that had become standards in the emerging field of domestic science. So, complementing theoretical and practical instruction in subjects germane to cultivating farms, gardens, orchards, and greenhouses – these included botany, chemistry, entomology, meteorology, soil science, and so forth – courses were also given in making farm-fresh foods like jams, butter, and cheeses, as

Figure 5.1 Dairy lessons in the lecture hall at Hextable House, Horticultural College, Swanley, date unknown, Hextable Heritage Centre, Horticultural College Collection, B9 D1/001H. By permission of the College Archives, Imperial College London.

well as in marketing the harvested and produced goods. Particularly within programmes especially created to train students for the management of colonial estates, courses addressed the efficient supervision and execution of housekeeping, including the minutiae associated with laundry, cooking, and more general 'housewifery'. The emphasis on 'domestic training' in the colonial departments of the agricultural and horticultural schools was strengthened with the renaming of Swanley's 'Colonial Branch' to 'Colonial and Home Domestic Training Branch' in 1909. Unfortunately, domestic science, and those branches of agriculture and horticulture most closely associated with the domestic sphere, tended to predominate in the schools' curricula, and so even when fuller agricultural training was offered, very few of the students completed the courses of study designed to qualify them for the standard farming and gardening occupations typically held by their male peers.[34]

Employing domesticity

Even given the different curricular emphases and pedagogic approaches, the proponents for women's collegiate agricultural and horticultural education shared a common understanding of its potential value within a broad employment sector. Whether instructed in the 'lighter branches of agriculture' or 'colonial and home domestic training', the schools produced a human resource, through their alumnae, possessing the potential to improve their nations' domestic economies and advance a domesticating, civilizing mission, both at home and, for the British colonies, abroad. This, in turn, also addressed the problem of 'surplus', unemployed single women, a growing economic concern in Britain as well as the mid-Atlantic and New England regions of the USA, notwithstanding important class distinctions. An appeal for public support for Swanley's colonial branch illustrated the popularity of this multifaceted, domestic logic driving the movements: 'Every woman trained in dairy and garden, orchard and poultry-run, still-room and kitchen, plays no small part in developing permanent resources now lying fallow and in basing our colonial Empire on that excellent foundation, the thriving English country home.'[35] The educational schemes, with their emphases on scientific and technical instruction, tapped their respective nations' surpluses of human resources among unemployed women, for improvement and application within 'light' agricultural branches – effectively a domestic sphere – for the benefit of national, domestic economies; in the process, this application effectuated a domesticating, civilizing mission.

Paid occupations benefiting national agricultural industries consistently remained the idealized destinations for the trainees, yet proponents stressed the suitability of domestic contexts for women's work, even when that work's relevance for national economic development remained only implied. In Cobbe's early advocacy for gardening professions for women trained in horticulture, she predicted they would 'fit themselves to take the posts of head-gardeners in country-seats where a few under-gardeners are employed'.[36] The gentlewomanly horticulturalist, Theresa Earle, known for her popular advice books on gardening and household topics, carried forward Cobbe's vision in an endorsement of Swanley's Horticultural College: 'Another opening may be found in cases of larger villas, where single ladies might prefer a woman head-gardener with a man under her to do the rougher and heavier work.'[37] In 1899 Swanley secretary, Ada Goodrich Freer, observed this apparent preference in the requests she received from recruiters: 'Nine-tenths, at least, of would-be employers who have applied to me for women-gardeners are themselves women, and in very many cases they have offered as a reason that they thought it right to promote a new opening for women's work.' Britain's pioneering female doctor, Elizabeth Garrett Anderson, provided a case in point. As noted by Elisabeth Crawford, a 'series of ex-Swanley gardeners' acquired situations at her Alde House in the Suffolk village of Aldeburgh.[38]

Steeped in the rhetoric of domesticity, such forecasts and early indicators of trainees' job placements were borne out by later studies. Based on a British survey of several hundred women who obtained collegiate education in horticulture, in 1915 Louisa Wilkins, an expert on the smallholding system, observed among the returns 'more than half the women leaving college have gone straight into posts as head or single-handed gardeners', with a corresponding dearth of situations as under-gardeners and improvers. She explained, 'employers who keep a small staff naturally prefer to have a man to do the heavy work since he can do such work quicker and better than most women', and she hypothesized the influence of 'a prejudice amongst men head-gardeners against having women under them; many do not care to give orders to a lady'.[39] Like Earle and others before her, Wilkins invoked the reigning gendered conventions that assigned 'heavy' manual labour to men and the lighter dimensions of the work to women. This echoed parallel arguments across the Atlantic, for example, that of the alumnae magazine of the Pennsylvania School of Horticulture for Women, which asserted that although women, 'as a rule', are not 'physically adapted to such work as plowing, spraying and handling heavy boxes and barrels of fruit . . . , they can learn how such things should be done and can direct the efforts of laborers at the rougher, heavier work, while they can do the lighter parts'.[40]

Whilst parroting such assumptions about physiologically based differences between the sexes, the spokespersons for the movements nevertheless stressed the wide opportunities available to women, again drawing upon and applying the ideology of separate spheres. Advocates emphasized how women's experience and skills, cultivated in a domestic sphere, could be extended within cognate circumstances outside the home, and thereby, concomitantly, pushed the boundaries of the domestic sphere outward. 'How often the busy housewife finds the time to grow a few plants in the south window and by constant coaxing succeeds with them under decidedly unfavorable conditions', observed John Doan, botany instructor at the Pennsylvania School. He then extrapolated, 'When a woman can devote her entire time to the growing of plants under greenhouse conditions, it is perfectly natural that she should succeed.'[41] Thus deemed sex-appropriate, greenhouses at commercial nurseries and smallholdings offered coveted destinations for the students, and vignettes of successful alumnae so-placed appeared in the college publications. The first annual report of the newly opened Women's Branch of the Horticultural College at Swanley particularly highlighted how sisters Jessie and Mildred Smith, upon earning their certificates, 'were immediately engaged by a local nursery-man for green-house work . . . though eventually they hope to become growers on their own account'.[42] The implied trajectory in this example, which was replicated for work in other sex-appropriate work settings, was one of increasing independence made possible by the progressive accumulation of experience and skills exercised at home, at college, at workplaces, and, finally, under one's 'own account'.

The college alumnae secured a wide range of occupations: teaching nature study in schools; managing gardens at convents, sanatoriums, and private estates; working in market gardens and nurseries; performing administrative and consulting work; assisting in agricultural research; returning to teach at their alma maters; and directing their own gardening schools, smallholdings, market gardens, and consulting firms. But, until the onset of World War I in 1914, which called upon women farm and dairy workers to replace conscripted men, the majority of the occupations remained largely confined to domestic situations, most typically within home gardens and farms.[43] Increasingly, within both the British and American contexts, commentators noted the limitations faced by trained women seeking to engage in paid farm work, even amid a growing awareness of the need for their labour.

Within both national contexts, the problem was perceived and framed as one entangled with the degradation of rural life alongside urbanization. On the British side, the prevailing concern was to counteract the agricultural depression that took hold of the nation in the late 1870s and retained its grip for decades. Conversely, on the American side, demand outstripped production as labour shortages increased, the result of, according to critics, massive migrations from the countryside to urban areas. On both sides the focus became one of retaining and expanding agricultural labour, with British efforts organized around a 'Back to the Land' movement and American ones around a 'Country Life' one. In both, promoters argued that mechanization, accompanied by scientific and technical competence, promised to increase efficiency and improve productivity.[44]

Recognizing the potentially mutual advantages – for women, for the nation – feminist agitators yoked their campaigns to these national agrarian movements. In Britain, Lady Warwick repeatedly stressed the value of employing women who received scientific training in the lighter branches of agriculture as a means for retaining women on the land. In 1901 she wrote to the readers of the London *Times*:

> We hear a great deal at present of the decay of agriculture and depopulation of our villages . . . The lack of technical education in our country districts is an admitted scandal . . . Every year the evil grows, and more land goes out of cultivation, while the foreign producer supplies us with many million pounds' worth of dairy and market produce that could as easily be grown at home. It was with the idea of meeting this foreign competition by assisting in the lighter branches of agriculture that I established the Lady Warwick Hostel . . . [45]

The wider publicity regularly employed the rhetoric of the Back to the Land movement: '[T]he lasses . . . follow the course of training which, according to Lady Warwick's scheme, leads energy and intellect "back to the land", instead of allowing them to run to waste in the towns.'[46]

In the USA, similar arguments for educating 'the farm woman' in agricultural and domestic sciences accompanied the objectives of the Country Life Commission and the subsequent movement it spawned. A leading spokesperson of the movement, the Cornell horticulturalist Liberty Hyde Bailey, argued in 1911 specifically for rural women's collegiate education in connection with the movement's nationalistic focus on agrarian improvement: 'If country women are to develop a conscious sense of responsibility in country-life betterment, education facilities must be afforded them.'[47] Bailey noted the nation's possession of 'the most highly developed agricultural education in the world', yet he cautioned that a need existed for a 'new purpose and method in education', which included an emphasis on 'land-teaching', to supplement the usual 'laboratory and recitation courses' – in other words, he called for expanding the practical side of instruction within rural regions.[48] Precisely along these lines, the organizers for women's single-sex colleges saw a parallel need:

> Women have found it extremely difficult to obtain practice work in horticulture under suitable conditions. The Pennsylvania School of Horticulture for Women was established to meet a recognized need. It furnishes a place where educated women may not only receive scientific instruction, but also enjoy the advantages of living in closest daily contact with their work throughout the varying seasons of the year.[49]

Home economists such as Ilena Bailey emphasized that women's contributions to farm work resided precisely in the domestic sphere, consisting of agriculture's lighter branches: 'Milk, butter, eggs, meats, fruits, and vegetables are furnished by the farm, and collecting these or converting them into a form suitable for household use is often part of the farm woman's work in addition to her usual household duties.' She echoed the concern over lacking education: 'However, in the regular courses in the agricultural colleges, few girls have claimed the right to receive instruction in such subjects as poultry husbandry, gardening, and floriculture, yet these are subjects with which nearly every farm woman has to deal in real life.'[50]

Wilkins similarly linked the cause for women's underemployment on farms to the lack of opportunities in practical education, that is, until World War I catalysed widespread awareness for addressing it. She named Studley, which by then had added a full agricultural department, as being among the British colleges that rose to the challenge. On both sides of the Atlantic, specialized programmes sprung up to train students for the Women's Land Army in Britain and its variant, the Woman's Land Army, in America; according to one advertisement, the Ambler campus, for instance, 'became a miniature training camp, with its army of women mobilized with hoe and rake'. Although a full analysis of the shift in the educational emphasis of the colleges during wartime is beyond this chapter's scope, an important continuity between the domestic ideologies of the earlier movements with that of the land armies deserves special mention. As Susan Grayzel has shown, the British propaganda designed to recruit 'Land Girls' emphasized the close alignment between agricultural labour on the rural 'home front' with women's traditional domesticity, even as the work itself exposed contradictions between rhetoric and practice. Elizabeth Weiss analysed a parallel alignment in the United States. Despite being one of the 'great fissures in modern history', World War I thus saw a curious continuity between the domestic discourses of the women's land armies and those of the educational movements preceding – and feeding into – them.[51]

Conclusion

The explicit positioning of women within domesticated spheres in the fields of agriculture and horticulture in the decades around 1900 utilized a common strategy for asserting women's suitability for employment within traditionally male professions. The case of scientific education in agriculture and horticulture paralleled that of women's education in other sciences, and in certain respects the result constituted another form of what Margaret Rossiter termed 'territorial segregation'. As she concluded about late nineteenth-century efforts to open up science to women:

> Although acceptance of such patterns of 'womanly' involvement in science had at first seemed the only way to convince a hostile public that women could indeed 'do' science, in time it became clear that this partial and segregated acceptance had not proven the 'entering wedge' to a broader range of employment and activities for which the women of the 1890s had hoped.[52]

This pattern also applied in the international movements for women's agricultural and horticultural education, which emphasized both scientific theory and manual practice, and yet their emphases on domesticity aligned well with the rise of opportunities for women to contribute to wartime labour on the 'home fronts', leading to unprecedented employment. In response to the specialized training needs of the women's land armies both in Britain and the USA, new programmes multiplied on college campuses everywhere, which expanded the focus beyond horticulture and agriculture's 'lighter branches' into a wider sphere of productive farm work.

The curricula of the new women's colleges for agriculture and horticulture included a robust complement of science subjects germane to farming and gardening, thereby providing women with a significant source of scientific training that is often neglected in studies of women in science. The 'domestic science' emphasis of these educational opportunities explains the neglect to some degree, as much of the historical literature concerning the rise of domestic science and home economics saw those areas as 'niches' rather than successful 'entering edges' for women in science, and thereby redirected historians' efforts along other routes.[53] As I have highlighted elsewhere, the new women's horticultural and agricultural colleges partook in the trend to professionalize these traditionally practical fields in ways that asserted the value of scientific theory above brute practice, and in the process they advanced more than a few research careers of women in experimental sciences like botany and genetics.[54]

As the present chapter shows, domestications of agricultural science education for women had another kind of impact within the overall arc of women's advancement in agriculture. Leading women's voices in the movements self-consciously adapted the logic of separate spheres to carve out feminine domains within masculine enterprises, a logic that extrapolated women's potential from the strength of their skills at home for suitable, typically 'light' work in the outdoors. Their advocacy ultimately envisioned paid employment for women in 'lighter' areas that supplemented, as opposed to supplanted, the acknowledged rougher areas of men's agricultural work, and in doing so they developed a workforce that promised to simultaneously ameliorate economic distress among single, unemployed women, and advance national agricultural industry needs – in Britain, to combat depression, in America, to meet production demands. The educational schemes flourished, as did a range of occupations in which the alumnae worked, yet the design and delivery of the training programmes, and the destinations of the trainees, remained fairly circumscribed within a domesticated paradigm that failed to significantly expand until World War I. Similarly domesticating the landscapes for the women's land armies, the wartime strategies for promoting women's contributions on the 'home front' utilized the existing domestic ideologies and institutions that had been decades in the making.

Notes

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Center for History of Science for a research fellowship (2013) that benefited this project.

1. J. Ruskin (1865) 'Of Queens' Gardens', in *Sesame and Lilies: Two Lectures Delivered at Manchester in 1864* (London: Smith and Elder), pp. 119–96: 147–8.
2. The first two books of Patmore's poem are considered to form a complete narrative and are often cited as the original: C. Patmore (1854) *The Angel in the House: The Betrothal* (London: John W. Parker and Sons); and C. Patmore (1856) *The Angel in the House: The Espousals* (London: John W. Parker and Sons). For 'helpmate': S. Smiles (1881) *Character* (Chicago: Bedford, Clarke and Company), p. 336. On the broader literary trends and the mythical character of the imagery, see especially M.J. Peterson (1984) 'No Angels in the House: The Victorian Myth and the Paget Women', *The American Historical Review, 89*, 677–709; L. Nead (1988) *Myths of Sexuality: Representations of Women in Victorian Britain* (Oxford: Basil Blackwell); and J. Bristow (1996) 'Coventry Patmore and the Womanly Mission of the Mid-Victorian Poet', in A.H. Miller and J.E. Adams (eds) *Sexualities in Victorian Britain* (Bloomington: Indiana University Press), pp. 118–39. On Ruskin's construction and its application in garden advice literature particularly, see S. Bilston (2008) 'Queens of the Gardens: Victorian Women Gardeners and the Rise of the Gardening Advice Text', *Victorian Literature and Culture, 36*, 1–19. Bilston argues in favour of the view that Ruskin intended a female sphere that extended beyond the home and encompassed the whole of England. See also S.A. Weltman (1997) ' "Be No More Housewives, But Queens": Queen Victoria and Ruskin's Domestic Mythology', in M. Homans and A. Munich (eds) *Remaking Queen Victoria* (Cambridge: Cambridge University Press), pp. 105–22.
3. J. Habermas (1962) *Strukturwandel der Öffentlichkeit: Untersuchungen zu einer Kategorie der bürgerlichen Gesellschaft* (Neuwied am Rhein: Luchterhand). For an overview of the literature and debates for the American context see L.K. Kerber (1988) 'Separate Spheres, Female Worlds, Woman's Place: The Rhetoric of Women's History', *The Journal of American History, 75*, 9–39; for the English context see A. Vickery (1993) 'Golden Age to Separate Spheres? A Review of the Categories and Chronology of English Women's History', *The Historical Journal, 36*, 383–414.
4. P. White (2003) *Thomas Huxley: Making the 'Man of Science'* (Cambridge: Cambridge University Press); P. Abir-Am and D. Outram (eds) (1987) *Uneasy Careers and Intimate Lives: Women in Science, 1789–1979* (New Brunswick: Rutgers University Press). On couples in science, see H.M. Pycior, N.G. Slack and P.G. Abir-Am (eds) (1996) *Creative Couples in the Sciences* (New Brunswick: Rutgers University Press); and A. Lykknes, D.L. Opitz and B. Van Tiggelen (eds) (2012) *For Better or for Worse? Collaborative Couples in the Sciences* (Basel: Birkhäuser).
5. M.L. Richmond (2006) 'The "Domestication" of Heredity: The Familial Organization of Geneticists at Cambridge, 1895–1910', *Journal of the History of Biology, 39*, 565–605; S.A. Leavitt (2002) *From Catharine Beecher to Martha Stewart: A Cultural History of Domestic Advice* (Chapel Hill: University of North Carolina Press).

6. On the tensions in the historical literature, see S. Stage and V.B. Vincenti (eds) (1997) *Rethinking Home Economics: Women and the History of a Profession* (Ithaca: Cornell University Press). On domesticity as a political tool, see P. Baker (1984) 'The Domestication of Politics: Women and American Political Society, 1780–1920', *The American Historical Review, 89*, 620–47.
7. The international networking among the distinctive national movements beckons for fuller analysis, currently lacking in the literature. The formation of the Women's Agricultural and Horticultural International Union in 1899, for example, provided one means for organizing internationally; see P. King (1999) *Women Rule the Plot: The Story of the 100 Year Fight to Establish Women's Place in Farm and Garden* (London: Duckworth). More broadly on international academic women's networks, see C. von Oertzen (2014) *Science, Gender, and Internationalism: Women's Academic Networks, 1917–1955* (New York: Palgrave Macmillan). I thank Staffan Bergwik for suggesting the relevance of this work.
8. W. Cobbett (1922) *Cottage Economy* (London: C. Clement); S. McMurry (1984) 'Progressive Farm Families and their Houses, 1830–1855: A Study in Independent Design', *Agricultural History, 58*, 330–46; and J.M. Jensen (1986) *Loosening the Bonds: Mid-Atlantic Farm Women, 1750–1850* (New Haven: Yale University Press).
9. Jensen, *Loosening the Bonds*.
10. Histories of female agricultural education in Great Britain and Ireland are primarily concerned with horticultural schools, but a few deal with instruction in dairying and other 'lighter branches' of agriculture: M. Forrest and V.M. Ingram (1999) 'Education for Lady Gardeners in Ireland', *Garden History, 27*, 206–18; M. Forrest (2005) 'Women's Horticultural Colleges in Dublin in the Early 20th Century', *Dublin Historical Record, 58*, 31–8; A. Meredith (2003) 'Horticultural Education in England, 1900–40: Middle-Class Women and Private Gardening Schools', *Garden History, 31*, 67–79; N. Verdon (2012) 'Business and Pleasure: Middle-Class Women's Work and the Professionalization of Farming in England, 1890–1939', *Journal of British Studies, 51*, 393–415; D.L. Opitz (2013) ' "A Triumph of Brains over Brute": Women and Science at the Horticultural College, Swanley, 1890–1910', *Isis, 104*, 30–62; and D.L. Opitz (2014) ' "Back to the land": Lady Warwick and the Movement for Women's Collegiate Agricultural Education', *Agricultural History Review, 62*, 119–45. For an overview dealing with British agricultural education more generally, but also touching on coeducational and women-only institutions, see P. Brassley (2000) 'Agricultural Science and Education', in E.J.T. Collins (ed.) *The Agrarian History of England and Wales* (Cambridge: Cambridge University Press), pp. 594–649. In the United States, the classic comprehensive study, which also highlights women enrolments in agricultural colleges and university departments, is A.C. True (1969) *A History of Agricultural Education in the United States, 1785–1925* (New York: Arno Press). Three studies concerning women's agricultural education appear in a special issue of *Agricultural History* devoted to 'Agriculture and Education' and focus, respectively, on New Mexico, Utah, and Iowa: J.M. Jensen (1986) 'Crossing Ethnic Barriers in the Southwest: Women's Agricultural Extension Education, 1914–1940', *Agricultural History, 60*, 169–81; C. Sturgis (1986) ' "How're You Gonna Keep 'Em Down on the Farm?" Rural Women and the Urban Model

in Utah', *Agricultural History, 60*, 182–99; and D. Schweider (1986) 'Education and Change in the Lives of Iowa Farm Women, 1900–1940', *Agricultural History, 60*, 200–15. Highlighting schools devoted to horticulture, especially in New England, is V. Libby (2011) 'Cultivating Mind, Body, and Spirit: Educating the "New Woman" for Careers in Landscape Architecture', in L.A. Mozingo and L. Jewell (eds) *Women in Landscape Architecture: Essays on History and Practice* (Jefferson: McFarland), pp. 69–75.

11. This drew upon what Roberta Wein termed the 'cult of feminine domestic sanctity' that infused justifications for women's collegiate education: R. Wein (1974) 'Women's Colleges and Domesticity, 1875–1918', *History of Education Quarterly, 14*, 31–47: 31. 'Domesticity', according to Barbara Welter in her classic essay, formed one of the 'four cardinal virtues' of the 'cult of True Womanhood' in nineteenth-century American literature: B. Welter (1966) 'The Cult of True Womanhood, 1820–1860', *American Quarterly, 18*, 151–74: 152. In the British context, Catherine Hall argued for the significance of Evangelical domesticity and its promotion through the campaigning of the so-called Clapham Sect: C. Hall (1979) 'The Early Formation of Victorian Domestic Ideology', in S. Burman (ed.) *Fit Work for Women* (London: Croom Helm), pp. 15–32.
12. A. Brisbane (1840) *Social Destiny of Man: Or, Association and Reorganization of Industry* (Philadelphia: C.F. Stollmeyer); C.J. Guarneri (1991) *The Utopian Alternative: Fourierism in Nineteenth-Century America* (Ithaca: Cornell University Press).
13. M.E. Dodge (1864) 'Woman on the Farm', *Harper's New Monthly Magazine, 29*, 357. James Jay Mapes was a noted agricultural chemist who experimented with fertilizers and promoted the advancement of agricultural science in the United States. His daughter Mary was otherwise known as a writer of children's literature, of which her 1865 book *Hans Brinker: or, the Silver Skates* (New York: James O'Kane) is most famous. She also edited *The Working Farmer* and *The United States Journal*, an article for which she debuted her writing on women's roles in 1861. See M.R. Finlay (2000) 'Mapes, James Jay', in *American National Biography Online*, ed. J.A. Garraty and M.C. Carnes (New York: Oxford); and C.M. Wright (1979) *Lady of the Silver Skates: The Life and Correspondence of Mary Mapes Dodge* (Jamestown: Clingstone), esp. pp. 19–28.
14. D. Fink (1992) *Agrarian Women: Wives and Mothers in Rural Nebraska, 1880–1940* (Chapel Hill: University of North Carolina Press), pp. 22–4.
15. Brisbane, *Social Destiny of Man*. On the contemporary physiological arguments upon which such arguments are based, see especially C.E. Russett (1989) *Sexual Science: The Victorian Construction of Womanhood* (Cambridge, MA: Harvard University Press). As noted by Sue Drum, the division of labour according to gendered assumptions about bodily strength also operated in veterinary medicine: '[I]t was thought that all veterinarians would be men. This view is understandable, because most graduates earned their living during long hours in dark, drafty barns or stables, treating sick horses and cows that required great strength to restrain and medicate'; S. Drum and H.E. Whiteley (1991) *Women in Veterinary Medicine: Profiles of Success* (Ames: Iowa State University), p. xi. Interestingly, the socialist ideas of Brisbane and others radically pushed women's sphere of work *outside* the house,

and yet they replicated a rather traditional gendered separation of spheres outdoors.

16. Anonymous (1879) 'A Woman Farmer', *Demorest's Monthly Magazine, 15*, 479. Emily Faithfull brought this story to British readers of the women's periodical she edited: Anonymous (1879) 'Miscellanea', *The Victoria Magazine, 33*, 534–6. Thomas's 1875 autobiographical account was included among the sketches of 'Women Agriculturalists' in P.A. Hanaford (1882) *Daughters of America; or, Women of the Century* (Augusta: True), pp. 704–8.
17. Hanaford (1882) *Daughters of America*, pp. 705–6.
18. Hanaford (1882) *Daughters of America*, p. 704.
19. E. Faithfull (1884) *Three Visits to America* (Edinburgh: David Douglass), p. 249; B.J. Gisel (2001) *Kindred and Related Spirits: The Letters of John Muir and Jeanne C. Carr* (Salt Lake City: University of Utah Press).
20. F.P. Cobbe (1877) 'Correspondence', *The Woman's Gazette, 2*, 109. See also M.E. Phillips (1876) 'Lady Gardeners', *The Woman's Gazette, 1*, 126; and F.P. Cobbe (1877) 'Correspondence', *The Woman's Gazette, 2*, 61.
21. J. Chesney (1879) 'A New Vocation for Women', *Macmillan's Magazine, 60*, 341–6: 341–2. See also F.W. Burbidge (1877) *Horticulture* (London: Edward Stanford), esp. p. 233; and J. O'Donnell (1878) 'What Women Can Be and Do', *Social Notes, 17*, 262–3.
22. Opitz, 'Back to the land'; Opitz, 'A Triumph of Brains over Brute'.
23. C.W. Kimmins (1898) 'Introduction', in F.E. Warwick (ed.) *Progress in Women's Education in the British Empire* (London: Longmans and Green), pp. xv–xxvi.
24. G. Vernon (1898) 'The Training of Women in Dairy Work and Other Outdoor Industries', in Warwick (ed.) *Progress in Women's Education in the British Empire*, pp. 127–8.
25. Vernon, 'The Training of Women in Dairy Work', p. 133.
26. F.E. Warwick (1897) 'Woman and the Future of Agriculture', *The Land Magazine, 1*, 723–9.
27. Warwick, 'Woman and the Future of Agriculture', p. 724.
28. Warwick, 'Woman and the Future of Agriculture', p. 725, emphasis in original.
29. Anon. (1891) 'Robert Johnson, Esq., Director of The Colonial College', *Education: A Journal for the Scholastic World, 2*, 12–20: 20.
30. For more on this pairing of theory and practice, see Opitz, 'A Triumph of Brains over Brute'; also S. Richards (1988) 'The South-Eastern Agricultural College and Public Support for Technical Education, 1894–1914', *Agricultural Historical Review, 36*, 172–87.
31. In Great Britain, this partook in a broader trend of divestment among the landed classes; see D. Cannadine (1999) *The Decline and Fall of the British Aristocracy* (New York: Vintage Books).
32. Anon. (1912) *The Pennsylvania School of Horticulture for Women*, prospectus, Temple University Ambler Archives, PSHW Collection. On the Colonial Training Home, see J.A. Hammerton (1979) *Emigrant Gentlewomen: Genteel Poverty and Female Emigration, 1830–1914* (London: Croom Helm); and S.R. Herstein (1985) *Mid-Victorian Feminist Barbara Leigh Smith Bodichon* (New Haven: Yale University Press); on Studley, D.M. Garstang (1953) 'Studley College', *Agricultural Progress, 28*, 4–15; on the Pennsylvania School, V. Libby

(2002) 'Jaine Haines' Vision: The Pennsylvania School of Horticulture for Women, 1910–1958', *Journal of the New England Garden Society, 10*, 44–52; and J.R. Carey and M.A.B. Fry (2011) *A Century of Cultivation, 1911–2011* (Langhorne: Temple University).

33. Anon. (1901) 'Guild of Daughter of Ceres', *The Woman's Agricultural Times, 2*(7), 13; F.E. Warwick (1903) 'Lady Warwick College, Studley Castle', *The Woman's Agricultural Times, 4*(11), 161–4; J.E.T. (1893) 'A Visit to the Lady Gardeners at Swanley', *Shafts: A Magazine of Progressive Thought, 4*, June 1893, 82.
34. For further details, see Opitz, 'A Triumph of Brains over Brute', and Opitz, 'Back to the land'.
35. A. Balfour, K. Falmouth, M.G. Fawcett, E. Lyttelton, A. Knox, A. Dobson, T.E. Fuller, C.A.D. Miller and J.A. Cockburn (1904) 'Training for Colonial Life', *The Times*, London, 14 December 1904, 10. Within the American context, this kind of logic also applied at the frontiers; see J.R. Jeffrey (1979) *Frontier Women: The Trans-Mississippi West, 1840–1880* (New York: Hill and Wang). On the 'surplus' women problem in comparative perspective, see C. Bolt (1993) *The Women's Movements in the United States and Britain from the 1790s to the 1920s* (New York: Harvester Wheatsheaf), pp. 116–17.
36. Cobbe, 'Correspondence', p. 109.
37. Mrs. C.W. Earle (1897) *Pot-Pourri from a Surrey Garden* (London: Smith, Elder and Co.), pp. 39–40.
38. A.G. Freer (1899) 'Horticulture as a Profession for the Educated', *Nineteenth Century, 46*, 769–81: 776; E. Crawford (2009) *Enterprising Women: The Garretts and their Circle* (London: Francis Boutle), p. 234.
39. M.R. Wilkins (1915) *The Work of Educated Women in Horticulture and Agriculture* (London: Jason Truscott and Sons), pp. 18–19.
40. J.L. Doan (1914) 'The Outlook in the Field of Horticulture', *Wise Acres, 1*(4), December 1914, 5–8: 5. The author, John L. Doan, taught botany at the Pennsylvania School during its early years; see Carey and Fry, *A Century of Cultivation*, p. 14.
41. Doan, 'The Outlook in the Field of Horticulture', p. 5.
42. Anon. (1892) 'First Report, Women's Branch of the Horticultural College, Swanley, Kent, December 1892', in *Reports, 1892–1912*, bound volume of pamphlets, Hextable Heritage Centre, Swanley Town Council, SWAN00015. The greenhouse was nevertheless a contested site: at the Royal Botanic Gardens, Kew, men habitually worked shirtless, causing concern when female Swanleyites began securing work there as improvers; see Opitz, 'A Triumph of Brains over Brute', p. 54.
43. For this period, a few sources provide systematic statistics on women's employment in agriculture and horticulture at this level of detail, and the college records are uniformly anecdotal. For a few impressionistic summaries, see M.R. Wilkins (1915) *The Work of Educated Women in Horticulture and Agriculture* (London: Jason Truscott and Sons); E. Morrow (1985) 'A History of Swanley Horticultural College', *Wye: The Journal of the Agricola Club and Swanley Guild, 12*, 59–142; and Carey and Fry, *A Century of Cultivation*.
44. For the USA, see W.L. Bowers (1971) 'Country-Life Reform, 1900–1920: A Neglected Aspect of Progressive Era History', *Agricultural History, 45*,

211–21. For Britain, see J. Marsh (1982) *Back to the Land: The Pastoral Impulse in England, from 1880 to 1914* (London: Quartet Books).

45. F. Warwick (1901) ‘Agricultural Education for Women’, *The Times*, London, 13 May 1901, 10.
46. R. Challice (1903) ‘The Lady Warwick College at Studley Castle’, *West Sussex Gazette*, [n.d.], newspaper clipping, Museum of English Rural Life, University of Reading, FR WAR 5/6/4. For more on this theme, see Opitz, ‘Back to the land’.
47. L.H. Bailey (1911) *The Country-Life Movement in the United States* (New York: Macmillan), pp. 93–4. For more on the ‘farm woman problem’, see E.A. Ramey (2014) *Class, Gender, and the American Family Farm in the 20th Century* (New York: Routledge).
48. Bailey, *The Country-Life Movement in the United States*, pp. 65, 81.
49. Anon., *The Pennsylvania School of Horticulture for Women*.
50. I.M. Bailey (1913) ‘The Farm Woman’s Share in the New Agriculture’, *Michigan State Farmers’ Institutes Bulletin*, no. 13, 108–11: 110.
51. Wilkins, *The Work of Educated Women in Horticulture and Agriculture*, p. 23; Carey and Fry, *A Century of Cultivation*, p. 22; S.R. Grayzel (1999) ‘Nostalgia, Gender, and the Countryside: Placing the “Land Girl” in First World War Britain’, *Rural History, 10*, 155–70: 168. For more on the Women’s Land Army in Britain during World War I, see B. White (2014) *Women’s Land Army in First World War Britain* (Basingstoke: Palgrave Macmillan). For the American (‘Woman’s’) equivalent, see E.F. Weiss (2008) *Fruits of Victory: The Woman’s Land Army of America in the Great War* (Dulles: Potomac Books).
52. M.W. Rossiter (1982) *Women Scientists in America: Struggles and Strategies to 1940* (Baltimore: Johns Hopkins University Press), p. 314.
53. Rossiter, *Women Scientists in America*, pp. 314–15. But see the revisionist efforts advanced by the contributors to Stage and Vincenti, *Rethinking Home Economics*.
54. Opitz, ‘A Triumph of Brains over Brute’; for more on women in genetics, see M.L. Richmond (2015) ‘Women as Mendelians and Geneticists’, *Science & Education, 24*, 125–50.

6

Gender and the Domestication of Wireless Technology in 1920s Pulp Fiction

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The history of radio broadcasting in the 1920s is associated with a domestication narrative along gendered and institutional lines. A predominantly male and homosocial activity of amateur wireless operation was countered by images of families, heterosexual couples, and mixed groups listening together, accompanied by the development of content aimed specifically at women and children. Framing this gendered shift was institutional growth, as experiments in wireless telephony were sidelined by corporate organization of broadcast content and attempted regulation of listening habits. Yet the domestication of radio additionally saw negotiations around both gender identity and the home as a site for experimenting bodies. Instead of viewing domestication as a narrative in which given gender roles are mobilized around technological change in the home, I will examine domestication as an opportunity for gendered bodies to test and reconfigure, or reaffirm, their orientation to each other and to their surroundings.

The competing interests of broadcasters, manufacturers, those seeking airtime, amateur experimenters, and audiences are documented in a rich literature addressing early radio in Britain.[1] Caroline Mitchell notes the invisibility of women in these narratives and offers some restitution of key female personnel to the record.[2] Turning to America, Richard Butsch documents 'a brief liberating moment in 1922–24', when political suffrage was accompanied by 'assertions of women's competence with technology' in radio magazines, followed by 'a rhetorical return of women to their domestic and romantic spheres', and 'the demise of a gender-sameness discourse about radio'.[3] Shaun Moores's oral history implies a comparable British narrative. Interviews with elderly residents in the North of England inform the conclusion that 'radio had quite different meanings across gender divisions and those varied interpretations were a focus of friction in households' during the 1920s, but 'radio's capturing of time and space in the home' during the 1930s symbolically repositioned women 'at the heart of the intended audience'.[4] Popular culture can serve as a useful corollary to sociological analyses, and where material is syndicated it can also enable transatlantic perspectives. Jeffrey Sconce in *Haunted Media* traces a cultural history of communications technology in America from telegraphy to television, noting that with the removal of wires came a note of 'sad estrangement', with 'anxious, pessimistic, and melancholy' representations of wireless technology that are expressive of 'modernity's increasingly profound social atomization'.[5] Gender becomes a blank in this trajectory precisely at the moment of radio's domestication, when the 'elusive and uncanny presence' of wireless signals yields to the broadcast schedule as 'marker of an unknown alien presence, extra-terrestrial or otherwise, and a harbinger of potential subjugation'.[6] This is because *Haunted Media* is focused on the mutual relations of consciousness and communication, offering a narrative that can accommodate the empowerment of female mediums in relation to telegraphy's spiritualist affiliations, and the role of housewives in television insanity narratives, but not the embodied negotiation of gender offered by popular fictions of radio. A somatic history of radio can be built into the *Haunted Media* narrative by taking a cue from Laura Otis's examination of exchanges between telegraphy and neurophysiology in the eighteenth and nineteenth centuries. While 'scientists studying organic and technological communication systems inspired one another', the telegraph operator's 'hands, ears, nerves, and brain' merged with the apparatus 'to form a doubly empowered device for transmitting and receiving information'.[7] Analysing telegraphic fictions, Otis reveals that promises of social unification and personal integration into the web of humanity were tempered by concerns about loss of privacy and connection to the unknown. As a step towards a somatic history of radio in the home, the present chapter analyses bodily empowerment in representations of domestic wireless, and investigates the terms on which bodies are connected to those of other listeners-in, radiophans, radiomaniacs, etherites, and wireless men.

Multiple meanings for radio thrived in the lively and at times chaotic state of broadcasting during the early 1920s. Stations and audiences alike were more concerned with technical problems of transmission and reception than with the quality of broadcast content, and there was 'a natural tendency to gimmickry and stunts, in line with the activities of the popular press and magazines of the time, in a new medium seeking to draw attention to itself and to build up its audiences'.[8] In November 1922, the British Broadcasting Company began broadcasting from stations run by three different manufacturers: London 2LO, Birmingham 5IT, and Manchester 2ZY.[9] Regional transmitters allowed for variation in broadcast content and audience relationships, and the BBC was operating from almost 20 locations throughout the United Kingdom by the end of 1924. Informality and experimentation were checked through measures imposed from London, such as the requirement for announcers to wear dinner jackets from late 1925, and a veto on quizzes in 1926.[10] The mid-1920s saw a 'retreat away from direct contact with listeners, from their participation in programmes, from informality, friendliness and easy accessibility into a distanced, anonymous, collective voice'.[11] William Reith, the BBC's first director general, complained that listeners were paying more attention to 'wires and switches and boxes' than broadcast content, and he countered the hunger for popular music with an appeal for engaged listening:

> [W]e sit down with our eyes glued to the loud speaker, and frequently come to the conclusion that the sound is metallic and unsatisfying, and that we do not like our music tinned. The fact is that our minds are obsessed and distracted by the agency, and the music has not had a fair chance.[12]

Reith also deplored 'the objectionable habit' of referring to 'the listener-in . . . a relic of the days when he actually did listen in to messages not primarily intended for him; now he is the one addressed, and he accordingly listens. Only the unlicensed listen-in.'[13]

In what follows, I use popular fiction and British wireless magazines to explore domestic relationships mediated through the 'paraphernalia' that Reith wanted to downplay in the listening experience. These resources indicate a multiplicity of listening experiences that take us beyond Reith's distinction between 'listening' and 'listening-in'. Three stories published in pulp magazines between 1923 and 1925, featuring radio as a disruptive presence in the home, are analysed, alongside content from three British wireless magazines. *Wireless World*, founded in 1913, absorbed the *Radio Review* in 1922 and became a weekly paper, the official publication of the Radio Society of Great Britain. Aimed at amateur experimenters, the magazine advocated for telephony licensing, and carried reports of wireless activity from regional British societies as well as international wireless news. *Modern Wireless* was launched in February 1923 by the Radio Press, a 'new publishing phenomenon' that fulfilled the need for 'step-by-step yet affordable technical guidance' through a stream of books as well as spin-off magazines *Wireless Weekly* and *Junior Wireless*.[14] *The Broadcaster*, established in August 1922, was a more glamorous monthly publication of a somewhat unfocused character until November 1923 when it transformed into a paper for the wireless trade, *The Broadcaster and Wireless Retailer*. These three magazines allow for exploration of wireless bodies and their interconnections from the perspective of three distinct interest groups: amateur experts, the radio publishing industry, and the wireless trade.

'The fun of uncling'

'Radio Death' was published in the American pulp *Midnight Mystery Stories* (3 February 1923) and the British pulp *Hutchinson's Mystery-Story Magazine* (May 1923). The author, George Briggs Jenkins, Jr (1890–1929), produced over a hundred stories and sketches for the pulp market between 1916 and 1927.[15] *Midnight*, an 'obscure tabloid magazine', cost 10 cents and ran to 24 weekly issues from 1922 to 1923, with some numbers 'destroyed by court order as being too risque'.[16] *Mystery-Story* cost 7 pence and ran from 1923 to 1927, printing 'a mixture of new material and stories selected from the American pulps'.[17] 'Radio Death', tagged as 'A story of the new wireless craze', inspired the *Mystery-Story* cover art for May 1923: a struggle between heroine and villain, with the radio standing tall and dark against a bright yellow wall.[18] The young woman with golden bobbed curls is Evelyn Graham, who has gone to stay with her uncle: 'a prim, trim, immaculately dressed man, in the early 60s, not dangerous physically. But there seemed something strange about him, something sinister and repulsive.'[19] The uncle's mechanical hobby is marked as unnatural: 'He had such queer and intricate pieces of machinery, delicate, fragile combinations of wheels and cogs and levers, that one might think he had gone mad seeking after the secret of perpetual motion, or a similar unbalancing quest.'[20] The flat is wired so that electric lights signal the opening of any door or window, and Grant Graham informs his niece with relish that three men who attempted to access his safe have been carried away dead.

Despite these elaborate defences, Evelyn is attacked by an intruder, who has hung her uncle from the chandelier by his thumbs. Her struggle is interspersed with the sound of a female voice reading a children's story, giving the violent events a surreal turn while playing on the uncanny qualities of wireless. ' "And Little Johnny Rabbit went hippity-hop down the road carrying his umbrella . . . Little Johnny Rabbit lifted his hat to Miss Lizzie Duck . . . and he asked her if her father was well. He had never met Mr. Oscar Duck, the young lady's father." '[21] For British readers the intruding story was more bizarre and violent: ' "Biff! Bang! The baby rabbits were shot out of the rabbit hole. They ran to Conrad the cock." . . . "Oh, keep your peckers up!" Cried Conrad. "But no, you have not got peckers, have you?" '[22] At the height of narrative conflict, the radio bursts in once more with the Six Snappy Saxophonists, causing Evelyn to reflect on the contrast between 'her position here, with death peering at her from the doorway', and 'the thousands of other homes where the radio announcer's voice was heard . . . peaceful and contented, waiting to be entertained'.[23] While broadcast content heightens Evelyn's isolation, radio paraphernalia saves her: Graham's wiring ensures that when the instrument is active, anyone attempting to open the safe will be electrocuted. The intruder is fried, saving Evelyn from the fate of being stripped on the balcony and strangled. Her uncle, it transpires, was a fence for stolen goods and has failed to pay up. He has been shot, but dies happy because the death toll resulting from his ingenuity has risen.

'Radio Death' updates the established tradition of wireless mystery and romance in light of radio as a powerful force in the home. Sconce describes Rudyard Kipling's 'Wireless' (1902) as 'paradigmatic of the haunted wireless stories to follow', with their constellation of 'wireless, separation, and death'.[24] Otis identifies Bram Stoker's *Dracula* (1897) and Mark Twain's 'Mental Telegraphy' (1891) as earlier precedents.[25] Jenkins uses the pulp convention of the amoral inventor and thriller plot devices to assert the criminal nature of domestic wireless installations over telegraphy's supernatural affinities, and in doing so validates the experience of those who found the domestic space invaded by 'unsightly' arrangements, 'ungainly' apparatus, wires, and battery acid.[26] The choice of 'uncle' for the role of inventor would have introduced a note of irony for readers on both sides of the Atlantic. Radio content aimed at children was frequently narrated by 'uncles', such as Uncle Wip at Philadelphia WIP and Uncle George at Newark WOR from 1922, and Uncle Remus, a 'well-educated negro' in whom 'the peculiar "sing-song" qualities of the coloured man's voice were especially effective for radio purposes and . . . greatly increased the realism of the fairy tales'.[27] The BBC's *Children's Hour* began with Uncle Tom or Thompson from Birmingham 5IT in 1922, followed by many other regional uncles and aunties.[28] *The Broadcaster* carried full-page photographs of handsome young men in the uncle role, and a chatty first person account from Captain C.A. Lewis (Uncle Caractacus) in which he recounted 'the fun of uncling'.[29] 'Radio Death' counters the image of attractive, trusted men and women at the frontier of communications technology with deadly male paraphernalia and the isolation of the female listener. The story's moral is open to differing interpretations however, amid diversifying aspects of radio's domestic presence, electrical power, and masculine affiliations that emerge across the wireless magazines.

The domestic environment was peripheral in *Wireless World*, and while some installations did incorporate fantastic amounts of wire, sets were often praised for being 'neat', and from May 1922 the magazine began referring to hidden wiring and concealed receivers. *Modern Wireless* made further concessions to decor in a feature on decorative loudspeakers 'ranging from Chinese dragons in gold upon a black background to a floral design in green and orange', while an article on 'Wireless without Worry' stressed the importance of good reception and tidy equipment to avoid distressing wife and family.[30] *The Broadcaster*, meanwhile, promoted the use of wireless everywhere, from ambulances to airships, and even while swimming, as demonstrated in a photograph of a woman in bathing costume with receiving equipment attached to a rubber tube.[31] While *Modern Wireless* and *The Broadcaster* carried advertisements for the protection of life and property from lightning damage via radio equipment, *Wireless World* criticized sensationalism on this topic and called for a more scientific approach to evaluating the risks.[32] The power of radio apparatus was promoted in advertising across all magazines, through illustrations featuring electrical flashes, rays, genies, and muscular torsos, and branding of crystals with names like Neutron, Saturnium, and The Mighty Atom. *The Broadcaster* promoted apparently unlimited capacities for wireless, ranging from hypnotism over the radio to the prospects for transmitting power and making tea by wireless.[33] A comic poem, modelled on the popular racist songs 'Ten Little Indians' and 'Ten Little Niggers', listed ways for amateurs to die from wireless hazards such as lightning, gas, short circuits, and poisonous chemicals.[34]

Wireless as a colonial instrument was a universal theme, with 'broadcasting for the blacks' in *Wireless World*, a photograph of 'red Indians listening to a concert' in the *Junior Wireless* supplement to *Modern Wireless*, and an article on wartime 'Wireless experiences in Arabia' in *The Broadcaster*.[35] Bodies in photographs and drawings were predominantly white, with the exception of Arabian genie figures invoking the wish-granting power of wireless apparatus, occasional photographs of colonial subjects, and cartoon stereotyped 'negro' figures trading bananas for wireless equipment at the head of a regular column 'World Wide Wireless' in *The Broadcaster* from September 1924. Wireless men were represented in all magazines as members of an international network, competing to receive and transmit messages across the globe and perhaps even beyond, to Mars. Yet participation in the global brotherhood of wireless was disrupted by problematic behaviour more locally. Wireless crimes included oscillation, transmission of gramophone records and inane banter, and piracy of other men's call signs. Contrasting facets of radio masculinity were stressed in *The Broadcaster*, which depicted male users of radio satisfying their families, attracting the opposite sex, and competing with their neighbours or with sons and nephews to assert wireless competence. Jokes about wireless masculinity featured in a regular satirical column in *Modern Wireless* from October 1923, with tips for boasting about wireless prowess on the commuter train, a comparison of men purchasing wireless components to women shopping for clothes, a description of the magazine's editorial staff as a 'galaxy of manly beauty', and a proposal for modern trouser design with a sharp crease maintained by wires doubling as wave traps to eliminate the local station.[36]

Just at the point when radio magazines began to qualify the romance of wireless telegraphy with concessions to family relationships and home furnishing, 'Radio Death' reasserted male involvement in homosocial technology, translating competition and conflict between male users into radio as weapon. The unappealing protagonist invites readers to view the apparatus itself as evil, but the black-and-white illustration taking up the half page above the narrative's title and opening in *Mystery-Story* complicates that verdict. While the short and grasping uncle and his flinching niece look on, the dark and handsomely dressed intruder is ablaze with electricity, his arms aloft in radiant glory before the safe door (Figure 6.1). In the text the uncle is prostrate on the floor by this point, but this image adjusts the narrative to parallel the advertisements for electrical body gadgets that were frequently printed throughout the mass media and often seen in the pulps. Strongly gendered, these ads depicted contrasting specimens of invigorated and enfeebled male or female figures. Likening the story's villainous victim of radio power to a hyper-invigorated consumer, the illustration hints at commercial validation of disruptive electrical hobbies in the home and affirms the virile power of wireless technology in the story's deliverance of Evelyn. The story's incommensurable messages about wireless masculinity are held together through pulp formulae that ensure villains die and heroines are saved. 'Radio Death' experiments with a shift in

Figure 6.1 'Radio Death' illustration by Richard Caton Woodville, Jr., from *Hutchinson's Mystery-Story Magazine*, Per. 25612 d. 22, v.1, May 1923, by kind permission of The Bodleian Libraries, The University of Oxford.

the function of wireless from protection of life at sea, to protection of domestic property and criminal interests. The empowered body of the telegraph operator is split into those of the feeble yet clever inventor and the manly villain, with radio mediating their conflict as it comes to stand for that ultimate homosocial item, the gun. At the same time, Evelyn's predicament complicates Reith's progress-oriented distinction between listeners-in and listeners: the heroic yet melancholic practice of listening-in to distress signals is reversed, as we are shown the individual in distress listening-in to happier lifestyles that elude her.

Aunt Boadicea and the Marconi amazons

Owen Oliver took up direct female involvement with wireless in 'A Martyr to Wireless', published in the *Yellow Magazine* in 1924. The *Yellow* was owned by the Amalgamated Press, established by British press baron Alfred Harmsworth (Lord Northcliffe) in 1901. One of several spin-offs from the longer-running *Harmsworth Red Magazine* (1908–1939), the *Yellow* (1921–1926) was published fortnightly at 7d and offered humorous content with 'some stronger character-driven stories that considered the tensions of the day'.[37] Oliver (pseudonym of Joshua Albert Flynn, 1863–1933), produced over 250 stories for the pulp market between 1901 and 1934, including 27 in the *Yellow*.[38] A graduate of Mental and Moral Science from London University, Flynn served in the Admiralty and received a medal for his role as financial advisor to the British military leader Lord Kitchener. 'A Martyr to Wireless', published 18 April 1924, was copyrighted in the United States, but a counterpart publication is unknown.

Oliver's story brings bathos to the tradition of 'wireless, separation and death' by invoking the modern condition of 'wireless widows'. Ethelberta's marriage and health are in jeopardy when her husband Eustace yields to the 'wireless epidemic'.[39] Her description of his hobby shows that an obsession with paraphernalia can be active in a way not allowed for by Reith:

> It's just the kind of performance that nothing would induce him to take a ticket for. It doesn't seem to me to by any better because it comes crackling out of a spout, or through things that hurt your ears; but I suppose he likes playing about with the wires and things; feels as if *he's* doing it.[40]

Experimental sound textures enter the story as the narrator, Ethelberta's father, provides a transcript of what is presented to his ears by the 'instrument of torture': '*Bur-ur-ur. Crur-ur-ur. You ought to know my wife. She – tut-tut-tut-ter-er-little dog. Well– ter-er-er– who-oo-oo. She didn't – Bur-ur-tut-tut. Cr-aack. Dog went mad. Tr-er-er. Srur-ur-ur. Ha, ha, ha! Now I'll tell you – bur-ur-ur-story about –who-oo, who-oo, who-oo–.*'[41] Wireless reception has close affinities with Dada sound poetry and Futurist concerts: Eustace claims to have 'got Glasgow', but it 'sounded as if he had got the infernal regions, and the Zoo, and a saw-mill'.[42] Radio experiments in the home are disruptive of syntax and style, allowing the pulp author to harness avant-garde energies without compromising narrative conventions. At the moment of crisis, Ethelberta 'said she was a loud speaker, and that we were listening-in to Rangoon. She kept shrieking *Br-ur-ur! Woo-woo-woo! Tick-tick-tick! Cr-ur-ur-crack!*' A water jug, its contents emptied on the floor, serves as radio horn, while the towel-horse is 'suspended in the air, by strings fastened to pictures. She said they were the aerials.'[43] Under threat of wireless widowhood, Ethelberta has taken the active principle of wireless sound creation to its extreme. But it has all been a ruse, with the successful aim of getting Eustace to banish radio equipment from the home.

Butsch identifies two forms of women's active radio use in American magazines during the early 1920s. Cartoons and stories depicted 'the man's loss of his domain to the domineering wife who used the radio to extend her power . . . retrieving men and boys from moments of freedom to follow female orders'.[44] There was also a 'short-lived but overt espousal of women's equality', asserting 'women's technical competence' as constructors, operators, and purchasers of radio equipment.[45] Assertions of equality soon yielded to 'pictures of young women in bathing suits, or dancing, legs exposed, while listening to radio', along with cartoons 'restoring the boundaries of gender spheres', for instance by depicting 'a housewife . . . using the radio aerial as a clothesline'.[46] 'A Martyr to Wireless' verges on a satire of both these modes, while also affirming them. Ethelberta spends the entire story up to her episode of wireless mania embroidering a cushion cover, while her parents fret over her old-fashioned submissive nature. Her ruse, causing Eustace to turn abruptly against all wireless activity, is a more subtle form of control than the wifely broadcast orders and embarrassments featured in American cartoons, for Ethelberta retrieves her husband from the wireless craze without appearing to exercise her will at all. By turning herself into a radio set, inverting the aerial-as-clothes-line joke, she becomes ultra-modern beneath the veneer of her antiquated feminine disposition. The story's twist involves Ethelberta demonstrating equal incompetence to her husband: she, too, can produce the sounds '*Br-ur-ur! Woo-woo-woo! Tick-tick-tick! Cr-ur-ur-crack!*' while raving about valves and loudspeakers.[47] Oliver provides readers with affirmation of both female use of radio to control husbands, and women's equal technical competence, within a narrative that nevertheless preserves a nag-free household where women are preoccupied with towel-horses and string rather than actually operating wireless equipment. An absurdist wireless history emerges through the narrator's garbled report of a magazine article read out by Eustace, describing 'two of the people who send out the noises. One was Uncle Percy, who was born in 1893. . . . The other was Aunt Boadicea.'[48] Here the wireless uncles are conflated with Nikola Tesla's early demonstrations of wireless power and his proposals for wireless transmission of intelligible signals, while the BBC is renamed for the Celtic tribal queen famed for having driven the Romans out of London. These jokes are engaged with narratives of pioneering male and female wireless operation during World War I, and with subsequent renegotiation of gender roles.

Wireless World served as a repository of heroism by 'Marconi men' during the war. Photographs of wireless operators who had lost their lives in combat were a regular feature. Smart uniforms and details of war service featured alongside celebratory poems of deeds in battle, adventure fiction on wartime wireless themes, discussion of war strain, and a scheme for retraining maimed soldiers as telegraphists. A regular column, 'Pastimes for Wireless Operators', gave advice on banjo playing, photography, and other hobbies suitable for men whose work often consisted of long, lonely hours in post. Women's wireless work was actively promoted alongside that of the Marconi men, albeit with reservations. 'Lady operators are being trained for certain branches of wireless work on shore', it was reported in April 1916:

> [B]ut at present they are not being appointed to marine duty. Experienced operators and professional wireless men generally will readily realise the difficulties which confront us when we consider placing women for this work on board ship, but, of course, no one can tell what will be done in the future.[49]

By October 1917 the uncertain future had edged closer, for a lady telegraphist had come to the rescue on board ship.[50] In May 1917 it was reported that Miss Florence L. Gateshill of 'Newcastle-on-Tyne' had 'obtained the Postmaster-General's first-class certificate in the Marconi, Poulsen and Telefunken systems', and was thought to be 'the first lady in Great Britain' to have attained all of these qualifications.[51] The wartime wireless work of American women was described as 'patriotic' in November 1917, but a call for 'More Women for Wireless' in February 1918 focused on 'employment of the fair sex in the construction and testing of apparatus' rather than women as operators.[52] Nevertheless, this was accompanied by strong support for 'scientific education for girls and young women'. Photographs of lady operators featured occasionally, and even those employed for manufacturing were portrayed in terms of gender equality in a photograph of the Ladies' Football Club at the Chelmsford Marconi Works.[53] At the same time, there was a fear that men might be replaced by 'Marconi amazons'. An illustrated feature on the 'Marconi man's uniform' depicted uniformed white males in front and rear view around a table with wireless equipment.[54] Text on the facing page envisaged a time when 'the young "sparks" in the merchant service will be extinguished and the Marconi cabin will be "manned" instead by a bevy of fair ones whose knowledge of waves, hirsute, tidal and etheric, will be even more extensive than their predecessors'.[55] But the need for operators to 'sit calmly and unruffled at their posts when faced with death and disaster' and to 'endure the severest tests that can be imposed upon mind and body' made such work unsuited for a woman, whose 'natural weakness' might reveal itself 'at a critical moment'. Young women were much better suited to 'constructional tasks requiring patience and delicacy of touch outside the common virtues of mere man. The romance of wireless is real and unending; so, too, are the perils of the seas; but to introduce women for ship work would be unfair to womankind and the mercantile marine.' A photograph of a 'Lady Wireless Operator and her Ship', Miss M. Alsen and the SS *Jupiter*, was presented 18 months later without further comment.[56] In April 1920, one of the first female wireless operators in Great Britain, A.C. Rainie, expressed the hope 'that one day wireless operators of her sex will be attached to every steamer'.[57]

Rainie was a novelty. After the war, *Wireless World* shifted active wireless women out the main articles but they remained present in the reports from local wireless clubs. The first lady member of the Newcastle and District Wireless Association in April 1920, Miss Gilbert of Gateshead, was described as a 'genuine "amateur" who has applied for her own licence, and is constructing her own station'.[58] Four years later, the South Norwood Radio Association was thought to be the first radio society 'to have an honorary secretary of the fair sex' in D.M.B. Cullis.[59] In Berlin, 'pupils of the fair sex' taking a wireless course 'intended to make radio their career', but girls at the London Foundling School appeared more distant from those wartime prospects of a scientific education, having simply 'derived much pleasure from listening-in'.[60] Occasionally, club reports suggested a blend of education and entertainment accessible to women, as when the Durham City and District Wireless Club reported that a Morse code buzzer class had been 'quite exciting, the ladies particularly enjoying themselves'.[61] But advertisements consistently appealed to 'men in the wireless service', 'Enterprising Wireless Men', 'Practical Men', 'Mr Amateur', 'Mr Professional', and to 'Parents desirous of placing their sons.'[62] Photographs in articles and advertisements limited female contact with radio technology to factory work, studio performance, and companionship to male experimenters. An article headed 'Woman and Wireless' by the Countess de Armil in *The Daily Graphic* was described as having 'discussed the scientific attractions with more charm than technical accuracy', and quotations from the article were included for the affirmation of *Wireless World*'s more knowledgeable readers.[63]

On the pages of *Modern Wireless*, radio was consolidated as a serious scientific pursuit for men. Appreciation of uniformed wireless heroes was strong, with regular contributions from men with military titles, photographs of military men, and nostalgic articles about wartime and colonial wireless endeavours. Enthusiasm for 'Wireless in the Next War' was conveyed by cover art for October 1923, depicting a ship being shelled, with an aeroplane overhead picked out by searchlight. Lacking any formal relationship with radio clubs and societies, *Modern Wireless* relegated women to the role of occasional adornment. A photograph of 'Lady Operators in an American Broadcasting Station' bore no relation to the surrounding text, which was about the reception of American signals in Britain.[64] The closest that *Modern Wireless* came to depicting women as lone users of radio was through advertisements for *The Broadcaster* featuring that magazine's more glamorous cover art. *The Broadcaster* itself underwent a significant change in its handling of the relationship between women and radio as it transformed into a trade paper aimed at men working in wireless retail. Gone were the pictures of fashionable young women actively engaged with radio in every conceivable circumstance, from childcare to swimming. Women now featured in reproduced images of advertising posters and sales cards, with praise directed at the attractive design of promotional materials. Their role in the sales process was now emphasized. 'Take Your Wife: Let your wife sell your stock' urged one article, advising the salesman to take his wife to Wembley and peruse with her 'receivers that are encased in cabinets of Chinese lacquer design . . . sure to attract womenfolk. Never mind how many valves there are. That's the man's business to know what the set will receive – but let your wife think of that instrument in a lounge of Oriental design.'[65] Having won his own wife over to the exotic charms of modern radio furniture, a salesman could then call upon her to persuade the wives of keen purchasers held back from parting with cash for wireless nuisances by wifely objections to 'messy wires and things with acid in them'. A show card proclaiming 'When your Husband is at the Club' had been noted in a wireless retailer's window, accompanied by 'some very excellent reasons why a woman should coax her husband into buying a wireless set. Clever allusions were made to lone evenings when books proved a bore and knitting needles were duller than the books.'[66] Observing that 'it pays . . . to play up to the wife', this retailer spoke from personal experience: 'I'm away from home a good bit myself . . . I don't know what my wife would do without a wireless set in the home when I'm away.'

Ethelberta's feigned radio seizure in 'A Martyr to Wireless' is deftly engaged with the trajectory for women from Marconi amazons to passive companions and sales accessories. Oliver's narrative translates female competence back into the domestic realm, which Ethelberta defends against wireless hazards: tying the cat to her chair to prevent further singeing of its whiskers for instance, where a Marconi amazon might flourish 'cats' whiskers' for her crystal set. The phrase 'wireless widow', used as a warning to Ethelberta, has a slightly different connotation to the 'radio widow' and 'radio divorcées' referenced in the American magazines analysed by Butsch.[67] The *w*-alliteration has 'war widow' behind it, a condition more widespread in Britain than America during the 1920s. Ethelberta's conciliatory modernity consists in her ability to absorb wireless technology and disgorge it from the home, as she navigates between bereavement and Amazonian powers of reception. Her manipulation of male psychology is more than a match for the wireless retail strategies aimed at women, introducing advanced subterfuge to the battle over radio in the home. But the vanquishing of that empowered and patriotic female body, Aunt Boadicea, also neutralizes the prospect of equal technological competence and domestic independence for women, restoring the home to a site of imagined prewar stability in marital relations while also restoring the connections between bodies at home that had been distanced from each other in their yearning for Glasgow or Rangoon.

'These accursed 'phones'

A further wireless story in the *Yellow Magazine* for July 1925 explores radio's disruption of marriage on contrasting terms. 'A Call from 2.L.O.' by Alan J. Thompson was also copyrighted in the United States, but a counterpart publication is unknown.[68] Nothing is known about the author beyond that he (or perhaps she, using a pseudonym) contributed a handful of stories to the British pulps between 1911 and 1932, and published three novels. Named for the first British transmitter in London, 'A Call from 2.L.O.' features radio as a mechanism for transferring possession of a woman from one man to another. The story's ambivalence lies in its portrayal of radio to break up a marriage, mitigated by the husband being a villain and the promotion of broadcasting as a means of restoring true love.

Leslie Hammond is a self-made man who has worked his way up to becoming manager of a store in London's West End and now relishes his situation, complete with a pretty wife who 'ran the household and attended to his meals and other creature comforts with rare efficiency'.[69] He enjoys the radio in a similar vein: 'Just smoke and listen and switch off anything boring'.[70] Unlike the men in previous pulp radio stories, Hammond does pay attention to broadcast content, in this case a political speech on the theme of 'success won against circumstance' delivered by a socialist peer named Lord Carwardine. Hammond is frustrated to find that his wife Sheila has not been listening and has failed to boost his ego with reflections on his own successes, which include having won her from 'that conceited ass, Coningsby Vaughan'.[71] The most intimate item of wireless technology is bound up with a transfer of power, as the couple attempt to listen to a concert together: 'We'll have the headphones', she remarks. 'They're better than the loud speaker, which is still a bit twangy', and she places them on her husband's head 'with a swift grace'.[72] A last-minute substitution in the programme introduces a new tenor, whom Hammond finds excellent, as 'nodding approval, he pressed the 'phones a little closer'.[73] Yet within a short space of time 'the hands holding the 'phones shook', and soon Hammond 'longed to drag these accursed 'phones from his ears and to silence that merciless voice': he has recognized the singing of his rival, Sheila's former fiancé, whom Hammond had reported dead several years previously.[74] Tricked by Hammond into leaving for America, Coningsby Vaughan has returned an accomplished tenor, and Hammond's hard-won comforts have been disrupted by 'That infernal wireless!'[75] A fatal car crash dispenses with the fraudulent husband as he races to recover Sheila from a reunion with her lover at the Savoy Hill studio. The part of Lord Carwardine's speech that he had disagreed with comes back to Hammond as life ebbs away on the pavement: 'It frequently happens that at the very hour in which a man his lauding himself on the splendour of his success, he learns the completeness of his failure'.[76]

Butsch notes a conjunction of gender and class dynamics in the popularization of radio during the early 1920s. Cover art shifted to depict 'upper middle-class' and 'affluent family' life, with cocktails and elegant clothing, while cartoons undermining male technical expertise made fun of 'lower middle-class, white-collar workers . . . in striking contrast to the self-assured, affluent men in ads and on magazine covers'.[77] 'A Call from 2.L.O.' addresses class mobility and conflict through Hammond having worked his way up from office boy to manager, while his rival, the formerly dissolute Coningsby Vaughan Farrenfield, has more than enough syllables in his name to indicate a gilded start in life. The invasion of Hammond's hard-earned comforts by Vaughan's highbred broadcast voice is emphasized through Hammond's embodied response to the headphones. Moores reports the testimony of women unable to wrest listening equipment from men, conjecturing that 'earphones worn by early radio enthusiasts might . . . be read as a kind of crown, with similar connotations of power and control'.[78] Earphones in advertisements mediated sex relations. In *Wireless World*, an ad for Bull Dog Grip Connectors depicted a man and woman listening with phones, joined by a wire held by him, while an ad for Fellows promoted a special 'handphone', 'specially designed for ladies' with 'no headband to catch or tear the hair'.[79] A Brandes ad in *Modern Wireless* was more seductive, showing a glamorous young woman with bare shoulders and asking 'Are you sure that you can invite her to listen?'[80] A Telefunken advert in *The Broadcaster* portrayed a smiling man in evening dress with smoke curling up from his cigarette as he looks down at a bare-shouldered woman whose decorative function is underlined by the identical fabric of her dress and the lampshade; she listens enraptured through delicate headphones, the wire looped through her hands, which are clasped over her breasts (Figure 6.2).[81]

'A Call from 2.L.O.' indicates Sheila's power to mollify her husband using the phones, but ultimately the listening equipment punishes the overreaching, working-class man while restoring female property to the wayward, upper-class hero who has found success in the entertainment industry. At the same time, the narrative suggests a degree of ambivalence around radio as a feminized or sexualized agent of domesticity and pleasure during the early years of public broadcasting. The many pulp readers in heterosexual circumstances are offered the fantasy of a sexy tenor who might rescue women from the compromises of an imperfect marriage, but this doubles as a warning to men about the risk of losing their women to a romance of the airwaves. The wireless dealer's concern about 'what my wife would do without a wireless set in the home' is matched here by questions about what the wireless set will do with her. By now established as a broadcasting medium, the radio that had enhanced the distress of an isolated female listener in 'A Martyr to Wireless' here rescues a deceived woman, appearing to promote female choice while underlining male ownership. And the act of listening has become focused on broadcast content to the extent that an absent voice can intervene in home life and serve justice to good and bad listening bodies.

Conclusion

By assuming that there are given male and female identities on which the domestication of technology can operate, we miss the opportunities for active negotiation of gender when technology enters the home. Even pulp fiction, with its heavy use of stereotypes, affords glimpses of such negotiation through satirical humour, the matching of established

Figure 6.2 Telefunken headphone advertisement from *The Broadcaster*, October 1924, ©www.timeincukcontent.com.

technological narratives with genre formulae, and the reflection of reader involvement with social continuity and change. The stories analysed here suggest radio's flexibility in both narrative and domestic terms. In the thriller genre, it can serve as a weapon and, in romance, as a transmitter of female affection from one man to another. The selection of stations by listeners-in is matched by a selection of social and narrative functions. The gendered body of the radio user is engaged with technology in ways that are shaped by financial motives, homosocial conflict and competition, imperial interests, marital power dynamics, and class status. Variant radio masculinities in the pulp stories offer alternatives to both the wartime heroics of Marconi men and the peacetime campaigning of radio salesmen. Multiple roles for women at home also emerge in relation to a newly configuring public culture. Evelyn's intensified awareness of the disjunction between her circumstances and the consumers of jazz concerts, Ethelberta's cunning victory over Uncle Percy and Aunt Boadicea, and Sheila's ascent from an unhappy marriage into the arms of a flesh-and-blood radio tenor, offer more diverse possibilities for radio femininity than the advertising images of women with phones safely clamped over undisturbed bobbed hair, though these do not compensate for erasure of the Marconi amazon.

Paddy Scannell and David Cardiff discuss the ways in which broadcasting of events 'unobtrusively stitched together the private and the public spheres in a whole new range of contexts. At the same time the events themselves, previously discrete, now entered into new relations with each other, woven together as idioms of a common national life.'[82] The stories analysed here supplement Moores's oral history, confirming that the 'stitching' work of radio in the home could be highly obtrusive, while the purported 'common national life' was often experienced as disjunction, both at the level of fantasy and through daily lived experience. Graeme Gooday concludes his study of the domestication of electricity with the comment that this process was 'to some interesting extent at the discretion of household consumers themselves, not determined by the aims and fantasies of those promoting the domestication of electricity'.[83] The pulp narratives and wireless magazines analysed here offer some insights into the forms of discretion in play for radio consumers, serving as a reminder that, for all the documented endeavours of radio companies, corporations, societies, manufacturers, and retailers, the most significant and elusive relationships that early radio listeners had were with each other, in forms of intimacy and distance that could be more extensively reconstructed in histories of radio.

Notes

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21. G.B. Jenkins (1923) 'Radio Death', *Midnight Mystery Stories, 2*, 3 February 1923, 4–6, 10: 6.
22. Jenkins, 'Radio Death', *Hutchinson's*, p. 65.
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24. Sconce, *Haunted Media*, pp. 69, 74.
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7

Contemporary Homemade Meteorological Science: Co-constructing the Home and Weather–Climate Knowledges in the UK

Carol Morris and Georgina Endfield

This chapter addresses the following question: What happens when the contemporary home becomes a site of scientific knowledge production, both for the meanings and understandings of home but also for the practices and politics of knowledge production? We seek to contribute to recent scholarship on the cultural geographies of home, which has paid little attention to the home as a site of scientific knowledge production, and how this activity reconfigures the home and practices of homemaking. We also speak to multidisciplinary work on the spatialities of scientific knowledge production, which has undertaken limited analysis of what it means to produce scientific knowledge, both certified and unaccredited, within a *contemporary* domestic environment, and the implications for the status of knowledge produced in this location.[1] The spatialities of weather and climate knowledge production by amateur meteorologists provide the empirical focus of this chapter, and through this we also seek to contribute to recent work analysing the cultural dimensions of climate. This research uncovers the culturally specific and spatially and temporally distinctive meanings and practices of weather and climate beyond those produced by global climate change science.[2] More specifically, we explore these meanings and practices as they are played out in the domestic sphere, focusing in particular on those associated with amateur meteorology.

We approach our task through a case study of one UK-based amateur meteorology organization – the Climatological Observers Link (COL) – a focus that is justified in two ways. First, the production of weather and climate knowledges by COL members is undertaken in various sites within the domestic environment, including the garden, enabling its characterization as 'homemade meteorological science'. Although an 'amateur' organization, COL members follow professional standards and principles, making their meteorology a type of 'serious leisure' activity.[3] Second, even though there has been a long and vibrant history of amateur engagement in weather and climate, only recently has the value of amateur meteorologists as legitimate producers of knowledge about contemporary weather and climate begun to be acknowledged by scholars of climate science and professional climate organizations. Reflecting a broader process that has been described as the democratization of knowledge, amateur meteorologists are being (re)valued in various ways, for example as producers of weather data to 'official' meteorological networks and as on-ground witnesses of weather events that can confirm the timing, features, and immediate impacts of unusual or extreme episodes.[4] COL is considered to be the most significant organization in the UK representing amateur meteorologists who observe and record weather on a daily basis at home.

In the following section, we provide further context by discussing the three areas of scholarship that frame our investigation and to which we seek to contribute: geographies of the home and domestic life, spatial studies of science, and cultural studies of climate. The chapter then describes COL and the knowledge practices of its members in more detail before moving on to explore two empirical themes concerning the interrelationship between the domestic sphere, domestic life, and amateur meteorology, first in terms of constraint and secondly of enablement. In concluding, we argue that a tension exists in the analysis of amateur meteorology as homemade science since it runs the risk of exposing the difficulties and limitations in practising science in a domestic context, while simultaneously helping to draw attention to the unique contribution of homemade meteorological science to wider circuits of climate knowledge.

Contextualizing the study of homemade meteorological science

Since the late 1990s, scholars have undertaken a wide range of research into the home and domesticity, both within and beyond geography, which, as Alison Blunt has claimed, has done much to 'unsettle the familiar and mundane'.[5] Recent studies have paid increasing attention to the home as a potential site of struggle and conflict, producing a 'gloomier', critical perspective on domestic space and life that inspires our consideration of the ways in which amateur meteorology produces domestic disruptions.[6] Also of relevance to this chapter's approach is the conceptualization of home in processual and heterogeneous terms; home and homemaking are best understood as ongoing, involving processes, such as negotiation, in order to be felt and experienced, and they are the outcome of interrelationships between humans and non-humans, both living and artefactual.[7] This attention to the 'complex entanglements' of nature and culture, and of human and non-human agency in shaping the domestic sphere, is particularly pertinent to our case since amateur meteorology involves multiple knowledge practices of weather within various sites inside and outside the house.[8] Specifically, it has been argued by Maria Kaika that homemaking within modernity necessarily involves the deliberate exclusion of nature and natural processes.[9] However, when the home becomes a site of knowledge production within amateur meteorology this assertion can be problematized, since amateur meteorologists actively seek familiarity with 'nature', as weather(s), *within* the bounds of the home, particularly the garden. Nevertheless, Kaika suggests that natural elements are *selectively* allowed to enter the home, having undergone what she refers to as significant material and social transformations, for example, through purification and commodification, although this process is enabled by a set of *invisible* social and material connections. Within amateur meteorology, weathers are typically transformed into data that allow them to come inside the home, to be subject to analysis and wider circulation and discussion, but (and in distinction to Kaika) this occurs through a set of very *visible* social and material connections which can be themselves problematic and contentious, as our empirical material will reveal.

Although geographies of home provide a valuable framework for our investigation, we note that this scholarship has not attended to the implications of the contemporary home as a site of knowledge production for conceptualizations of home. For example, it has been observed that the meanings and lived experiences of home are diverse, encompassing belonging, alienation, intimacy, violence, desire, and fear.[10] However, there has been no acknowledgement that *knowledge production and circulation* is one of these lived experiences and sources of relationships, meaning, and contestation within the domestic sphere. This chapter asserts that ignoring the role that domestic locations play in the constitution of scientific knowledge production and circulation helps to reproduce the idea that these processes are confined to other, non-domestic sites, such as the laboratory, university, and 'field', associated exclusively with the 'certified expertise' of scientists.[11]

Alongside this work on the geographies of the home, our analysis is informed by spatially sensitive work within science studies scholarship. This has been produced both by geographers and scholars in other disciplines.[12] As a result, the spatial has been conceptualized in ways that are variable and sometimes competing.[13] Nevertheless, this has been regarded as a source of strength rather than weakness, and a justification for resisting the institutionalization of geographies of science. Within the discipline of geography, the spatiality of science project has evolved as the *historical* geography of science.[14] This provides scope for other geographies of science, both of geographical science itself but also other fields of geographical interest.[15] This chapter's empirical focus on a *contemporary* form of science associated with amateur meteorology represents a novel departure for geographical studies of science and work on amateur meteorology. It examines the site-specific practices of science, including their materialities, an approach that accepts the co-construction, or relationality, of space and science that follows directly from previous geographical studies of science. However, the concern of this chapter is distinctive through its focus on the co-construction of non-certified scientific knowledge and contemporary domestic environments.[16]

In pursuing this research problem we take seriously Beth Greenhough's observation that practitioners of science studies, and geographers in particular, have a tendency to be 'spatially captured' by the science(s) that they are investigating.[17] In other words, the spaces of analysis are those defined by scientific practitioners with scientific objectives in mind, and by making those spaces the object of their enquiry, science studies scholars can end up reproducing them. What is needed instead, Greenhough argues, is a greater questioning of the spatial assumptions that inscribe and authenticate the sites of science and science studies. In short, she suggests, we need to go beyond simply 'adopting' scientific spaces and conceptualize research space differently. We respond to this challenge by investigating a space that would not, ordinarily, be considered 'scientific', and by doing so, we explore what happens to our understandings of science/scientific knowledge production when a typical or 'alternative' scientific spaces are brought into view.

Our research is also situated within a growing body of scholarship on the cultural dimensions of climate knowledge.[18] This work has emerged in response to a predominantly global, scientific meta-narrative that emphasizes climate change over the distinctive meaning that climate holds, and has held in the past, for different people and places.[19] It is increasingly being recognized that climate 'means different things to different people in different contexts, places and networks'.[20] Recent research, therefore, is highlighting the need to gain a better understanding of how different groups of people have conceptualized climate and have responded to its fluctuations in the past, to explore the 'idea' of climate as a 'hybrid phenomenon', constructed, not only through the use of meteorological statistics but also through 'sensory experiences, mental assimilation, social learning and cultural interpretations', and to investigate how 'ordinary people', that is to say, non-certified experts, understand, talk, or write about climate and weather.[21] Another aspect to this work is recognition of the need to situate knowledge claims, to particularize climatic experience, to draw out the plurality of meanings around climate, and to identify what constitutes climatological 'expertise'.[22] There is now a growing body of scholarship investigating the spatialities of meteorological knowledge production through a historical perspective, although, as yet, little attention has been paid to the home as a space in which meteorological knowledge is produced, and even less to the contemporary production of meteorological knowledge in the domestic space.[23] Our research seeks to make a novel contribution to this work in a number of ways. First, we are concerned with the production of climate knowledge at the local scale, through the observation and recording of local weather on a quotidian basis and also as a science produced or made in the 'home'. Secondly, we are interested in the way in which this knowledge is produced by a distinctly amateur community, the details of which are provided in the next section.

The Climatological Observers Link (COL)

COL was founded in 1970 to enable the exchange of weather data between amateur observers located in different parts of the UK. Currently, membership of COL stands at over 400, but the number of members actively contributing observational data is nearer 300. Many COL members have maintained weather records for decades, their interest beginning during their childhood or teenage years, and often stimulated by direct experience of unusual or extreme weather. COL aims to be an inclusive organization, welcoming anyone with an interest in weather, whether or not they undertake formally weather observation and recording. COL members are interested in the day-to-day changes in weather, although many have a passionate interest in the physical and visual manifestations of weather, including, but by no means limited to, its extremes. As such, we note the importance, to this group of amateur meteorologists, of a set of embodied, sensory knowledge practices that are developed in relation to particular aspects of weather 'directly' through weather observing and recording, but also through reading about weather in various media and ongoing relationships with other COL members.

Although 'being in', 'looking at', and other means of sensing weather are integral to what it means to become and identify as an amateur meteorologist, it is a particular set of routinely executed knowledge practices that are core to COL. Significant here is the maintenance of daily weather records using a standard range of instruments, some of which are housed in a 'Stevenson Screen', to record a range of weather phenomena such as air and soil temperatures, humidity, rainfall, wind speed and direction, and sunshine. Together these constitute a 'weather station'. In association with these instrumental records, COL members also, typically, use their visual skills to observe the amount, height, and type of cloud and the strength and direction of the wind, and record these using a standardized set of symbols and scales that are published in the *Weather Observer's Handbook* and/or their own systems of measuring these phenomena.[24] Narrative records of weather – brief notes and more extensive diary entries – are also kept alongside instrumental and observational data, and these are recognized as complementary knowledge practices. Such qualitative records are used to document more extreme or unusual weather events such as thunderstorms, heavy rainfall, hail, snow, or fog.

Typically, observers' instruments are located in their gardens or on land immediately adjacent to their houses, requiring them to go outside to take their readings. Readings are normally taken at 9 am and 9 pm (GMT) in accordance with Meteorological Office guidelines, although there is some variation. Members that also use automated weather stations often locate these alongside their manual instruments in or near the Stephenson Screen, although the data displays are typically indoors within spaces (sometimes particular rooms) dedicated to the processing, interpretation, and archiving of these data. Many COL members, therefore, employ a systematic and rigorous approach to their observing and recording practices in order to produce a material record of change which can be used for comparative purposes, both with other COL weather observers as well as individuals and organizations beyond COL with an interest in weather and climate. A further aspect of this is the intention to produce as consistent and continuous a record as possible for a particular location. Alongside these dominant knowledge practices, a small number of members are engaged in 'alternative' knowledge practices, notably the practising and circulation of weather lore and weather forecasting.

COL's activities are governed by a committee. The production of a monthly bulletin by the editor, which publishes members' observational data, represents a key mechanism of knowledge circulation within COL. The exchange and comparison of data from members' weather stations, together with exchange of other information such as books and articles about weather, also occurs via informal meetings that take place between members co-located in different regions of the UK. In addition to these meetings, members communicate with one another by phone and email, and are often prompted to do so by a severe or exceptional weather event. An annual general meeting of COL usually takes place in the autumn and constitutes another site in which the production, circulation, and contestation of weather and climate knowledge practices takes place.

Methodology for exploring 'home is where the weather is'

We invited members of COL to participate in our research during a presentation at the organization's annual general meeting in October 2007 and through an advertisement in the COL bulletin. Interviewees represent a cross-section of amateur meteorologists in terms of their socioeconomic status, geographical location, recording practices, level of skill and expertise, degree and length of engagement in COL, and their relationships with professionals and wider publics. We completed, in total, 24 in-depth, semi-structured interviews with COL members between 2007 and 2010.[25] Interviews focused on a broad range of themes that addressed motivations for observing and recording the weather, what they measure, and what purpose and audiences their data serve. Interviews also focused on the equipment and technology employed. As a science that is very much produced within the domestic space, including the garden, discussion also focused on the relationships between homemaking, home space, and home life in shaping and informing weather observation practices. Two key themes emerged from these discussions. First, it became clear that the home and home life served to constrain weather observation in a number of ways, while weather observation practices, in turn, also caused tensions in terms of domestic routines; and second, our interviews revealed multiple ways in which the home, and specifically homemaking, facilitated or enabled weather observation practices. The two following sections draw on our interview transcripts to address these two interconnected themes.

When domestic life disrupts weather observation and recording

The material characteristics of the domestic environment, specifically of the garden space, challenged many observers, as these often adversely impacted the exposure of their instruments. This was described as a general 'problem' for amateur meteorologists by an interviewee who argued that 'it is not likely that by and large they are able to have what are ideal conditions [for their instruments]'.[26] Unduly sheltered gardens, particularly in suburban locations, are what this COL member is referring to: weather stations in these situations typically have to be located in relatively close proximity to houses and boundary features such as fences, hedges, and trees, because gardens are not large enough for more open placements. Another observer described a house in which he had resided during an earlier period in his life as '... a very bad site; the temperatures were far too high on it'.[27] Two cases further illustrate the material constraints of producing weather knowledge in a domestic context:

> With sunshine I just make a note of when there is sunshine or not in the day time because the position [of the house] isn't good enough [for a sunshine recorder], unless I stand on the roof of the house ... and that would be very difficult to access (laughs).[28]

> At that time [my home was in] ... a village about three miles away from here ... , but it *was a sheltered site there, on a then-modern housing development*. So here is certainly a better site, although one is always looking for better things. It would be nice to live miles in the country or something.[29]

Another observer described how his garden had been assessed by the Meteorological Office as a potential site for contributing rainfall and temperature data to the official network.[30] Although deemed suitable as a site for rainfall data, once he had relocated his rain gauge away from a hedge, he was told by the Meteorological Office assessor that his temperature readings would not be accepted because the site was too sheltered. It was suggested by one interviewee, who is also a weather writer and journalist, that the situation for amateur meteorologists could be worsening in these respects, due to changes in garden maintenance practices and building design trends:

> One thing that has struck me again over the last five to ten years in respect of my own station in my mother's back garden is how suburban sites in the last 10 years have become much more overgrown. Up until the early to mid-1980s people had vegetable gardens and they kept their gardens clear mostly, but trees, fruit trees, and such all seem to have grown up in the last 10 years or so, and of course that makes it much more difficult to get a decent site in the back garden as well as the fact that back gardens are smaller now.[31]

Although COL members' current gardens were often described as not ideal in terms of their exposure, these compared favourably with the material conditions for weather observation and recording provided by the homes in which they resided earlier in their lives. Interviewees frequently talked about occupying a small home (a flat, but sometimes a small house) when they began living independently, away from their parents, and these residences made weather recording very difficult, because there was no garden in which to locate the instruments or the garden was not secure, as the following interviewee recounted:

> We lived in a maisonette for the first four years of our married life, and the garden we had was out facing the street so you couldn't keep instruments really because they would probably go [i.e., be stolen]. I . . . put them out say if there was a big shower coming, I would put my rain gauge out and record something then but on a permanent basis *I wouldn't record because we didn't have the facilities*.[32]

The frequent changes of residence that often characterize early adulthood also militated against the keeping of a consistent weather record, as this observer described:

> There have been periods when I have been in transit and I haven't kept a weather station, more particularly in the late 1970s, that was when I lived in [name of place] for a bit . . . The . . . [name of place] ones [i.e., observations] were bitty because we kept moving house . . . I had weather books like that but they were bitty. I think that was about the only time in my life when things [i.e., the weather records] were not continuous.[33]

Other dimensions of domestic life, beyond its material conditions, were also identified as constraining or disrupting weather observation and recording practices. In cases where COL members had children, this diverted time and money away from their meteorology, as described by the following interviewee:

> The kids were being born and . . . so everything was in a state of flux really . . . I was in [name of place] from 1983 until 1987 [and started recording again but] . . . It wasn't the same detail as when I left [name of place]. I still had my old Stevenson Screen and my old rain gauge, but I was busy as a schoolteacher and bringing up two young kids. Unfortunately my marriage had also started to go downhill then which you know, other pressures were taking over.[34]

Children were reported to disrupt weather observation in other ways. Instruments sometimes had to be sited in places away from where children played, and these were not always ideal for their exposure. Even then, the instruments were still vulnerable to damage. An observer described how he had 'had those instruments all that time [since 1974–1975], although I have had to buy replacements occasionally. My daughter's friend stood on a grass thermometer for instance (laughs).'[35] Even family pets were also, occasionally, identified as having similarly disruptive effects. For example, a cat belonging to an observer 'drinks from my electronic rain gauge and it doesn't work now. When it gets a fair bit of water in it he goes and drinks out of it.'[36]

Interviewees talked at length about the activities that took them away from their homes and how these impacted adversely their ability to maintain both a continuous weather record and one that is produced at the standard observation times of 9 am and 9 pm. Important here were periods spent away from their parental homes (where many observers had begun to record the weather) to attend college/university, and then later, when living independently, to pursue paid employment outside the home, as illustrated in the following case:

> I have been recording the weather pretty much ever since I started with a short break when I went to university in the early 1970s . . . In the morning, the standard 0900 time [for observations] is impossible for somebody who works because in the summer time that is 10 o'clock so that is impractical and I think that is probably the same for many amateurs.[37]

Other domestic commitments such as family holidays were also identified as particular sources of tension and irritation, with some observers describing these as a 'nuisance'. The use of automated instruments is one strategy for managing observers' absence from their homes. However, this is not always within the financial and technical means of COL members, and informants reported concerns about the reliability and accuracy of the instrumentation.

Interviewees also revealed how their enthusiasm for weather observation and recording could, at the very least, intrude on and at times disrupt domestic life. The wife of one observer described how he had installed his rain gauge the day before their wedding and that she had 'got a photograph with him holding a thermograph report and I showed it to my friend and she said "is that your marriage license!?" [Laughter.] It was quite funny though, you had it in your pocket on the wedding day'.[38] Interviewees deliberated about the extent to which their meteorology was a domestic priority, with some claiming that their weather observing and recording practices acted as structures around which other domestic activities had to work, that is, take second place. 'It [i.e., my enthusiasm/commitment] means the family has to work around it to an extent, they have to accommodate it', explained one observer.[39] Another asserted, 'I won't go out until I have done it, or if I am out shopping, I will come back at the right time'.[40] Such practices were widely shared. Others suggested that although 'the weather comes first' it did not interfere unduly with other aspects of domestic/family life:

> [Observer:] Yes, one of the first things I think about in the morning is the recording and the weather.
>
> [Interviewer:] So what you're saying is that other things have to fit around it? So if you were planning to go out as a family you would have to wait until you had done your recordings?
>
> [Observer:] Oh no no no! In the winter time I will have to wait until I have seen the weather forecast . . . but I am not that obsessed because I can get it on the German website, I go on the computer now. I might have been more obsessed in the past . . .[41]

The requirement to *record* weather data at particular times of the day was only one of the ways that amateur meteorology placed constraints on other household members. Also mentioned was the potential or actual disruption caused by the desire to simply *observe* the weather (and extreme weather events in particular) at unusual times of the day or night. One observer described how on a particular occasion when his wife had cooked a special celebration meal:

> [T]his fantastic thunderstorm broke out and the rain and the hail, the biggest hail I have ever seen . . . And the hail were just enormous – there were cars wrecked by the hail, and there were enormous amounts of rain, and everything else and the dinner was burnt because I was watching the hail.[42]

Beyond the impact of routine weather recording and the observing of extreme weather events, the purchasing of weather instruments was described as 'domestically controversial', as this involved diverting funds from a limited household budget.[43] Also controversial for other household members, but this time for aesthetic reasons, is 'having your instruments in the back garden, I think initially it looks a bit ugly but it is something you get used to, it blends in with the rest of the garden furniture'.[44]

Domestic life enabling weather observation

In this section we consider the degree to which domestic life, familial support, and homemaking enable or facilitate weather observation and recording practices. First, the provision of a family home and familial support is considered as a factor that may have encouraged our interviewees to develop their interest while young, and which may have also ensured the maintenance of records during times of absence from the family home. We then consider the importance of establishing a 'permanent' home and also homemaking, which, our interviewees felt, helped them to further develop their interests in and practices associated with weather observation.

A number of interviewees discussed the centrality of their parental home and family support in facilitating their pursuit of weather observation and recording when young. One observer, for example, noted that he began collecting rainfall and maximum and minimum temperatures while a schoolboy in 1979, and, he adds:

> I started doing both of those, and then again I just kept on doing it throughout my school life. I upgraded to a sort of proper max and min thermometer and a sort of homemade Stevenson screen . . . again that was a couple of years later, I think, and that went into the garden, and then it was pretty much standard readings then.[45]

In this case a permanent, familial domestic space, in which he found support from his parents, helped him develop his weather interests. Others similarly reported on how familial assistance enabled them to maintain a consistent record of the weather despite being temporarily absent. For example, a respondent noted how his 'very long-suffering' father took the temperature for him while he was at university.[46]

Other family members also appear to have become involved, either directly or indirectly, in weather observation at home. One long-serving member from the South-East even recalls persuading his mother to use her dressmaking skills to make a windsock, and this was exposed high on a tree in the back garden, to enable the observer to determine wind direction while he also used the Beaufort scale for recording wind speed. Yet for others, the use of other extended familial domestic spaces allowed a continuation of recording, even when away on vacation during school holidays: 'I would arrange for some relation hopefully to step in and read the thermometer or take it up to my grandfather's a mile or two away and he would read it'.[47]

Yet it was the setting up of their own home – homemaking at a 'permanent' base – that enabled many of our respondents to really develop and extend their interest in weather observation and recording. For some, having a permanent home meant installing the equipment they had from their youth, such as the observer who noted that, from 1987 until 2000, he 'was moving around the country a lot, so it was difficult to be settled in one place'. Although he tried whenever possible to engage in some recordings wherever he was based, it was only really since he 'stayed in a settled area' that he has been able to set up his equipment, starting with 'a rain gauge initially, and I got the old maximum and minimum thermometers out again, set up in the garden with the old Stevenson screen'.[48]

For others, however, homemaking, coupled with having independent income, meant investing in new instruments. Indeed, one observer noted how the acquisition of 'proper equipment' went hand in hand with moving into his own house, after a period when he and his wife had lived with her parents:

> When we got married and had a house together in 1992, then I could get more proper equipment . . . I got a rain gauge when I had the garden to put the rain gauge in, so before that it was just temperature that I was recording because I couldn't dig out your [i.e., his wife's parents] garden, could I?![49]

Establishing a home with a garden appears to have helped develop allied interests too. It was noted by one observer, for example, that although he was not in a financial position to invest in costly weather instruments when he first set up home and started a family, having a domestic context allowed him to develop his weather interests in alternative ways. He went on to explain:

> There was then a gap until I was married with a family on a low income and I didn't have much to spend to have an interest in and I looked back through my notes, because we had a garden then for the first time in my life, and I was keeping a note of what to plant and when it came into flower, and I noticed these notes I had made about snow and I think I had carried on doing them, but there had been very little snow during that period.[50]

For this interviewee, an interest in gardening and phenology allowed him to maintain an enthusiasm for weather and provided a substitute for weather-recording instruments.

Many COL members are retired, and this allows them more flexibility to engage with weather recording than those who are still in employment. For some, retirement means greater financial investment in weather-recording instruments. Yet, importantly, retirement also affords more time at home as well as flexibility to record regularly without being constrained by the demands of having to be at work. In discussing the constraints of the Meteorological Office recording schedule, one retired observer noted that '9 o'clock is fine, because I am retired anyway, so today I had to go out early, but it doesn't always happen, usually I am around at 9 am'. He also commented that he had a degree of flexibility such that he could 'usually try and arrange things as far as possible so that I am around at the crucial time and by and large I am'.[51] Yet establishing a domestic routine can facilitate recording even for those facing time constraints associated with employment. As one COL member, who works in the health sector, noted, for example, while it is difficult to find enough time to spend on weather observation, he was able to fit his weather observation regime around his employment:

> Obviously when I am at home in the morning, I will spend about fifteen minutes going down to do my observations, about 7:30 am to 8 am, [then] in [to] enter them into my records, and I enter them onto my webpage so they are up and running every morning.[52]

In as much as our interviewees commented on the assistance of family members in weather observation when they were young, many of our interviewees also indicated that their spouses and family members had roles to play in the observing and recording process, although often as, adopting Steven Shapin's terminology, 'invisible technicians'.[53] A number of COL members, for example, highlighted how their wives would step in to record during times when they themselves were unable to do so.[54] Yet for some observers, the spouse's role was absolutely pivotal to the maintenance of consistent records. One interviewee was only able to manage his weather recording because both he and his wife worked part-time but on different days, allowing for continuous weather recording throughout the week:

> Yes she does during the week at 10 am ... She goes to work on Tuesdays and Thursdays; she is very much part-time. I started doing a four-day week, and I tend to have Tuesday and Thursday morning off, you know, just to avoid her. [Laughs.] She always did the official readings, and still does, on Monday, Wednesday, and Friday. She is very reliable.[55]

Many of our interviewees commented on the impacts of their dedication to observing on daily, familial, and domestic routines.[56] For most interviewees, however, it seems that familial and domestic commitments were managed, whenever possible, around the demands of regular recording, and many suggested that wives, parents, and siblings 'accommodated' their interest, or that family life 'has to work around it'. In talking of his wife's accommodation of his interests into the daily domestic routine, one observer noted how his wife was 'so used to it that if I didn't do it she would wonder what was going on with me, if I am really ill or something'.[57]

To some extent, then, the practices associated with weather observation can, and have, become normalized within the domestic routine. Moreover, for some of our observers, the need to be physically present in the domestic space to maintain weather observation and recording seems to have acted in a way to support home life. As one observer noted, for example, his interest in amateur meteorology seems to have had a positive impact for his family, as his wife 'knows it is an interest, and she knows it keeps me at home'. He added that 'there are a lot more expensive hobbies that you can do, so you know, it works well. But no, we are still married after 25 years, so I guess it has probably not got in the way.'[58]

Discussion and conclusions

In this chapter we have explored the interrelationship between the contemporary home – its meanings and conceptualizations – and scientific knowledge production – its practices and politics. We have undertaken our task through a case study of the UK's COL, the members of which practise a form of homemade meteorological science, in that the home is the site in which the majority of weather observation and recording takes place. A focus on amateur meteorology has been justified in relation to the broader growth in interest in non-certified expertise in environmental monitoring and the resolution of environmental problems, and within this, the emerging recognition of amateur meteorologists as valuable producers of weather and climate knowledge.

A key finding of our chapter is that there are many impediments to producing weather and climate knowledge in the home. These difficulties and constraints are associated with the material characteristics of amateur meteorologists' houses and gardens, which impact the exposure of their instruments as well as their ability to set up their instruments in the first place. These constraints, in turn, are entangled with a set of socioeconomic factors (for example, level of household income, the need to undertake employment outside the home) and life-course stages (being away from home to attend college/university, raising a family) that are, in part, constituted through domestic space and have particular implications for the ability of amateur meteorologists to practise and produce their science according to the professional standards to which many of them aspire. Also apparent are the disruptions to domestic life caused by the practising of homemade meteorological science, with weather observation and recording practices determining domestic routines and upsetting the aesthetics of home spaces.

Our evidence also reveals the considerable effort that is devoted to ameliorating the (worst) effects of domestically imposed constraints on amateur meteorology and, building on earlier cultural geographic work on the home, suggests that this effort needs to be understood in collective or relational/associational terms, involving a range of other human (for example, family assistants) and non-human (automated weather stations) agents within the home. Amateur meteorologists employ a variety of strategies to enable them to overcome the domestically imposed constraints on their weather and climate knowledge-producing practices, and these strategies are themselves tied up with, and produced through, domestic space and life. These can lead to a normalization of weather observing and recording practices within the home, in that they become a routine or mundane aspect of everyday domestic life, largely accepted and accommodated by other household members. This normalization in itself can be understood as a form of domestic enablement of amateur meteorological science.

The chapter has drawn attention to knowledge production as one important activity within the home that has previously been overlooked in cultural geographic work on domestic life. For members of COL, *home is where the weather is* because it is the domestic environment, with its various sites of weather observation and recording, in which their knowledge-producing practices of weather and climate are enacted. Weather takes on much of its meaning and its scientific form (data sets) within a domestic context. As such, we suggest that knowledge production is an important means by which home is produced and made meaningful, and this needs to be recognized, but also further investigated, in future studies of the home.

By focusing on the contemporary home as an 'alternative' space of scientific knowledge production, our chapter contributes to literature on the spatialities of science as it challenges conventional understandings of where science is made (in laboratories, in scientific 'fields'). However, we conclude by suggesting that there are tensions associated with this analytical perspective, which need to be considered. On the one hand, by revealing, as we have done, the challenges and difficulties associated with the making of homemade meteorological science, this could run the risk of undermining amateur meteorology and its actual and potential further contribution to wider circuits of weather and climate knowledge. This is because the combined effects of domestically constituted constraints on amateur meteorology might legitimately lead to a questioning of the quality of COL members' weather and climate knowledge. In other words, the application of a domestic analytical lens to the practices of contemporary amateur meteorologists might confirm to some of the more sceptical 'certified' weather/climate experts the limits of this form of science. This extends Katherine Brickell's discussion of 'critical geographies of home', in which she argues that mapping, or revealing, the darker sides of domestic life could have negative effects for those being mapped; we would argue this should include the ways in which domestic life disrupts activities such as the production of knowledge.[59] On the other hand, the potentially negative effects on amateur meteorology of a home-oriented analysis can be counterbalanced by its ability to highlight the lengths to which observers will go to both observe and record weather phenomena that an increasingly automated network of official meteorological stations do not and cannot.[60] In this way, COL members observe and record the minutiae of local weather in particular contexts, giving them a level of expertise in local weathers that is all their own. As this observer asserted:

> There is a hell of a lot of good data here. Okay, the site may be in a suburban garden, and it is a little bit more sheltered than you would expect on an airfield, but that is going to give you a better representative reading of local areas, because it damn well isn't the RAF [Royal Air Force] station 15 miles away. That is the point. When people are looking for urban heat island studies or local climatology studies, that is more representative. I want people to have more confidence and ability in COL data.[61]

In the sense that COL members can respond to calls for greater particularity in climate knowledge, we close by suggesting that COL members have the potential to be considered as a discrete form of weather and climate expert. Domestic space is central to the development of that expertise.

Notes

1. As such, we acknowledge an emerging body of scholarship which takes seriously the environmental knowledge produced by amateurs or enthusiasts within both the context of 'crowd-sourcing' initiatives and more formalized 'participatory monitoring networks': S. Bell, M. Marzano, J. Cent, H. Kobierska, D. Podjed, D. Vandzinskaite, H. Reinert, A. Armaitiene, M. Grodzińska-Jurczak and R. Muršič (2008) 'What Counts? Volunteers and their Organizations in the Recording and Monitoring of Biodiversity', *Biodiversity Conservation, 17*, 3443–54. However, we note that this body of work has given little consideration to the home and domestic life in shaping amateur knowledge production.
2. M. Hulme (2008) 'Geographical Work at the Boundaries of Climate Change', *Transactions of the Institute of British Geographers, 33*, 5–11.
3. R. Stebbins (1992) *Amateurs, Professionals and Serious Leisure* (Montreal: McGill University Press).
4. This process is facilitated by the recent establishment of the UK's Meteorological Office of the Weather Observations website, http://wow.metoffice.gov.uk, which enables data sharing, both historical and near real time, between amateurs: S. Bell, D. Cornford and S. Bastin (2013) 'The State of Automated Amateur Weather Observations', *Weather, 68*, 36–41.
5. A. Blunt (2005) 'Cultural Geography: Cultural Geographies of Home', *Progress in Human Geography, 29*, 505–15.
6. K. Brickell (2012) 'Mapping and Doing Critical Geographies of Home', *Progress in Human Geography, 36*, 225–44.

7. See, for example: R. Hitchings (2003) 'People, Plants and Performance: On Actor Network Theory and the Material Pleasures of the Private Garden', *Social and Cultural Geography, 4*, 99–113; M. Kaika (2004) 'Interrogating the Geographies of the Familiar: Domesticating Nature and Constructing the Autonomy of the Modern Home', *International Journal of Urban and Regional Research, 28*, 265–86; E. Power (2009) 'Domestic Temporalities: Nature Times in the House-as-Home', *Geoforum, 40*, 1024–32; K. Walsh (2011) 'Migrant Masculinities and Domestic Space: British Home-Making Practices in Dubai', *Transactions of the Institute of British Geographers, 36*, 516–29.
8. Blunt, 'Cultural Geography'.
9. Kaika, 'Interrogating the Geographies of the Familiar'.
10. Blunt, 'Cultural Geography'.
11. H.M. Collins and R. Evans (2002) 'The Third Wave of Science Studies: Studies of Expertise and Experience', *Social Studies of Science, 32*, 235–96.
12. D. Turnbull (2002) 'Travelling Knowledge: Narratives, Assemblage and Encounters', in M. Bourguet, C. Licoppe and H.O. Sibum (eds) *Instruments, Travel and Science: Itineraries of Precision from the Seventeenth to the Twentieth Century* (London: Routledge), pp. 273–94; S. Shapin (1998) 'Placing the View from Nowhere: Historical and Sociological Problems in the Location of Science', *Transactions of the Institute of British Geographers, 23*, 5–12.
13. R. Powell (2007) 'Geographies of Science: Histories, Localities, Practices, Futures', *Progress in Human Geography, 31*, 309–29.
14. D. Livingstone (2003) *Putting Science in Its Place: Geographies of Scientific Knowledge* (Chicago: University of Chicago Press).
15. Powell, 'Geographies of Science'.
16. The concept of 'non-certified expertise' is derived from the work of Science and Technology Studies (STS) scholars Harry Collins and Robert Evans, who consider different types of expertise within the context of wider concerns over decision-making rights and legitimacy in the operation of science more broadly. An individual may be said to have non-certified expertise when they do not have a formal training, qualification, or certificate in a scientific arena, in this case meteorology. See Collins and Evans, 'The Third Wave of Science Studies'.
17. B. Greenhough (2006) 'Tales of an Island-Laboratory: Defining the Field in Geography and Science Studies', *Transactions of the Institute of British Geographers, 31*, 224–37.
18. M. Hulme (2009) *Why We Disagree about Climate Change* (Cambridge: Cambridge University Press); M. Hulme (2013) *Exploring Climate Change through Science and in Society: An Anthology of Mike Hulme's Essays, Interviews and Speeches* (Abingdon: Routledge); V. Jankovic and C. Barboza (eds) (2009) *Weather, Local Knowledge and Everyday Life: Issues in Integrated Climate Studies* (Rio de Janeiro: Mast).
19. Hulme, *Why We Disagree about Climate Change*.
20. Hulme, *Why We Disagree about Climate Change*, p. 25.
21. M. Hulme, S. Dessai, I. Lorenzoni, and D.R. Nelson (2009) 'Unstable Climates: Exploring the Statistical and Social Constructions of Normal Climate', *Geoforum, 40*, 197–206: 197; Jankovic and Barboza, *Weather, Local Knowledge and Everyday Life*.

22. D.N. Livingstone (2012) 'Reflections on the Cultural Spaces of Climate', *Climatic Change, 113*, 91–3.
23. S.K. Naylor (2006) 'Nationalising Provincial Weather: Meteorology in Nineteenth-Century Cornwall', *British Journal for the History of Science, 39*, 1–27; V. Jankovic (2001) *Reading the Skies: A Cultural History of the English Weather, 1650–1820* (Manchester: Manchester University Press).
24. S. Burt (2012) *The Weather Observer's Handbook* (Cambridge: Cambridge University Press). This handbook is a practical guide to weather observing and is aimed at both amateur and professional weather-observing networks around the world.
25. Interviews were fully transcribed, and where material from them is quoted verbatim, the anonymity of the interviewee is preserved by referring only to the region of the UK in which the COL member lives and the year in which the interview took place. Interview materials are currently held by Morris and Endfield.
26. Interview with COL member, north-east, 2008.
27. Interview with COL member, south-east, 2008.
28. Interview with COL member, south-east, 2009.
29. Interview with COL member, south-east, 2008, emphasis added.
30. Interview with COL member, north-east, 2008.
31. Interview with COL member, south-east, 2009.
32. Interview with COL member, south-east, 2009, emphasis added.
33. Interview with COL member, north-west, 2008.
34. Interview with COL member, north-west, 2008.
35. Interview with COL member, south-east, 2009.
36. Interview with COL member, north-east, 2008.
37. Interview with COL member, south-east, 2009.
38. Interview with COL member, north-east, 2008.
39. Interview with COL member, south-east, 2009.
40. Interview with COL member, north-west, 2008.
41. Interview with COL member, south-east, 2008.
42. Interview with COL member, south-east, 2009.
43. Interview with COL member, south-east, 2008.
44. Interview with COL member, north-west, 2008.
45. Interview with COL member, north-west, 2008.
46. Interview with COL member, north-west, 2008.
47. Interview with COL member, north-east, 2009.
48. Interview with COL member, north-west, 2008.
49. Interview with COL member, north-west, 2008.
50. Interview with COL member, north-west, 2009.
51. Interview with COL member, north-east, 2008.
52. Interview with COL member, Midlands, 2008.
53. S. Shapin (1989) 'The Invisible Technician', *American Scientist, 77*, 554–63.
54. For more on this issue, see G. Endfield and C. Morris (2012) ' "Well weather is not a girl thing is it?" Contemporary Amateur Meteorology, Gender Relations and the Shaping of Domestic Masculinity', *Social & Cultural Geography, 13*, 233–53.
55. Interview with COL member, north-east, 2008.
56. Endfield and Morris, 'Well weather is not a girl thing is it?'

57. Interview with COL member, south-east, 2009.
58. Interview with COL member, south-east, 2009.
59. Brickell, 'Mapping and Doing Critical Geographies of Home'.
60. P. Eden (2009) 'Traditional Weather Observing in the UK: An Historical Overview', *Weather, 64*, 239–45.
61. Interview with COL member, south-east, 2009.

Part III

Familial Science: Sustaining Knowledge across Generations and Distances

8
Merchants, Scientists, and Artists: Scientific Families and Scientific Practice in Nineteenth-Century Greece

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Introduction: All in the family

In his 40-year quest for a sociology of practice, Pierre Bourdieu developed a panoply of analytical tools which he applied to areas of study as diverse as French academia, Algerian peasant life, education, and art. Throughout his career, he continuously added, revisited, and redefined central analytical concepts.[1] Moreover, Bourdieu was insistent, and proved by example, that theory should engage with, and follow from, applied enquiry. Nevertheless, few historical or sociological studies of science have drawn upon his theories.[2] This chapter uses the concepts of 'fields' and types of 'capital' to describe the function of family in Greek scientific life during the nineteenth century.[3]

A 'field' is defined as an agonistic configuration of relations between positions, which in turn are occupied by actors. Fields impose struggle, defined by the capital of the agents, whose actions, in turn, are mediated through the structure of the field. 'Capital' is economic as well as cultural and social. Its transformations from one kind to the other go alongside the formation and establishment of fields. Cultural capital is embodied in the form of dispositions of the mind and the body, but can also be institutionalized, for instance as educational qualifications, or take the shape of books, collections, instruments, and other paraphernalia of the 'cultured man'. Social capital is similar to symbolic capital and is defined as 'the aggregate of the actual and or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition.'[4]

In the following, we specifically want to show how family was an important agent in shaping the practice of science. Our analysis aims to problematize explanations of nepotism and elitism, by asking how families of scientists and intellectuals emerged in a socio-political space which was instituted almost *ex nihilo*. What kinds of resources did the making of a scientist demand, and how did the family provide those assets? How did the role of a scientist depend upon, or contribute to, the status of an elite family? How was the status of the respected and recognized intellectual maintained, through and for the family?

To answer these questions, we intend to show how the family functioned as the node through which strategies of intellectual and social ascendance and hegemony became possible. Familial relationships enabled pathways for the mobilization of assets and structured multiple social spaces. They also enabled economic resources to be converted into social and intellectual recognition, as well as into scientific qualifications. Families maintained and helped construct the role of the scientific expert in the intellectual, social, and cultural fields of early Greece.

Across states and borders: The Orfanidis brothers

Beyond being mere supporters, families in Greece enabled agents to harness different types of capital within the scientific practice of the period; they were formative actors *within* and *for* the scientific field. In our chapter, we will examine two families, the Orfanidis and the Christomanos, because they can serve to highlight the reciprocal relation between family and the scientific life in early Greece. These families also allow us to compare the dynamics of different familial collaborations, such as those between siblings, parents, and offspring. Finally, these families flourished across the whole period of our study, from before the founding of the Greek state to the first decades of the twentieth century.

Greece as a sovereign state came to being after an eight-year revolution against the Ottoman Empire, from 1821 to approximately 1828. Before that, several large and prosperous Greek-speaking, Orthodox Christian communities were to be found across both the Ottoman world and Europe. Collectively known as the Greek diaspora, they gave birth to a distinct class of 'conquering merchants', individuals who made considerable fortunes in commerce across the Ottoman Empire and Europe.[5] One such thriving community was situated in the city of Smyrna, in Asia

Minor, where the Orfanidis family lived and the two brothers were born. Their parents descended from the island of Chios. In the wake of the Greek revolution, the community in Smyrna faced retaliatory actions in 1827, prompting the Orfanidis family to move to the island of Syros, which was a centre of mercantile and cultural activity. The island was under the jurisdiction of the Ottoman Empire, but it was also protected by the French state and the Vatican. Theodoros Orfanidis (1817–1886) and his younger brother Dimitrios (1820–1898) both were initially educated in Syros.[6] By the time they were in their teens, Greece was declared a sovereign nation and the family moved to Nafplio, which served as the capital of the new state from 1827 to 1834. By 1832, the Bavarian prince Otto (1815–1867) became the king of Greece and arrived with a number of Bavarian intellectuals and administrators to take command of the Greek polity. Nafplio had thus become a hotbed for political activity by the time the Orfanidis family made their home there. The town also hosted the only gymnasium in Greece, which served as an institution of both secondary and higher education.[7] Since they attended the gymnasium, the brothers received the best education available in Greece at the time.

The older brother, Theodoros, soon became involved in the turbulent politics of the era, despite the fact that his education led him to secure a minor position in the Ministry of Foreign Affairs. Following many other Greek intellectuals, Theodoros also took up poetry as a way to engage the public sphere politically and intervene in the emerging Greek cultural field at the same time.[8] He took part in protests and wrote satirical lyrics targeting the Bavarian administrators and their Greek allies. He was always careful, however, to portray the young king as a well-meaning monarch led astray by bad advice. In the end, Theodoros had to stand trial alongside other critics of the Bavarian polity, reputedly delivering his *apologia* in rhymes.[9] Both brothers attracted the favour of powerful political figures, among them the famed advocate and future Professor and Rector of the University of Athens, Periklis Argyropoulos (1801–1860), and the powerful politician Ioannis Kolettis (1773–1847).[10] The latter made sure that Theodoros escaped his entanglement with the law unscathed.[11]

In 1834, the Bavarian regency moved the capital to Athens and made a conscious effort to turn what was a rather insignificant town in the foothills of Acropolis into a major centre of the new kingdom. Towards this end, a number of institutions were established in the new capital, among them the University of Athens (1838) and the Polytechnics School (1838). To staff the new institutions, professors were initially appointed from among the Bavarian scholars already in the king's retinue and from the small number of Greek scholars who had studied in Paris or the German lands.[12] The number of eligible scholars was quite small, and disputes over positions were few. In that context, Theodoros Orfanidis, already having established a reputation for his satirical and polemical articles, secured a four-year scholarship to study in Paris. To the surprise of his mentors, instead of studying journalism or literature, he chose botany, and worked in the famed Muséum d'Histoire Naturelle, finally returning to Greece in 1848.[13] Having started his studies in the University of Athens in 1839, Dimitrios Orfanidis followed his brother abroad in 1841; in 1850, he came back, from the University of Paris, a certified medical doctor. Both brothers assumed prominent positions, Theodoros becoming Professor of Botany in the University of Athens in 1850, and Dimitrios becoming Director of the City Hospital in the same year.

The joint appointments were no coincidence. Ioannis Kolettis, the Minister of Education at the time, tried to staff the university with his political supporters, including the Orfanidis brothers.[14] Theodoros, despite being a feared and quite poignant political commentator, had developed a friendship with Queen Amalia (1818–1875), Otto's wife, who shared his enthusiasm for botanical gardens.[15] His brother Dimitrios had achieved renown and Kolettis's support for his actions during an outbreak of plague which decimated Athens and Piraeus in 1854, earning a medal from King Otto in the process.[16]

In the final decades of their lives, the Orfanidis brothers managed to weather the political storms, such as the deposition of King Otto in 1868, and continued to command the esteem, or at least the respect, of friends and foes alike. While Theodoros embroiled himself in fierce debates over poetry, botany, and politics until his death, he also won in several prestigious poetry competitions held by the University of Athens. He represented Greece at international scientific conferences, held political positions, served as judge in poetry competitions, and became the Rector of the University of Athens.[17] He was also one of the founders of modern theatre in Greece, acting as a patron and proponent. The younger Dimitrios was the Director of the City Hospital for over 30 years, held the accompanying chair in the university, and participated in international medical conferences. He presided over the Medical Council of Greece for several decades and served in the Ministry of Internal Affairs. Finally, he was known in the Orient as the doctor of the rich and famous, with a clientele that included rich bankers and merchants, high-ranking officials of the Ottoman Empire and ministers. He died in 1898, 13 years after his older brother.

Establishing prominence

Many important factors stand out in the unfolding of the Orfanidis story that seem to explain their success at attaining elite positions and establishing themselves as prominent intellectual figures: family and political connections, educational qualifications, appointments to prestigious positions, and elite social status. But the crucial questions have not yet been addressed: What did it mean to be an elite family, in a socio-political space that was just being instituted? How did the Orfanidis brothers secure political patronage, given that they had neither involvement in the recent revolution, nor close allegiance with any of the major political figures of the era? That the brothers came to know the right people, especially in very turbulent times where a fall from grace could be sudden, was by no means a given. Also, why did both pursue an intellectual career, at the time when promising young men of Greek descent both in Greece and in the Ottoman Empire were expected to become either 'diplomats or merchants'?[18] Finally, how did both brothers manage to maintain their highly visible positions in a state that, within their lifetime, changed its capital, its regency, and its polity more than once?

The Orfanidis case shows the interplay of fields and capitals in the Bourdieusian sense. The Orfanidis family was a moderately successful Greek mercantile family. Within the Ottoman Empire, that signified a specific kind of cosmopolitan, successful, mostly middle-class (if we allow the anachronism) social strata.[19] The Orfanidis family had access to economic capital, but they also cultivated social connections. Through family contacts, and in a rather forced manner, they moved to Syros. On the island, their economic resources could be converted into cultural capital.[20] For instance, it allowed the Orfanidis brothers to get access to education at a time when academic credentials were still in short supply within the Greek space. The state apparatus also made education valuable. Later on, the family again relocated, first to Nafplio and then to Athens. This was a gamble that paid off. For a merchant, there were other Greek cities, such as Patras and Syros itself, which were far larger commercial centres. However, the Orfanidis brothers came of age in the Greek capital and they followed its relocation to Athens. This enabled them to acquire cultural capital in the form of education and a position in the emerging Greek intellectual field. Moreover, it generated connections with agents rising to power, including Ioannis Kolettis and Periklis Argyropoulos, praise from influential intellectuals, and a strong public presence. All of these assets can be understood as symbolic capital.[21] The family converted capital from economic resources to symbolic power, and such a switch was made possible by their families. The two brothers had the necessary familial support to attend the

Nafplion Gymnasium at a time when higher education was rare and of dubious importance to commerce. The capital conversion, where economic assets produced a good education, enabled the Orfanidis brothers to communicate with the Bavarian regency in French. They were properly groomed and attracted the attention of powerful political personae. Furthermore, Theodoros was actively engaged with politics and satirical poetry, which was at the time, alongside journalism, the most prevalent form of political commentary. This again amounted to the acquisition of social capital, but of a dubious character: the political atmosphere was highly charged and volatile, and the various influential agents formed shifting alliances with each other and with the Bavarian regency. An association with a specific political figure could prove to be detrimental later on. Thus, the social and cultural capital that Theodoros Orfanidis, as the oldest, acquired in the 1830s, could prove useless later on. Nevertheless, in the initial stages of their careers, both brothers proved extraordinarily successful in mustering these resources.

The social and cultural capital that the brothers acquired could have been invested in political or mercantile endeavours. In comparison, the scientific field in Greece was almost non-existent: there were no universities, no scientific academies or societies, and virtually no positions for trained men of science. By the time that Theodoros Orfanidis was sent abroad however, the University of Athens had been founded, along with scientific departments, and it needed teaching staff.[22] Theodoros chose to study botany, a field that had a corresponding chair at the University of Athens, and one that had a symbolic significance for a fundamentally agricultural country like Greece.[23] He also came back to Greece at a time when the previous chair, Kyriakos Domnados (1789–1852), was laid off for political reasons. Theodoros thus had the scientific capital, the cultural capital, and the social capital to enter the scientific field and pursue its stakes. Later on, he continued to accumulate scientific influence, by making long and frequent botanical excursions, taking care of botanical gardens, and partaking in scientific conferences. Through his concurrent role as a poet and a patron for the theatre he also received recognition in the cultural field.

Dimitrios Orfanidis's public life diverges in small but crucial ways from his brother's. He had the same education and social standing as his brother, although he was not as politically active. However, a medical career was a more established and profitable pursuit than purely academic work. According to Bourdieu, fields establish a form of interest, a tacit recognition of the value of the struggle and of the practical mastery of the rules that govern it. This, Bourdieu calls the *illusio* of the field. The *illusio* of the medical field was different from the scientific.[24] By acquiring the appropriate medical credentials abroad, Dimitrios could pursue different paths to prominence. His work was inherently socio-political, and he had no need to mimic his brother's boisterous public presence. He tackled the cholera outbreak of 1854, earning highly prestigious positions within the government and the presidency of the sole medical body in Greece. Dimitrios Orfanidis managed to accumulate the right kinds of capital, so that the rules of the medical game favoured his strategies, thus making him dominant in the medical field.

To highlight how the life strategies pursued by the Orfanidis were neither deterministic nor uncontentious we wish to briefly contrast their story with the brothers Alexandros (1803–1868) and Panagiotis Soutsos (1806–1868). They provided inspiration for young Theodoros Orfanidis, yet did not achieve the same recognition.[25] The Soutsos brothers had an impeccable lineage that had produced governors and philosophers. They were heavily engaged with politics, very well educated, and hailed from poets and *hommes des lettres*. However, they also constantly harassed the powers that be, chose the losing side, and made few friends among the powerful. They also did not accept the stakes of the game, the *illusio* of the scientific field, and were not able to convert their forms of capital into scholarly power. Tellingly, one of the brothers, Panagiotis, died in poverty. They were well regarded as intellectuals, but not able to secure influential positions or withstand the pressure that the changing political and cultural landscape imposed. Their capital remained confined to the cultural field, at a time when different fields were emerging and becoming autonomous.

In contrast, the Orfanidis brothers were able to convert one type of capital into another, thus becoming prominent in several fields. The political favours they were bestowed enabled them to study abroad and come back to assume prestigious positions. The social capital of their connections was converted into cultural capital, which was subsequently multiplied since university chairs commanded significant respect and political weight within the Greek public sphere. This was one of the reasons that drove Ioannis Kolettis to appoint his supporters as professors. Furthermore, after the acquisition of the prestigious positions, the Orfanidis brothers continued to be in the thick of things, either by writing political and lyrical poetry, by tackling a cholera outbreak, or by participating in major political moments.

In all these events, the family formed the backbone of the conversions of capital between different fields. The initial capital was economic and came from the ancestors of the Orfanidis brothers. Later on, the fame of the elder brother Theodoros enhanced the status of the younger brother Dimitrios. The public actions of Dimitrios, battling the cholera outbreak in Athens even when its mayor had abandoned the city, gave prestige to his older brother as well.[26] But there is a deeper process at work here: the subfields that the Orfanidis brothers were engaging with, including the scientific field, were in the process of being established. Accordingly, it was not a given that the brothers would be able to occupy powerful positions in different fields simultaneously. Instead, it was through the family, with its resources and connections, that the brothers could be recognized simultaneously as poets, doctors, and professors. It was capital acquired through the family that made their life trajectories possible. Accordingly, explaining this with nepotism misses the crucial point. Both brothers had unquestionable merit in the eyes of their contemporaries; they were perceived as deserving of their position. Careers like those of Dimitrios and Theodoros helped establish the role that the family could play as the originator of legitimate strategies across the Greek social landscape. While following both the norms and stakes of their respective fields, the Orfanidis brothers also helped establish them, not despite, but because of and through, their kinship.

There and back again: The Christomanos family

The Orfanidis brothers worked in the first decades of the Greek state. However, the role of the family in the creation and continuation of the scientific field can be seen in other periods. The case of the Christomanos family is such an example.

The patriarch of the family was Konstantinos Christomanos (1815–1861), who was born in Meleniko, the present-day Bulgarian city of Melnik. Political reasons forced him to abandon his birthplace when he was 8, and stay with relatives in Vienna, Austria.[27] Vienna hosted a large Greek-speaking, Orthodox community, part of the Greek diaspora. Konstantinos Christomanos married Maria Kazasi, the daughter of a wealthy Greek merchant, in 1839; she gave birth to their son Anastasios in 1841. Konstantinos became a successful merchant himself, following his father-in-law's trade. Konstantinos acquired enough money to provide his son Anastasios with an education that followed the norm for upper-class families. Anastasios was schooled at home by a number of distinguished, mostly Greek, scholars. He also attended the Sunday chemistry lessons of Professor Anton Schrötter at the Polytechnic Institute of Vienna. His family had at first planned for him to take up the family business, but their liberal mentality enabled Anastasios to pursue his interest in studying science, despite the fact that this was rather unusual. Even after the poor health of Konstantinos forced the family to relocate to Greece in 1855, Anastasios was allowed to stay in Vienna and continue his studies.

In 1858, Anastasios Christomanos returned to Greece, where initially he planned to study at the University of Athens. However, the pharmaceutical chemist Xavier Landerer and other scholars, including Anastasios Konstantinidis and Phillipos Ioannou, persuaded Konstantinos Christomanos to send his son back to Europe to continue his studies. After a very short period at the Technical University of Vienna, Anastasios Christomanos moved to the University of Giessen, then to Berlin, and finally to Karlsruhe (1859–1861). He attended the Karlsruhe Conference, and in 1861, he became a student at the University of Heidelberg.

After the death of Konstantinos in 1861, the financial status of the family deteriorated substantially, but Anastasios's mother insisted that he should continue his studies. The sudden loss of access to economic capital forced a series of risky readjustments to the family's strategy. Anastasios could have been forced to abandon the strategy of pursuing cultural capital through education and symbolic power through social contacts, to try and resurrect his father's financial advantages. However, the University of Athens was undergoing a gradual change at the time, following the general turmoil caused by the consolidation of Greek space that was underway. There would be possible openings for a well-groomed young man, with the right education and contacts in the right places.

Bunsen had secured a position for Anastasios Christomanos as a chemist in the dyeing factory of Millidinger in Frankfurt, but the Greek Minister of Education Epameinondas Deligiorgis called Christomanos back to Greece in 1862 to assist in the restructuring of Greek science education. Deligiorgis was a well-established political magnate of the era and could act as a powerful patron for young Christomanos. However, the prime mover was the General Secretary of the Ministry of Education, Professor Georgios Papadopoulos, who was an old friend of the Christomanos family and its legal trustee at the time. Through Papadopoulos's influence, Christomanos obtained an appointment as Professor of Chemistry in the University of Athens. Settled professionally, he then married the daughter of the Bavarian physician of the court, Anton von Lindermayer. Christomanos achieved recognition as the representative of Greek chemistry, both within Greece and abroad.[28]

Anastasios's first son was Konstantinos Christomanos (1867–1911), who became a renowned, and notorious, poet and playwright. He initially studied to become a doctor, but he abandoned the field to study philosophy and philology in Vienna and Innsbruck. At the age of 21, Konstantinos met the Empress Elisabeth ('Sisi') in Vienna and was hired as her tutor. Owing to the scandal created by the unauthorized publication of extracts from his diary concerning Sissy, he returned to Greece and established a radical theatrical group known as 'New Age'. Konstantinos's plays attracted wide interest and helped him establish his reputation as an intellectual and artistic figure. He later patronized many new actors and actresses, among them Kyveli, who later became a legendary Greek thespian. Konstantinos, despite a physical deformity, was also a famous playboy and one of the first to own a car in modern Greece. He is considered today to be one of the founders of modern Greek theatre.[29]

Anastasios's other son, Antonios Christomanos (1871–1933), studied medicine in Vienna, and graduated in 1894. When he came back to Greece, he worked in various posts in the Evangelismos, the central hospital of Athens, and eventually became the Director of Pathology there and a professor in the University of Athens in 1912. He was also very much involved with the political developments of his time. Antonios left his medical career in 1921 and was subsequently elected as a member of parliament. Later on, he served as Minister of Transportation and Minister of Health.[30] His son, also named Anastasios Christomanos, was the first Professor of Biological Chemistry in the Medical School of the University of Thessaloniki.

Family fortunes

The Christomanos family helps us better understand the processes of charting a successful career strategy in nineteenth-century Greece. Once again, as in the case of the Orfanidis brothers, we observe the initial acquisition of economic capital through mercantile activities. The status of international Greek merchants enabled the acquisition of social and cultural capital for the subsequent generation, through the educational opportunities and social contacts that wealth enabled, in Vienna or elsewhere. The founding of the Greek nation and the institutions that appeared alongside it opened up new paths for educated men of good standing. Anastasios Christomanos turned away from a mercantile career and pursued higher studies in science, which at the time was an unusual decision for someone of his social position. Cultural and economic capital was being converted into scientific capital. But the scientific field in the 1860s was more established than when Theodoros Orfanidis started his career. When Christomanos went to Athens to study in 1858, there were scientists who could act as his mentors. His family had given him the 'right upbringing' and important connections, which is illustrated by the fact that well-established scholars like Landerer and Ioannou advised Christomanos's father on how the son should proceed with his scientific career.[31] The family was the crucial node for creating mentorship. As a result, Christomanos went back to Vienna, while retaining his contacts with Greek intellectuals. He acquired scientific capital by studying at a prestigious university and under renowned chemists, but also by choosing chemistry as a specialty. There were few expert chemists in Greece, and the country was developing a rhetoric of modernization that called for new technological advancements. When Christomanos came back from Vienna in 1862, he could use his connections to manoeuvre in the political changes underway. King Otto was dethroned the same year, marking the end of the old political regime and its accompanying political parties. Georgios Papadopoulos, the family's trustee, worked closely with Epameinondas Deligiorgis, who in 1862 was the interim government's Minister of Education. Deligiorgis's power was increasing, and three years later he became the prime minister. Through their ties to Georgios Papadopoulos, the Christomanos family benefited from the increasing political influence of their allies.

Even when the economic capital of the family diminished, their social and cultural assets were enough for Anastasios Christomanos to secure an influential position. Once again, political patronage and strong references from abroad were crucial. Christomanos's appointment, however, was not seen by contemporaries as favouritism. Quite the contrary, in the consolidating scientific field of early modern Greece, these kinds of credentials were becoming the norm. And indeed, Christomanos became the exemplar of the well-respected, public intellectual, to the point that he was able to pursue grand projects, such as the building of a new chemistry laboratory, in times of great economic distress. He was well known, socially respected, and had many contacts home and abroad. Moreover, Christomanos rarely engaged in direct political actions and interventions the way Theodoros Orfanidis did. There was no need: the scientific field was now more autonomous. There were, by then, legitimate, well-established strategies for the conversion of cultural and social capital into scientific capital, and back again. Christomanos used them all at a time when they were most effective: discreet political patronage, respectable lineage, gentlemanly grooming, and impeccable educational and scientific credentials. Vice versa, scientific authority and recognition enabled government positions, prestigious expeditions, the funding of laboratories, and the control of appointments. The economic base necessary for such actions had, early on, faded into obscurity.

This virtual self-sufficiency can be seen in the life trajectories of the third generation. They had the economic and social capital to pursue expensive studies in centres of learning like Vienna. The older brother, Konstantinos Christomanos, could successfully partake in the arts. His younger brother, Antonios, pursued more narrowly scientific endeavours. However, he could also move successfully in the political field, since cultural and social capital went hand in hand, criss-crossing the scientific field. And the family was at the crux of the intersection: it was through familial support that Konstantinos could study abroad and it was by familial connections that he could act as a patron of the arts and a theatrical magnate. For Antonios, the role of the family was even more important. He could use his father's scientific capital to study abroad and his family's social capital to secure positions in important hospitals. And he could do the same for his son.

Family was the hub through which capital flowed, across generations and fields. The type of resources families could marshal enabled the acquisition of cultural, social, and symbolic capital. Families also maintained influence and enabled strategies of inheritance and transmutation. Indeed, Greek scientific life, or, to be more specific, the stakes, rules of engagement, and actions possible within the scientific field, depended on these conversions. And after a generation or so, the economic base of the conversion became hidden, and only the symbolic and cultural were left visible. The work, ethos, and public engagement of the agents were celebrated and discussed, in jubilees and commemorative volumes. The economic capital that made them possible was hidden from view in these recollections.

Conclusions: The emergence of Greek scientific practice revisited

During the first decades of the Greek state, the institutional, social, and intellectual changes that the establishment of a new polity entailed created the context for the emergence of Greek scientific practice. However, an analysis that focuses on the internal scientific work would be at a loss to explain the recurring appearance of specific families in scientific practice. And vice versa, the emergence and consolidation of science depended on agents with similar patterns of behaviour and life trajectories, indeed, often with the same name.

In order to analytically bring scientific practice and family together we have used theoretical concepts from Pierre Bourdieu. Our study of two different families suggested, first, that they had remarkably similar backgrounds. Both originated from successful mercantile interests, in Europe and the Ottoman Empire, especially in Vienna, Smyrna, Chios, and Ioannina. These families were successful, yet not wealthy, magnates, for whom a career in an esoteric field like science would not have been respectable. In both families, economic capital, and its associated social and symbolic power, was passed on to the next generation and simultaneously transformed into cultural capital, defined as an embodied ability to act and speak as a well-bred gentleman. The cultural capital, moreover, was institutionalized in the form of academic credentials, and objectified in the form of books and collections. The Greek scholars also benefited from references given by prominent scientists. Political patrons supported academic appointments, and powerful professors wielded internal networks of support. While economic and symbolic capital were available to several actors, the transformation into cultural capital was more difficult to achieve. At the time of the emergence of a centrally controlled government by the Bavarian regime and the founding of the University of Athens, it became very valuable.

Greek scholars had a background similar to that of other intellectuals of the era. Brothers would receive similar education in similar institutions, and acquire the favour of the same political patrons. With their appointment, even in widely different fields, their economic capital would fade from visibility, or even existence in many cases, and cultural and social capital would become much more prominent. Members of the same family would be able to successfully pursue activities in different fields, writing poetry, publishing novellas, and securing political appointments. Their symbolic and cultural capital would multiply and would then be passed on to their sons, or in some cases, nephews.[32] The third generation, in the early twentieth century, would be able to act in the artistic or scientific field and often replicate the multiplicity of roles of the previous generation.

In all these parallel and field-spanning strategies, it was the family that formed the crucial nexus of activities. However, this is not to say that a brother's success should be sought in the agency of the other brother, or that of a nephew in his uncle's actions. That would be to misconstrue the point. Rather, the question is how, and under which preconditions, brothers were able to pursue successful careers in similar, but not identical fields, and then enable successful careers for their sons. And here we observe a similar pattern, which spans three different generations. The many resemblances between different families help us trace the role of the family as a unit. Initially, family firms and businesses were expanded, successful marriages made, and thus economic resources became available. This is the typical first stage of the accumulation of economic capital, and its use in securing cultural and social capital. Despite its obviousness, we must note that, for Greeks of the early nineteenth century, it was possible only through the family. It was the family that secured the right education of their children, sending them to first-class schools, moving to central cities, and pursuing relationships with the emerging political elite of the new state. In this phase, the family bequeathed cultural and social capital to the children, through educational credentials and political mentors, who were friends of the family. More importantly, the second generation acquired scientific capital in a way that was not otherwise possible: political patronage could be secured in many ways, but references from scientists abroad and doctorates in science could only be meaningfully achieved abroad. The preconditions for such strategies were made possible solely through the family.

After the initial phase of cultural and social capital accumulation, the symbolic fortunes of families were reinforced by the actions of second-generation brothers and sons. Even if the economic base collapsed, as in the case of the Christomanos family, the cultural and symbolic assets enabled the pursuit of winning strategies. As the scientific field solidified within Greece, its vis-à-vis importance relative to the cultural and political field was being established, and, as fields go, continuously renegotiated. In the end, Greek scientists were awarded prestige and social standing. Their scientific capital was firm enough to support its reconversion back to cultural and social capital, and thus, to symbolic power.[33] Finally, it was again through the actions of the family, which built and expanded its various cultural and social credentials, that these types of capitals were passed on to the next generation, which was thus free to pursue scientific and intellectual pursuits.

It is therefore crucial, in spaces such as nineteenth-century Greece, what goes into consolidating a scientific field and what processes contribute to the establishment of scientific practices. The theoretical insights of Bourdieu suggest that there are factors, such as the family, social prestige, and cultural credentials, which contribute decisively but tend to go unnoticed or be grouped together under blanket statements. To describe the role of family as 'nepotism', 'clientelism', or such other paraphernalia of development theories, is to miss the multiple and complex processes through which scientific, symbolic, and cultural fields were arising and being negotiated during the nineteenth century and beyond. At least in the case of Greece, it seems that scientists were not only respected intellectuals and cosmopolitan gentlemen, but also someone's son, father, and brother.

Notes

1. An example being the notion of the field, which is almost totally absent in his earlier work. See for example P. Bourdieu (1977) *Outline of a Theory of Practice* (Cambridge: Cambridge University Press). However, later on it becomes central to his theory of practices: see P. Bourdieu (1984) *Distinction: A Social Critique of the Judgment of Taste* (Cambridge, MA: Harvard University Press), p. 101.
2. For a discussion of Bourdieu's presence in Science Studies, see M. Albert and D. Kleinman (2011) 'Bringing Pierre Bourdieu to Science and Technology Studies', *Minerva, 49*, 263–73; and D. Hess (2011) 'Bourdieu and Science Studies: Toward a Reflexive Sociology', *Minerva, 49*, 333–48.
3. P. Bourdieu and L. Wacquant (1992) *An Invitation to Reflexive Sociology* (Chicago: University of Chicago Press), pp. 92–101; and P. Bourdieu (1988) *Homo Academicus* (Stanford: Stanford University Press), pp. 73–127. For a treatment of science in this context, see P. Bourdieu (2004) *Science of Science and Reflexivity* (Chicago: University of Chicago Press), pp. 32–71; P. Bourdieu (1986) 'The Forms of Capital', in J.G. Richardson (ed.) *Handbook of Theory and Research for the Sociology of Education* (New York: Greenwood Press), pp. 46–58; P. Bourdieu (1983) 'The Field of Cultural Production, or: The Economic World Reversed', *Poetics, 12*, 311–56; P. Bourdieu (1989) *La Noblesse d'Etat: Grandes Écoles Et Esprit De Corps* (Paris: Les Editions de Minuit).
4. Bourdieu, 'The Forms of Capital'.
5. T. Stoianovich (1960) 'The Conquering Balkan Orthodox Merchant', *The Journal of Economic History, 20*, 234–313.
6. See the introduction in T. Orfanidis (1858) *Τίρι Λίρι· ή Το Κυνηγέσιον Εν Τη Νήσω Σύρω, Ποίημα Ηρωικοκωμικόν Εις Μέρη Επτά* (Athens: Lakonias).
7. These at the time were not easily distinct, not only in Greece, but in most spaces that did not have a strong university tradition. Kapodistrias had made the conscious decision to focus his efforts in primary education and not in higher institutions of learning. For a comparative discussion of Greek education, see P. Kiprianos (2004) *Συγκριτική Ιστορία Της Ελληνικής Εκπαίδευσης* (Athens: Vivliorama).
8. The establishment of the new state went hand in hand with the emergence of a Greek cultural field, in the most classic Bourdieusian sense. There was a struggle for dominance among intellectuals where specific kinds of capital were allowed, there were specific assumptions on what could count as legitimate arguments and moves, and there was an implicit acceptance of the value of the struggle itself. See, for example, C. Guthenke (2008) *Placing Modern Greece: The Dynamics of Romantic Hellenism, 1770–1840* (Oxford: Oxford

University Press), pp. 140–90. For a working treatment of the concept of cultural field, see P. Bourdieu (1996) *The Rules of Art* (Cambridge: Polity), pp. 47–166.

9. T. Orfanidis (1841) *Τα Κατά Την Εορτήν Της 25 Μαρτίου Τα Κατά Την Δίκην Των Εωρτασάντων Ταύτην Και Έμμετρος Απολογία Θεόδωρου Ορφανίδου* (Athens: H Agathi Tyche).
10. Ioannis Kolettis was one of the major political figures of his era. He became the leader of one of the three major political parties, he served twice as prime minister, and he held several Ministries in his time. He was also credited with inaugurating the Megali Idea movement, which called for a full liberation of all Greek-speaking Orthodox populations still under the Ottoman Empire. For a detailed analysis of the political landscape of Greece in the nineteenth century, see G. Hering (1992) *Die Politischen Parteien in Griechenland, 1821–1936* (Oldenbourg: Oldenbourg Wissenschaftsverlag).
11. T. Ampelas (1916) *Ο Θεόδωρος Ορφανίδης Και η Εποχή Του* (Athens: Sakkelariou), p. 27.
12. Orfanidis, *Τα Κατά Την Εορτήν Της 25 Μαρτίου*, pp. 143–74.
13. T. Orfanidis (1887) 'Επιστολή Ανέκδοτος', *Poikili Stoa, 7*, 254–6.
14. S. Petmezas (2009) 'From Privileged Outcasts to Power Players: The "Romantic" Redefinition of the Hellenic Nation in the Mid-Nineteenth Century', in R. Beaton and D. Ricks (eds) *The Making of Modern Greece: Nationalism, Romanticism, and the Uses of the Past (1797–1896)* (Farnham Surrey: Ashgate).
15. Ampelas, *Ο Θεόδωρος Ορφανίδης*, p. 86.
16. A. Kouzis (1939) *Ιστορία Της Ιατρικής Σχολής* (Athens: Pirsos), p. 30.
17. M. Stefanidis (1948) *Εκατονταετηρίς 1837–1937: Ιστορία Της Φυσικομαθημ ατικής Σχολής* (Athens: National Printers), Vol. A, p. 10.
18. P. Argyropoulos (1852), 'Βιογραφία: Κυριάκος Δομνάδος', *Efterpi, 6*, 132.
19. M. Chatziioannou (2010) 'Creating the Pre-Industrial Ottoman-Greek Merchant: Sources, Methods and Interpretations', in L.T. Baruh and V. Kechriotis (eds) *Economy and Society on Both Shores of the Aegean* (Athens: Alpha Bank Historical Archives), pp. 311–35.
20. Bourdieu, 'The Forms of Capital', p. 51; D. Swartz (1998) *Culture and Power: The Sociology of Pierre Bourdieu* (Chicago: University of Chicago Press), pp. 88–93.
21. The function that public debate and public praise played in the creation of elite intellectual status throughout nineteenth-century Greece can be seen most clearly in eulogies. For Theodoros Orfanidis, see E. Chronopoulos (1886) 'Θεόδωρος Ορφανίδης', *Poikili Stoa, 6*, 30; A. Paraschos (1889) 'Ελεγεία δια τον Θεόδωρο Ορφανίδη', *Poikili Stoa, 8*, 35.
22. For a more detailed discussion, see K. Tampakis (2012) 'Science Education and the Emergence of the Specialized Scientist in Nineteenth Century Greece', *Science & Education, 22*, 789–805.
23. Stefanidis, *Εκατονταετηρίς 1837–1937*, Vol. A, pp. 11–16.
24. See Bourdieu and Wacquant, *An Invitation to Reflexive Sociology*, p. 117.
25. K. Dimaras (2000) *Ιστορία Της Νεοελληνικής Λογοτεχνίας: Από Τις Πρωτες Ρίζες Ως Την Εποχή Μας* (Athens: Gnosi), pp. 61–370.
26. It is worth noting that the history of the Medical School of Athens, published in 1939, takes pains to mention that Dimitrios Orfanidis was the brother of Theodoros. In the same vein, the son of Dimitrios Orfanidis,

Georgios, was one of the winners in the first Olympic Games in Athens, in 1896. Chroniclers of the time mention specifically his lineage. See P. de Coubertin, T. Philemon, N. Politis and C. Anninos (1897) *The Olympic Games B.C. 776–A.D. 1896*, Part II: *The Olympic Games in 1896* (London: Grevel and Co.).

27. The short biography of Christomanos is based on the recollections in N. Germanos (1896) *Βιογραφικαί σημειώσεις περί του καθηγητού Αναστασίου Κ. Χρηστομάνου. Τεύχος Πανηγυρικόν 1866–1896* (Athens: Paraskeva Leoni); and A. Christomanos (1906) *Ητεσσαρακονταετηρίςτου Αναστασίου Χρηστομάνου* (Athens: Paraskeva Leoni).
28. A brief scientific biography can be found in M. Stefanidis (1952) *Ιςτορία της Φυσικομαθηματικής Σχολής* (Athens: National Printers), Vol. B, pp. 12–14; G. Vlahakis (2006) 'Alchemy Survived? An Alchemical Manuscript, Anastasios Christomanos and the Status of Chemistry in the 19th Century Greece', in I. Malaquias, E. Homburg and M.E. Callapez (eds) *Proceedings of the 5th International Congress for the History of Chemistry* (Lisbon: Sociedade Portuguesa de Quimica), pp. 598–605; and G. Vlahakis (2000) 'Introducing Sciences in the New States: The Establishment of the Physics and Chemistry Laboratories in the University of Athens', in E. Nicolaidis and K. Chatzis (eds) *Science, Technology and the 19th Century State* (Athens: Institute for Neohellenic Research, National Hellenic Research Foundation), pp. 89–106.
29. For an appraisal of K. Christomanos, see I. Sarropoulou (ed.) (1999) *Ο Κωνσταντίνος Χρηστομάνος και η εποχή του. 130 χρόνια από τη γέννησή του* (Athens: Aioria).
30. Kouzis, *Ιστορία της ιατρικής σχολής*, p. 16.
31. Germanos, *Βιογραφικαί σημειώσεις*, p. 13.
32. See Stefanidis, *Ιστορία της Φυσικομαθηματικής Σχολής*, Vol. B, pp. 9–10, 16–17.
33. For the notion of symbolic power, see its later formulation in P. Bourdieu (1991) *Language and Symbolic Power* (Cambridge, MA: Harvard University Press), pp. 163–170.

9

Father, Son, and the Entrepreneurial Spirit: Otto Pettersson, Hans Pettersson, and the Early Twentieth-Century Inheritance of Oceanography

Staffan Bergwik

Like many other scientists before and after him, the Swedish oceanographer and physicist Hans Pettersson (1888–1966) was exposed to scientific activity from an early age. He grew up surrounded by scientific and cultural interests, in a household where 'the elite from the scientific world gathered'.[1] Later, he recreated the 'atmosphere' of his upbringing in his own home, with assistance from his wife Dagmar (*née* Wendel, 1888–1978).[2] In 1914, Pettersson received a PhD in physics. After doing radioactivity research at the Radium Institute in Vienna for a period in the 1920s – work for which he is best known – he returned to Sweden. In 1930 he was appointed the nation's first Professor of Oceanography. Since the 1890s, his father Otto Pettersson (1848–1941) had exercised an increasingly international influence over oceanography. Growing up with a 'renowned oceanographer' as a father, and with a laboratory on the family estate, Hans Pettersson inherited science as a product of family relations.[3]

Turn-of-the-twentieth-century Swedish natural science was an enterprise that, in many instances, was based on family ties. Transfer of academic power within the family was a repeated practice. Nevertheless, institutional transformations were underway: new research fields, institutions, and laboratories were created, and the process generated competition for resources. In this chapter, I analyse the mechanisms of inheriting oceanography as a scientific discipline within this historically specific setting of family-based privileges and emerging institutions.

As will become evident, the process of inheritance was far from smooth – in fact, it was fraught with tensions.

First, I explore how Otto Pettersson's efforts to create a successor within his own family co-evolved with new institutional configurations that he built (laboratory, commission, council university positions). I consider how family life structured the context within which he shaped the field of oceanography. Otto Pettersson was an academic patriarch who lived in accordance with bourgeois norms for private life. Part of the prerogative of the family leader was exerting control over his children. I address more specifically how he created an academic infrastructure where inheritance became possible, and how, through this, he facilitated his son's career.

Second, I turn to Hans Pettersson and the way he inherited oceanography and imitated his father's work. I will argue that there was a tension between, on the one hand, the pattern of sons inheriting their fathers' research and, on the other hand, an institutionalized norm that scholars should produce independent work of their own. How then did this tension between repetition and originality play out in Hans Pettersson's career? Whereas Otto moved oceanography in the direction of physics of ocean currents and climatological questions, Hans instead favoured pursuing research in the new and burgeoning area of atomic physics. Although he did not take up his father's research interests, I will argue that he instead imitated his father's entrepreneurial academic style in creating a research field, building academic institutions, and fighting adversaries for the institutional resources that were at stake. Hans thus mimicked a broader pattern of behaviour among elite scholars at the time, but his primary reference point in doing so was his father.

Family, inheritance, and the transfer of knowledge

Existing research on family life and domestic sites in the history of science has mainly addressed marriage and 'collaborative couples'. How knowledge-making practices are entangled with gendered norms has been a predominant concern. The relationships in the Pettersson family followed the patterns suggested by these studies; for instance, Dagmar Pettersson fulfilled the widespread role of wife as assistant. Even though this literature is part of a broader trend to write the history of intimate and private aspects of scientific life, it has not devoted much attention to the transfer of knowledge between generations of families.[4]

Instead, I will draw analytically on a well-established discussion in science studies on the transfer of knowledge. Scholars in the field have, since at least the 1980s, argued that knowledge making is locally situated and contextually determined. Nevertheless, historians and sociologists of science have also stressed the importance of exploring the complex nature of the circulation of knowledge. What – if knowledge diffuses from one context to the next – is the cause of its movement?[5] Two features of 'knowledge in transit' are crucial in understanding the mechanisms of inheritance and imitation. The first is the importance of building, in the words of Jan Golinski, an 'infrastructure of science', the 'extensive networks that enable scientific facts and artifacts to travel'.[6] The links between the local site and the world beyond are multifaceted, including, for example, trained personnel, artefacts, and instruments, as well as scientific societies or learned academies.[7] As I will show in this chapter, Otto Pettersson made repeated efforts to create an infrastructure through which oceanography could travel to the next generation.

Second, research on the nature of knowledge migration has indicated how the transfer of local knowledge making never equals mere copying. When science is moved, it is appropriated and thus changed: new meaning is added and the context can never be entirely duplicated. Transmission of knowledge entails transformation and conflict as much as understanding and reconciliation.[8] Drawing on this discussion, I will argue that the 'handing down' of oceanography from father to son did not occur 'without alterations'.[9] The bulk of the discussion about migration of scientific results, instruments, and practitioners has been geared towards geographical transfer to other places, or cultural circulation to wider audiences.[10] Questions of transfer between generations have received less attention, perhaps because the training of new scholars more generally has remained understudied in the history and sociology of science.[11]

Gillian Beer has discussed the process of sustaining knowledge through mimetic processes. She captures the tension between repetition and transformation that I wish to convey. Scientific practices, she argues, include both a 'conscious conservatism of its methods' and, simultaneously, an appraisal of the new 'in investigation and outcome'. The 'memory sustained over generations allows us to diverge from the past, not only to mimic it'.[12] Moreover, Beer's argument captures the historical specificity of mimetic processes: 'in a period of rapid change' the 'vital skill to be learnt may be that of how not blindly to imitate, yet how not to blindly expunge'.[13] The early twentieth century was precisely such a context: Hans Pettersson was tied into structures where scientific work was reproduced, but the framework also demanded new research. The coherence that Otto Pettersson sought to establish was repeatedly threatened as he attempted to pass his oceanographic enterprise onto his son.

Establishing oceanography: Family business

In early twentieth-century Sweden, the natural sciences were heavily dependent upon family relations. They were situated in a patriarchal bourgeois society where the father was the leader of the household and the sole guardian of the children. The academic scientist was almost always a family man.[14] Otto Pettersson matched contemporary norms: he never hesitated to control the members of his family.[15] Moreover, he was part of a group of Swedish scholars who managed to build academic institutions and establish new research fields. What, then, was the importance of family for building a productive scientific context?

Several studies have detailed how science was professionalized at the turn of the twentieth century, through the creation of institutions, paid posts, training in teaching laboratories, specialized publications, and a reward system for scientific careers.[16] Indeed, Otto Pettersson's efforts followed a pattern of discipline formation. He established an autonomous laboratory site and there tried to consolidate a community. After becoming Professor of Chemistry in Stockholm in 1881, Pettersson started to take an interest in oceanography. Together with his wealthy and close associate Gustaf Ekman, he 'founded Swedish oceanography' during a 'half century of scientific collaborations'.[17]

In 1892, Pettersson bought the Holma estate on the west coast of Sweden, located on the shore of the Gullmars Fjord, roughly 100 kilometres north of Gothenburg. Part of the property was the small island Bornö, where a research station was created in 1902. The island had a unique position because the Gullmars Fjord formed a natural basin for samples of ocean water. In 1895 Pettersson wrote Ekman about their plans to build Bornö as a 'fortress'.[18] The metaphor was appropriate, since the island was the first oceanographic centre in Sweden. Previously, research was 'scattered' between Gothenburg, Uppsala, and Stockholm. Some studies were made in the new institute at Kristineberg on the west coast, although mostly on marine zoology, while crucial hydrographic instruments were located in Gothenburg.[19]

Pettersson and Ekman also created the Swedish Hydrographic-Biological Commission (SHBC) in 1901, which was located at Bornö. They financed the station from private means, but the Swedish state rented it from Pettersson through SHBC. This arrangement was in place until 1932 when Bornö was transferred to the government and modernized.[20] The creation of Bornö and SHBC was finalized when, in 1909, Pettersson resigned from his professorship in chemistry at Stockholm University College and moved permanently to Holma. Besides creating national institutions, Pettersson was a crucial actor in the establishment of the most important international oceanographic institution, the International Council for the Exploration of the Seas (ICES). With decisiveness, he and Ekman planned the council, which was inaugurated in 1902. Until the 1930s, Pettersson held influential positions within the council, for instance as president between 1915 and 1920.[21]

The new academic institutions of oceanography were deeply entangled with private relations, as the family as practice and idea was of massive importance to Otto Pettersson. Descriptions of the new institutions were alive with family metaphors. Pettersson himself characterized Bornö as 'a true home'. In retrospect, the research station has been dubbed the '*cradle* of Swedish oceanography' and Pettersson the 'father' of ICES.[22] At Holma Pettersson lived together with his wife, the Norwegian Agnes Irgens (1851–1928), and their six children, born between 1876 and 1894 (Hans was the fifth). Otto enrolled his family in the 'system' for furthering oceanography. The sons became research assistants and the daughters secretaries.[23] Very little has been written on the role and importance of Agnes Irgens, and there is only one letter from Hans to her in his archive.[24] Judging from the literature on Otto Pettersson, she did not play the common role of scientific assistant.[25]

Holma had numerous counterparts where entire households were shaped around scientific work.[26] Indeed, the Petterssons repeated a pattern among equally powerful scholars in Sweden. For example, Otto's old friend and associate, Svante Arrhenius, was an international authority in physical chemistry. In 1905, he constructed a combined laboratory and scientific home in Stockholm to match those of his international colleagues.[27] In Uppsala, physics professor Knut Ångström, part of a powerful physics clan, integrated his family in the new physics institute, inaugurated in 1909.[28] Pettersson, Arrhenius, and Ångström were all influential Swedish scholars, influenced by the German laboratory model where a well-equipped research environment included living quarters for the director.[29] In addition, the natural sciences were part of broader norms of family life. As historian Leonore Davidoff has discussed about the nineteenth-century British context, the home in nineteenth-century England was the bedrock for the patriarch's professional strivings as well as a crucial arena for public life.[30]

The issue of inheritance: A framework for educating a son

Several influential Swedish families displayed the same pattern of inheritance: sons succeeded their fathers, often in the same academic discipline and sometimes even in the same professorship. Uppsala physics professors Anders and Knut Ångström, and Manne and Kai Siegbahn, are examples of this practice. More generally, families were important arenas for recruiting those in power. Children's choices, ambitions, and welfare were repeated topics of conversation among scholars.[31] Accordingly, Otto Pettersson created a framework that enabled his son to inherit his field of oceanography along with the institutions he had developed over several years.

The institutional expansion of the natural sciences in Sweden around 1900 has been described as 'Weberian': new disciplines were produced through personal professorships, followed by an institute and a formal discipline.[32] In the case of oceanography, it was the son who obtained the first professorship, created by the father's efforts. In 1929 Otto Pettersson wrote to his old collaborator Gustaf Ekman and discussed how to '*raise* a real hydrographer who could carry on science after us'.[33] The key interrelated concerns for Otto were to amass academic power and 'keep the family together'.[34] Both were part of the scientific persona and role of the academic leader. In addition, both issues increased his ability to maintain control over the academic field of oceanography.

The local setting at Holma, including the laboratory on Bornö, was critical for the framework of fostering a successor. As a schoolboy Hans Pettersson was already enrolled as an assistant on Bornö during summer vacations. In 1913 he was hired – thanks to arrangements made by his father – as assistant at SHBC with an annual salary. The year after, Gustaf Ekman secured funds for an associate professorship in oceanography, thus allowing Hans to get the first position at a Swedish university in the new discipline.[35] To become a successful scholar, however, he also needed to move within academic environments beyond the west coast of Sweden. For his undergraduate studies he went to the University of Uppsala, and he followed this by pursuing a PhD at the University College in Stockholm – under his father's friend, Svante Arrhenius.

But moving between Swedish universities was not enough. A longer visit at a foreign university was considered part of a good academic training among Swedish scholars. Accordingly, Hans Pettersson had to spend a period abroad like his father and other Swedish scientists.[36] Otto told his son that he would benefit from 'one or two semesters' at a foreign university.[37] Arrangements were made for Hans to spend a year at the University College London in the laboratory of Sir William Ramsay, an old friend and supporter of Otto as well as a guest at Holma on various occasions.[38] In Britain, Hans also met and enjoyed discussions with other associates of his father, in particular the 'grand old man of deep-sea research', Scotsman John Murray. Both Ramsay and Murray became crucial mentors who, according to Hans, 'kindled my imagination'.[39]

Ramsay taught Hans experimental skills; in London the latter worked on a precision instrument for measuring the atomic weight of radon. Murray introduced the young Swede to current trends in oceanography, in particular to measuring radioactivity in bottom sediments, which eventually became a key topic in Hans's oceanographic research. Equally important, Ramsay and Murray provided advice, encouragement, and access to influential scientific institutions, like the Royal Society of London. Such access greatly impressed Hans and put him in contact with members of the European scientific elite.[40]

Although Hans moved outside the realm of his home, family relations were a vital infrastructure for his formation as a scholar. At Holma, researchers socialized in a manner that collapsed the difference between professional and personal relationships. Homemade friendships and scientific collaborations merged; peers supported each other's kin in the informal networks.[41] The ideas and practices of home and family also spanned national borders. During his year in Britain, Hans kept a diary where he described visits to the homes of Ramsay and Murray. These venues were crucial sites for his entry into the scientific profession. Over Christmas 1911 for example, Hans visited Murray's family in Edinburgh. Christmas Day was spent enjoying games and social activities, which meshed with scientific discussions:

> The ladies disappeared and we men sat with our port when Sir James told me about his plans to study the radioactivity of bottom sediments; shared his theory about emanation being transported down from the surface to the bottom. Finally, Lady Murray called on us to join their games.[42]

Domestic sites in Sweden and Britain gave access to mentors like Ramsay and Murray. The home as an idea and as a social practice was highly movable and culturally intelligible in many places. Otto was not present in Britain, and he allowed old colleagues to educate his son. But through his network he produced the framework where his son Hans was shaped as a researcher.

Otto Pettersson's struggle to secure a succession, 1914–1928

The trip to England ended in 1912, and Otto Pettersson did not want his son to stray for too long. Chief among his priorities was to get Hans back to Bornö and Gothenburg University College, where his inheritance of Swedish oceanography could be secured. In a letter, sent to his son in London, from November 1912, Otto disclosed his plan to hire his son as an assistant, so that 'you can peacefully work on your studies'.[43] Hans was told to inform his teachers in Uppsala and Stockholm that he would 'move to Bornö', as Gustaf Ekman had provided a position as associate professor.[44]

The plans were executed in 1914 and subsequently, until 1921, Hans lived and worked at Gothenburg and Holma as his father's assistant. Simultaneously, Otto struggled to secure the transfer he sought. To his son he emphasized that 'one should not renounce the opportunities offered by the home', and announced that 'the quantity of possibilities for the future that lie in the trio: Gustaf [Ekman], you and myself' were promising.[45] Inheritance, however, was not a straightforward enterprise, even though it was common in the learned circles of Sweden.

As a patriarch, Otto Pettersson had the prerogative of governing his children's choices of professions and life partners. If Hans were to take over the academic setting that Otto had created – where science and family life were deeply entangled – it would be important that he found a suitable wife. Fortunately, Dagmar Wendel met such expectations. She and Hans had met in Uppsala when they were students. Wendel finished her chemistry studies in 1914 and returned to her hometown of Gothenburg where she reunited with Hans, who helped her to get a position as a chemical assistant at Bornö. They were married in 1917, and subsequently Wendel remained an important collaborator to her husband. At the time of their engagement, Otto judged that she was good for 'us', while simultaneously underscoring that married life demanded that a man of science position consider his professional future in terms of sustaining a family.[46] The patriarch offered living space for the spouses, with the aim of getting them to settle down at Holma. The newlyweds declined the offer and lived primarily in Gothenburg.[47]

Repeatedly, Hans Pettersson was frustrated over his father's many efforts to urge him to inherit his career in oceanography. In 1921 – and at least partly as a result of conflicts with his father – he left Sweden with Dagmar for the Radium Institute in Vienna where he planned to pursue research in atomic physics. This placed him beyond Otto's reach on a day-to-day basis. The father, however, did not relinquish his goal to convince his son to take over oceanography at Gothenburg. Importantly, throughout Hans's years in Vienna, Otto continued to provide his son with financial support, but Hans nevertheless needed to continue with some teaching in Sweden to sustain himself and his family; the couple had two children (Rutger and Agnes). As late as 1926 (at the age of 38) Hans wrote: 'thank you father for your kind promise to support me' with extra money.[48]

But there were other ways of maintaining control as well. During Hans's sojourn in Vienna, his father's letters would characteristically try to ascertain the couple's intentions. He urged his son to 'let me know what you are working on' and, similarly, he asked his daughter-in-law to 'keep me informed about your plans'.[49] Never abandoning his hopes that they would come home, Pettersson kept meddling: 'Please tell me honestly what your plans are, it is better if I know them and can further them than if I am kept in the dark.'[50] He also suggested a compromise: Hans could split his time between Vienna and Gothenburg to keep his 'chances as oceanographer'.[51] Moreover, Otto asked if he would consider 'writing some minor articles on hydrography' in Gothenburg's local newspaper.[52]

With increasing emphasis during the 1920s, Otto questioned the possibilities of a future in Vienna, rightly as it would turn out. Emilie Mellbye was Hans's older sister and confidante; the siblings discussed family matters, including strategies to handle their father. In 1928, Pettersson told his sister that their father 'has the funny notion that we are disintegrating atoms as a sport' and that 'soon there has been enough of that'.[53] To Dagmar, Otto stated that it was 'time for Hans to move to Sweden in regards to his future possibilities'.[54] He pleaded with his son to 'consider that you have a great platform' that 'I have built'.[55] His father's plans – to 'leave what rests upon his shoulders as a heritage to me' – were no secret to Hans. However, the interests of the son pointed 'in a different direction'; he viewed research in hydrography as a 'means of livelihood for the time being'. It was demoralizing to 'fake interests that one does not have'.[56]

Indeed, between 1921 and 1928, Otto worried that his son would manage to build his own research programme in Austria and remain there. Therefore, he briefly turned his hopes to his other son, Wilhelm: 'Of course I wish to get Wilhelm into hydrographic research with respect to the future when I am no longer here.'[57] Wilhelm moved to Berlin and got a doctorate at the Institute for Oceanography in 1925. Otto helped him to get a position with ICES in Berlin, but his son met with great resistance. Initiatives were taken to have him removed from the organization. Otto protested strenuously, and no one in ICES wanted to oppose him. Instead, the organization made Wilhelm's tasks superfluous. The incident has been interpreted as an effect of younger oceanographers protests against the 'nepotism' of the older generation.[58] After a few years in Berlin, Wilhelm left oceanography and carried on his previous career as an agronomist.

Meanwhile, Hans Pettersson's troubles with sustaining his research at the Radium Institute became apparent. In 1927, his dreams of establishing a research group were shattered, despite massive investments of time, energy, and money.[59] In his own words, he was 'forced to go back' to oceanography at Gothenburg University College.[60] His father had worked hard to create a professorship for him there.[61] To his sister Emilie, Hans explained that the creation of the position was 'an effect' of his father's wishes to 'secure the succession of Swedish oceanography' but also of the 'benevolence towards dad' from the Chairman of SHBC and Governor of the Gothenburg province – Oskar von Sydow.[62] Although Hans was appointed to the professorship without an open hiring process, which was a possibility at the time, a committee of peers still had to declare him competent. Now, Otto tried hard to exercise his influence in selecting the referees.[63] Ultimately, he succeeded: in 1930 Hans became the first full Professor of Oceanography in Sweden. This marked the end of his father's efforts to secure the academic discipline that he had created for a member of his family. When Otto learned of his son's appointment, he wrote a congratulatory letter: 'Good luck my dear Hans, now [we] will toast to your success in champagne.'[64] In his obituary about Otto, physics professor Carl Benedicks concluded: 'the fact that one of his sons carried on his work must have been a source of great satisfaction'.[65]

Hans Pettersson's matters of concern: To come up with something new

So far, I have focused on Otto Pettersson's dual effort to create academic institutions and secure a succession in his oceanographic dynasty. But in which ways did Hans Pettersson imitate his father's science? I will argue that he did not repeat his father's research interests but instead mimicked his entrepreneurial style of scholarship, also repeated among several other elite Swedish scientists. Indeed, his father was Hans's primary point of orientation, his exemplar of a particular style of academic entrepreneurship.

What then were the practices and ideas of this entrepreneurial style? Above all, Hans replicated the interconnected desire to develop his own area of studies and establish new scientific institutions. In these respects, his father was a good role model: Otto let his son know that it was fundamental to 'come up with something new'.[66] In literally every stage of his career, Hans struggled to create an independent career in the burgeoning field of atomic physics. Imitating science was thus paradoxical: on the one hand, it meant repeating what mentors had done. On the other hand, the scientific discipline demanded originality.

Since the 1890s, Otto Pettersson had developed oceanography away from marine biology and towards the physics of the ocean, in particular addressing wave phenomena and movement of seawater in different layers of the ocean.[67] He took an interest in developing oceanographic instruments, and he explored the interactions of the ocean and the atmosphere. These interests were shared by a group of Swedish scholars, which also included Svante Arrhenius, who developed a research programme geared towards what was dubbed 'cosmic physics'.[68]

Conversely, Hans Pettersson's primary scientific interests lay in atomic physics and radioactivity. Indeed, he is best known for his participation in a debate about the nature of the atom that raged through the 1920s between physicists in Vienna and Cambridge. Sir Ernest Rutherford was Hans's foremost opponent and, ultimately, the Swede lost the controversy. Throughout his career Hans focused on adapting atomic physics to oceanography. When he entered radioactivity research, he had roughly 30 publications in oceanography and geophysics. At the same time, radioactivity was a 'recognized, mature' discipline, and the links to oceanography were already in place. Primarily, Hans studied radium emanations from undersea sediments.[69]

Hans's desire to pursue research independently from his father was shaped in an academic system that had been transformed during the second half of the nineteenth century. Specialization had increased, and in the German university model – which became dominant in Europe and the United States – research was made the primary mission of universities. The thesis requirement for obtaining a PhD promoted 'a genuine contribution' to science, and the 'new' universities became 'devoted to the advancement of knowledge'.[70] In line with this model, university reforms in Sweden in the 1850s and 1870s established the modern PhD. Previously, students had merely defended a thesis produced by their professor; now they were expected to produce independent research. Moreover, a regulation from the 1850s stipulated that scientific qualifications should be decisive in the appointment of academic posts.[71] This institutional framework impressed upon Hans the norm of independent research, strongly contributing to his fraught relationship with his father. Between 1914 and 1921, Hans remained his father's assistant at Bornö and Gothenburg University College, resulting in his increasing misery, evident in his letters to Emilie. In 1916, he informed her about the disagreements and asked for her help through his 'ice-desert', a metaphor for sterile and repetitious work.[72] His life was a 'rocky ocean' because of his father's power over Holma, Bornö, and the entire oceanography field.[73]

Hans hoped his father would create a post with SHBC that included more academic freedom. In addition, he asked 'to be hired as the physicist of the commission', but Otto wanted him to remain 'first assistant'.[74] The son's duties with SHBC were 'junk work', including 'cleaning up after dad'.[75] In general, he was critical towards the older generation of oceanographers. To his sister he complained: 'If you only knew how perfectly sick I am with them.'[76] His father's and Ekman's 'grip on my ears' increased on a daily basis.[77] Urging his sister to give him advice, Hans wondered if she had any 'plan for my rescue'?[78] Part of the exasperation was Otto's unwillingness to change the condition of the post: 'He can do it if he wished to but he does not.'[79] The problematic collaboration was addressed by Otto as well. In a stern tone, he told Hans that he could either arrange the institutional set-up of oceanography 'with your interests in mind' or 'we part at once'.[80] If Otto were to maintain his benevolence, Hans needed to spare him 'quarrels and disputes'.[81] In the mid-1920s, Hans summed up his relationship with his father to Emilie: 'These last ten years of constant family conflicts and dreadful "collaboration" with father has worn me down.'[82]

Imitating institution building: From Gothenburg to Vienna and back

According to Elisabeth Crawford and Artur Svansson, Otto Pettersson's work in oceanography was done in a 'spirit of industriousness'.[83] He cultivated an entrepreneurial style and 'initiated numerous enterprises in the most impulsive manner'.[84] A 'good plan for the future' was at the top of the agenda.[85] When he became interested in oceanography in the 1890s, he organized the field 'almost single-handed in Sweden as well as internationally'.[86] He became part of a small group of Uppsala physicists, particularly Knut Ångström, Manne Siegbahn, The Svedberg, and Svante Arrhenius, who together created and utilized new institutional configurations.[87]

With his father presiding over Bornö, Hans Pettersson tried to mimic institution-building practices in Vienna, starting in 1921. His goal was to create a hotbed for atomic research, including studies on the artificial disintegration of light elements. There, he felt 'considerably better than in Gothenburg where the fact that it was impossible to do something along the lines of my main research interests was nerve wrecking'.[88] With Stefan Meyer as the director from 1920 onwards, Pettersson worked without a formal position. He was 'amazingly energetic and ingenious', independently financing his own research, assistants, and instruments, and he thereby gained a leading role at the Radium Institute.[89] From Austria he told his sister that he needed to balance the tasks of writing, 'begging for money', experimenting, presenting results, and promoting a high morale among his assistants.[90] Indeed, the Radium Institute had great potential as a research environment: it housed a vibrant social milieu with daily discussions about science, political upheavals, and contemporary culture. Vienna was at the heart of modern architecture, music, painting, and philosophy, and so Pettersson enjoyed the city's flourishing cultural life. There was also an ongoing construction of academic institutes in the area known as the Mediziner Viertel.[91] In similar ways to his father before him, he surrounded himself with associates. A group of young researchers came to the Radium Institute, among them his long-term collaborators Elisabeth Rona, Marietta Blau, and Hertha Wambacher.[92] Otto Pettersson observed to Ekman that his son's assistants called him their 'Bundespresident', and he concluded that his son was 'really good at leading work'.[93] It is important to note that even if Hans tried to build a research environment like his father, he cultivated an 'anti-hierarchical style' as a research leader, opposite Otto's style of management.[94]

In other matters, Hans more distinctly mimicked his father's approach, foremost in his drive to raise research funding. Otto was successful in securing funds for Bornö from private patrons at a time when state support for research was not yet in place.[95] How to approach financiers became a point of discussion between father and son, and the latter proved 'most effective' in his ability to 'interest donors for his research'.[96] He was 'feverishly searching for financial support', and the grants that Hans received from Swedish patrons and the International Education Board financed not only him but also strengthened the material culture of the Radium Institute.[97] As Maria Rentetzi concluded, 'Pettersson had inherited father's gift for raising funds.'[98]

Despite partial success, the desire to build a robust institution for atomic physics in Vienna never materialized. Reluctantly, indeed 'with great sadness', Hans Pettersson had to leave Austria.[99] In 1928, there was a passing opportunity to become a physics professor at Stockholm University College, but he was not appointed (for reasons I explain further in the next section). Instead, strategies were shaped between father and son to create a platform for his research through a professorship in Gothenburg.[100] In Sweden, the efforts to build a prolific research agenda continued.

The creation of the professorship resulted from Otto Pettersson's efforts to secure the post for his son. Hans, however, emphasized that he was 'not prepared to denounce' his interests in physics, while also admitting that the chair would be 'the best thing that could happen in regards to my abilities to carry on yours and Gustaf [Ekman]'s work'.[101] The chair's name became an important symbolic question: the position could not be labelled 'physics' since the donation letter stipulated that it had to be in oceanography. Instead, and due to his wish to protect his research interests, Hans suggested the name 'Oceanography and radioactivity'.[102] He was keen not to 'abandon' radioactivity and feared that the reviewers of the position would not find him competent for a professorship in oceanography proper.[103] In the end, the position was labelled 'Oceanography'. Never short of ideas, however, Otto encouraged Hans to tell the Rector of Gothenburg University College 'in a private way' that radioactivity was a current problem in oceanography, that he had educated himself for studying radium in seawater, and that the referees keep 'this specialty in mind'.[104] Otto had already explained to his colleagues in Gothenburg that his son was working at the intersection of radioactivity and oceanography.[105] Now he urged his son to come home to 'make arrangements *in private* to secure your future'.[106]

After Hans was appointed Professor of Oceanography, he maintained the practices of institution building, now with greater success. Like his father before him, Hans secured funding from the Wallenberg banking family that enabled the opening of a new Oceanographic Institute in Gothenburg in 1939. The bequest was the last in 'a series of donations to Swedish oceanography', making possible the institute's design along the lines of Hans's research interests.[107] The institute's site on the west coast of Sweden was isolated from the international centres of natural science, but the Petterssons had strong local political support.[108] In sum, its context could be controlled and maintained as a semi-family enterprise in a way that the bustling scientific environment of Vienna could not. At the institute's inauguration on 24 January 1939, the 91-year-old Otto Pettersson took part.[109] This can be seen as the crowning achievement of the family's endeavours to establish and control Swedish oceanography. However, it can also be seen as the site of Hans's independence (as he remained director there until 1956), ironically achieved through his imitation of the entrepreneurial style of his father.

Inheriting animosities, repeating controversy

Yet another crucial part of the entrepreneurial style of scholarship – as well as of Swedish academia where new disciplines took shape – was to enlist allies and fight adversaries. Personal animosity and strong feelings of competition were prevalent; indeed, there was a 'culture of conflict'.[110] I wish to suggest that debate as an institutional practice was inherited from father to son in two interrelated ways. First, there were well-established academic networks within which antagonisms were sustained across generations. Second, Hans Pettersson imitated, at least partly, his father's practice of stimulating scientific debate.

Among the few things that Otto Pettersson did not want his son to 'inherit' were 'enmities'; instead, foes of one's father should be considered as 'ordinary men until one has the possibility to judge for oneself'.[111] However, such wishes disregarded the structures of academia with its competing networks of scholars. On a couple of occasions Hans Pettersson's career was thwarted by the inheritance of controversies, yet the competing networks in Swedish academia also meant that his father's allies supported him.

Inherited animosities were decisive when Hans applied for a professorship in physics at Stockholm University College in 1928. Two years prior, the Vice Chancellor of the College planned to have him succeed his father's friend Arrhenius without an open application process. The opportunity was blocked, and central among those stopping it was physics professor Manne Siegbahn from Uppsala University. Through his correspondence with friends in Sweden, Hans learnt that Siegbahn was a staunch critic of him and that he held his foe Rutherford's research in high regard.[112] This tension between Siegbahn and Hans must be understood against the backdrop of a long-standing rivalry between scholars in Uppsala and Stockholm. Even though he started his academic career at Uppsala University, Otto had quarrelled with Uppsala-based physicists since the 1870s. In 1881, he moved to the new Stockholm University College, where he formed an academic network with, among others, Arrhenius and Carl Benedicks. These scholars critiqued the Uppsala physicists' conservative ideals – their emphasis on experimental skills and their scepticism towards far-reaching theoretical claims in physics.[113] The loyalties within Otto's network were passed on to his son. Throughout the 1920s, Arrhenius and Benedicks acted as Hans's supporters in Stockholm, primarily through representing him in matters of stipends and publications with the Royal Swedish Academy of Science. At the same time, the Uppsala physicists were primarily represented by Siegbahn.[114]

This ongoing, and reproduced, rivalry affected Hans's opportunities, since Siegbahn was elected one of four referees for the professorship in Stockholm. One of the other referees was Benedicks, who, together with the third reviewer, recommended Hans for the chair. Siegbahn and the fourth referee recommended Erik Hulthén instead, and the hiring committee at the College followed their recommendation. Siegbahn's critique was decisive in the matter. In letters to his sister and father, Hans described Siegbahn as an 'adversary' whose influence was 'a drawback'; 'he is much against me'.[115] When the Petterssons discussed the upcoming professorship in Gothenburg, Hans singled out Siegbahn as the main opponent. He argued that the chair should not be in physics because that would enable Siegbahn to exercise his influence again, potentially portraying Hans as a 'scientific fraud as he has already done in Stockholm'.[116]

Quarrels about fixed posts at the universities were widespread. Chairs were few and offered academic power; the professorship in Stockholm would have enabled Hans Pettersson to establish his research on radioactivity.[117] Old, and inherited, enmities were therefore brought to the fore when institutional resources were at stake. Roger Stuewer described Hans as an 'energetic, charming, aggressive man who could be autocratic, domineering and hot-tempered'. Other scholars intermittently reacted to the 'aggressive tone' of the Swede.[118] Instead of gesturing at Hans's individual character traits, however, I wish to suggest that he imitated debate as a pattern of academic interaction. Otto Pettersson has been described as emotional, with regular 'eruptions' of anger. He did not shun debate; 'in fact, he sought it out'.[119] Doing battle was a normal scientific practice for him. Certainly, Otto – along with his associates – were bearers of the contemporary 'culture of fiery quarreling' suggested by Robert Marc Friedman.[120]

The controversy with Rutherford on artificial disintegration shaped Hans Pettersson's career in decisive ways.[121] Radioactivity as a field was heavily affected by competition between laboratories as well as personal and professional affiliations and antipathies.[122] The researchers in Vienna, moreover, cultivated a combative style: they tried to enlist allies and convince guests that came to the Radium Institute of the correctness of their results.[123] Debates were a repeated topic between the Pettersson father and son, and Otto tried to instruct Hans in how to deal with the controversy with Rutherford: 'Keep the exchange to the point, with a chilly tone and as superior as you can.'[124] Hans, on the other hand, promised his father that he would do everything he could 'to come to an understanding'. But he also told Otto that he thought the 'main interest of these gentlemen' was to 'stay at the top of their fame'.[125] The strategy was to get the opponents to come to Vienna, which 'might produce some effects. I must be careful so that I do not give away the trumps I have, since that might mean the game is lost against gentlemen who hold half the deck.'[126]

Throughout the quarrel with the Cambridge physicists, Otto tried to instruct Hans how to behave correctly. Instead of fighting at a distance and keeping results and experiments from each other, Otto thought Hans should openly inform his opponent about planned studies and discoveries.[127] Moreover, Otto argued that the critique of Rutherford would be performed more 'elegantly' without the aggressive attacks. When one felt an itch to strike, one should 'retract one's claws'. The basic advice was 'courage, never overconfidence'.[128] Hans, on the other hand, assured his father that he did not have 'half the prestige and ambition that you think'.[129] Controversies were an integral part of the academic context. Hans mimicked the practice, in particular as part of the entrepreneurial style of trying to establish and dominate an area of research. Tellingly, his behaviour in Vienna was intelligible to Otto: he conceded that to overturn established assumptions could be enticing 'for a young man'.[130]

Conclusion

When he was denied the professorship in Stockholm in 1928, Hans Pettersson wrote a missive where he accused two of the reviewers of trying to hinder 'pioneers'.[131] The opponents, he argued, thought research was merely about copying what mentors had done through meticulous laboratory work. Instead, Hans argued, such miniscule advances within a research programme must be balanced by 'pioneer stages', where new ground was trodden.[132] Moreover, Hans claimed to have learnt a different set of norms, for example, from William Ramsay, 'the spirit which advances research'.[133]

This argument sums up the tensions of his academic life as an heir of Swedish oceanography. The inheritance of science included two aspects of knowledge migration previously indicated in history and sociology of science. First, there was an infrastructure of transfer, mainly constructed by his father, which merged family relations with the creation of new institutional forms. Otto facilitated his son's career through the massive control of oceanographic sites and resources – in particular Bornö, SHBC, and Gothenburg University College – all of which offered professional security. Crucially, however, the family was an equally important part of the infrastructure of transfer, although this has not been given the same attention in existing research. The passing on of science within the family was a crucial concern for Otto and a repeated practice among Swedish scholars. Indeed, the ideas and practices of family life were central, even when Hans went abroad. Through them Otto could put his son in contact with scientific role models like Ramsay and John Murray.

Second, the transfer and imitation of knowledge did not mean a mere copying. Given the harsh academic landscape surrounding him, Hans could not turn down the accumulated resources offered by his father. Nevertheless, he did not repeat his father's research interests. Instead he mimicked Otto's entrepreneurial style. Put differently, Pettersson inherited an academic infrastructure and, within it, he tried his best to imitate the practices and attitudes of an academic entrepreneur, thus shaping the route of oceanography. In both Vienna and Gothenburg he replicated his father's vision to create a research field and dominate over it, as well as to build sites and institutes central within that field. His entrepreneurial ambitions also meant that he inherited old, network-based enmities in the small circles of academia as well as the practice of fighting for scarce resources. The imitation of an entrepreneurial style generated the paradoxes of knowledge transfer indicated in previous research on the migration of science. The transmission of knowledge meant that its content and meaning changed, albeit within certain boundaries.

The inheritance of science took place in a historically specific context. The Petterssons lived at a time when Swedish academia was controlled by few and powerful actors who lived according to bourgeois patterns of family life. The scientist was the head of the family, and the inheritance of academic disciplines was a key concern. At the same time, twentieth-century academic institutions were being built: the Pettersson father and son, as well as several of their peers, could acquire key resources in this building process. But the very institutions that benefited the family-based transfer of oceanography also established norms of the value of independent research. The modern universities demanded independent contributions to research. Accordingly, the son could not simply repeat the work of the father to become successful.

Notes

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10

The Laboratory Society: Science and the Family in Sweden, *c.*1900–1950

Sven Widmalm

Science and private life have co-evolved. This fact, established through much historical research, is reflected in the gendered power structure of academic research. In Sweden, where female participation in the labour market has long been unusually high, women currently constitute about half of the PhD candidates at universities and a little over 20 per cent of the professoriate.[1] Welfare provisions such as tax-funded childcare has made it easier, from the 1970s at least, for women to pursue academic careers, but the lingering of a traditional division of labour within the family has led to women taking on a larger share of family responsibilities than men, often solving this equation by working part-time.[2] This has had detrimental career effects, contributing to the discrepancy between the entry and top-level representation of women in the Swedish academy.[3] Similarly, the demands of mobility and the emphasis on competitiveness put strains on two-career families.[4]

Whereas research policy and family or gender policy have worked in tandem in certain respects – such as their mutual emphasis, since the 1990s, on equal opportunity – there have also been conflicts and contradictions, as the statistics outlined indicate. In order to better understand the relationship between research policy and family policy in Sweden, the historical context of the welfare state is highly relevant. This chapter suggests that the co-evolution of science and private life should be seen not only from a micro-historical perspective, but also from the point of view of research and family policy in the emerging welfare state.

Traditionally, family policy has been seen as a central domain of the welfare state whereas research policy has not. But the increase of government support for research and higher education from the 1940s can hardly be seen as separate from the contemporaneous creation of a broad range of institutions providing social services for the citizens. Research and education were seen as services that would benefit the people – materially as well as spiritually. And science was integral to the general vision of welfare-oriented social democracy in Sweden, in particular social science, implemented through 'social engineering' and the usage of technological and scientific solutions to political problems by 'reform technocrats'.[5] The welfare state was sometimes described as an experiment in the application of academic methods and models in a 'social laboratory' (the relative sociocultural homogeneity of Sweden was metaphorically compared to the standardized conditions of laboratory work).[6] Similarly, the laboratory may be seen as a social microcosm, a 'laboratory society'. The latter was an arena for experimenting with new modes of combining private life and science long before measures that would have a lasting influence on the scientific family were implemented at the national level. At the same time, it would take a long while before policy changes would have a noticeable effect on gendered power relations and the sexual division of labour in science.

As family policy and research policy were both part of a welfare-reform package, initiated during the 1930s and 1940s, and gradually implemented from then onwards, the policies did, to some extent, follow the same logic, at least on the visionary level. Policies that aimed to facilitate the entry of women into the job market were envisaged and, in time, launched; simultaneously, market interests were emphasized in research policy. In both cases the benefits of using untapped human resources were stressed.

The period that will be investigated here – between 1900 and 1950 – was one of emerging ideological consolidation where the effects of concrete change were, as yet, limited. Public childcare was important in the reform programmes suggested in the 1930s, but by 1968 only 5 per cent of children had access to such services – a figure that increased fivefold over the following decade.[7] By 1940, between 20 and 30 per cent of women in the age bracket 25–64 were employed, whereas the same figure for men was between 90 and 100 per cent. Women started to move into the labour market on a broader scale from around 1950, and finally reached a level of employment similar to that of men around 1990.[8] In engineering, medicine, and the sciences, things moved at a similar pace, though from a very low starting point. In 1960, when around 35 per cent of the women between 25 and 64 were employed, they constituted 7 per cent of the scientifically educated workforce; by 1985, when between 70 and 80 per cent in that age group worked, the percentage of scientifically educated female employees had risen to 16 per cent.[9] On the highest academic level discrepancies were even larger. Of 630 women who received doctorates in engineering, science, and medicine between 1980 and 1985, 22 became professors within 12 years; for males the figures were 3,188 and 230 respectively. Hence women constituted 16 per cent of the doctorates – the same percentage as in scientific occupations in general – but they made up only 9 per cent of those who reached the top of the academic pyramid.[10]

If research policy and family policy were part of the same welfare-reform package, it took a long while before they actually started *overlapping*. This chapter investigates the correlation and contradictions between family and science policy in the formative period of the Swedish welfare state. Family and science policy should both be seen as important aspects of a welfare policy associated with Swedish social democracy, yet this has been overlooked in previous research on science policy. The fact that family and science policies failed to intersect seems to be a root cause behind the gendered academic labour market discussed. This phenomenon (by no means unique for Sweden) is not possible to explain in detail here, but some suggestions for how to interpret it will be given in the concluding section of the chapter. Furthermore, the chapter will discuss the relationship between scientific family life and broader policy changes, adding new perspectives on issues that historians of science have most often dealt with from a micro-historical perspective.[11] The empirical example used in order to illustrate the broader issues is that of Theodor (The) Svedberg (1884–1971), a well-known chemist whose scientific career was emblematic for the modernization of Swedish science in the interwar period, and whose family life exemplifies the tensions between family and science policy in the formative years of the Swedish welfare state.

Welfare and power

The welfare state has been defined from the point of view of 'social citizenship' – the provision by the democratic state of basic social securities, like unemployment insurance and public health care.[12] Often Scandinavia, and in particular Sweden, has been held up as having had the most extensive policies of this kind. An influential interpretation of the welfare state has been that associated with so-called Power Resources Theory (PRT) promoted by sociologists such as Walter Korpi and Gøsta Esping-Andersen. According to this view, power is distributed in three social spheres: those of economic exchange, of governing, and of private life.[13] Esping-Andersen has argued that comprehensive welfare regimes like the Swedish one provide a measure of security that, to some extent, balances the fundamental insecurity of commodified labour. Decommodification signifies the partial restoration of autonomy through the power of citizenship in Western-style democracies, to a workforce otherwise subjected to the amoral 'laws' of the market.

Various inadequacies with PRT have been pointed out, and two are of special significance here. First, the theory was, in its original conception, gender blind. As Julia S. O'Connor and Ann Shola Orloff have pointed out, the entrance of women into the labour market, which PRT interprets as a step towards commodification and consequent loss of autonomy, has historically been rather the opposite: dependency on the male breadwinner and the shackles of homemaking have lessened as employment possibilities have increased. O'Connor and Orloff have suggested that the concept of decommodification should include a provision for the possibility of women to lead an autonomous life outside of the family, and that policies that facilitate this are an important aspect of the welfare state.[14] As we will see, the idea of female autonomy was important in the early visionary phase of the Swedish welfare state, though the emphasis was on autonomy *within* the family – for example, on gender equality among spouses – rather than outside of it.

Second, it has been pointed out that PRT works less well in the current age of transnational capitalism, and that power resources other than the original ones, economic and political, must be taken into account if the model is to be of future use.[15] One such resource, I suggest, is *knowledge*, vital in the so-called knowledge economy with its 'knowledge politics', and having received a fair amount of attention already in the early days of the social democratic welfare state.[16] Education was a power resource between the World Wars (and earlier), providing the opportunity to gain individual autonomy when economic resources were lacking. The Swedish Social Democratic Workers' Party, with its emphasis on educational issues from early on, exemplifies an emancipatory educational ideal, as do other social movements like the free churches' and women's movements. But knowledge, as in research and development, was also recognized as a political and economic resource on the national level in this period.

In Sweden around 1940, research and higher education were seen as essential for economic development and security. Academic research policies that emerged at this time were forged in collaboration between the research community, government, and industry, in a manner similar to economic policies from the same period, and with similar long-term effects.[17] The parties involved aimed to achieve commodification in the sense that academic research should be put in direct contact with the market. There was also an awareness that commodification in science was tempered through government regulation so that autonomy was not completely lost. Contemporary family policy similarly worked to balance commodification and decommodification by encouraging women's entry into the labour market while promoting reforms that would strengthen their autonomy within the family by relieving them from certain traditional chores.

These are some of the preconditions for the modernization of the scientific family laid down in the first half of twentieth-century Sweden. With women gaining the right not only to employment in most sectors but to keeping their jobs when married and after having had children, and with intimate links being forged between science and industry, family and science policies may both be said to have striven towards marketization. These tendencies affected the chemist The Svedberg, whose own family was extensive, with 4 marriages resulting in 12 children. The case of Svedberg will be used in order to exemplify gender issues in the scientific family, but also the drive towards industry-oriented research policy, of which he was not only an example but a prime mover.

The companionship model: Early failures

The Svedberg experimented with combining marriage and scientific collaboration in the context of the first 'wave' of women researchers in the natural sciences in the decade before World War I. He was also an important modernizer in Swedish science. His first wife, Andrea (Dea) Andreen (1888–1972), was a practising physician, a director of a laboratory for diabetes testing, a medical researcher, an influential feminist, a sex educator, and a peace activist; furthermore, she helped forge the family policies that were drawn up in the 1930s and would be implemented in the coming decades.[18] Svedberg and Andreen could be compared to a few other well-known couples in the emerging Swedish welfare state, like Gunnar and Alva Myrdal or Axel and Signe Höjer, except that Svedberg and Andreen made their most important contributions after having split up. Despite the early disintegration of their marriage, they are illustrative representatives of the scientific family as they attempted to create a working professional relationship in academic research.

Throughout much of the nineteenth century, a patriarchal model characterized academic science as well as the bourgeois family.[19] Young researchers were educated under the supervision of a professor who embodied not only the department (which he ruled autocratically) but also the discipline (of which he was the sole representative at his university). Normally, aspiring scientists would do a PhD and then, if the marks were good enough, go on to an academic career or, if they were not, become a *gymnasium* teacher.[20] In both cases it was expected that they would become providers of economic security and social status in one-salary families. As head of a university department, the male scientist was expected to provide for a small group of intellectual heirs and to guide them until they reached maturity and could fend for themselves. This was a social form of reproduction founded on what Marshall Sahlins has called post-natal kinship.[21] Around 1900 cracks in the patriarchal model were appearing, though it would take a long time for the model to crumble.

In 1873 women were allowed to attend Swedish universities; hence female participation not only in higher education but also in academic research became viable. By 1900, a handful of women PhDs strove to establish themselves academically, though the road to a fully-fledged academic career would turn out to be much longer than they envisaged.[22] Meanwhile, research collaboration in 'companionship marriages' (*kamratäktenskap*) emerged as an alternative for the scientific family.[23] Women joining spouses in professional partnerships tended to work as assistants on soft, if any, money. Arrangements of this kind were fairly common among Svedberg's colleagues and would be part of the grey economy of Swedish university research until the 1930s.[24]

The phenomenon of successful collaboration between spouses – 'creative couples' – in the sciences has received a fair amount of historical attention.[25] But such collaborations often floundered for various reasons. Two of Svedberg's most prominent chemistry colleagues attempted matrimonial collaboration with uneven results. Svante Arrhenius married the chemistry student Sofia Rudbeck, described at the time as 'madly emancipated', who had come from the fairly misogynist Uppsala to the more progressive Stockholm University College in 1892, apparently with the intention of becoming a professional chemist.[26] There she met Arrhenius who promptly hired her as his personal research assistant. After they married, Rudbeck realized that an independent career in chemistry would be impossible, and divorce followed quickly. When Arrhenius married next, the terms would be traditionally patriarchal.[27]

The partnership between Hans von Euler and Astrid Cleve was more productive but ultimately a failure. The former had come to Sweden from Germany at the turn of the century in order to work with Arrhenius at Stockholm University College. In 1902 he married Cleve and in 1906 he became Professor of Organic Chemistry in Stockholm. Not only was Cleve the first woman PhD in the natural sciences (botany) in Sweden, she was also the daughter of a chemistry professor, P.T. Cleve, at Uppsala University. She read chemistry, and when she married von Euler, scientific collaboration seems to have been part of the deal; over a ten-year period they published a number of papers together. After the divorce Cleve commented that she had forsaken her own research interest in order to promote her husband's career – not by staying at home taking care of the children (they had five) but by submitting to his research programme. A year after the divorce von Euler married Beth af Ugglas, with whom he collaborated throughout the rest of his long working life.[28]

In 1909, when he was 25 and she 21, Svedberg and Andreen, a medical student, married. Svedberg's career was meteoric; he received a personal chair in physical chemistry in 1912, before he had turned 28. Andreen had by then switched from medicine to chemistry, as Svedberg thought it more convenient if they could work together in the laboratory. In other ways Andreen did not follow her husband. She was involved with radical youth movements of right-wing politics as well as the Lutheran State Church, whereas Svedberg was a Nietzschean, a Strindbergian, an atheist, a monist, and politically on the left.[29] He envisaged himself as a scientific *Übermensch*, an impression that was seemingly verified by his early scientific success and by his ability to gather and charismatically lead a flock of young disciples.

Svedberg would blame the disintegration of their marriage on political and religious differences. But he also blamed his own ambition to mix matrimony and research, claiming that it had been a mistake to make his wife his assistant when she would have liked to pursue a medical career.[30] Fifty years after the event, he described the birth of their first child Hillevi: 'How did I feel now? I suppose it brought us closer, me and Dea, and in particular for her I suppose it was satisfactory to have a child. I probably went in so much for my research that the event did not change my life much.'[31] Indeed, Svedberg described the marriage as a failed attempt to create a collaborative relationship in the lab as well as in the home.

On 19 November 1914, the Svedberg couple appeared before the Church Council. It was The who had sued for divorce and the spouses were required by law to go through a procedure of being 'cautioned'. In effect, this process amounted to a strong condemnation of Svedberg.

He was accused of having fallen in love with another woman and was roundly condemned by the Dean of the Cathedral Parish as well as the archbishop for behaving immorally. As he was known as a philosophical radical, these accusations may be read as an enactment of the ongoing *Kulturkampf* of modernization. The incident was also something of a farce as Svedberg had to deny having an affair, not only because admission would have blotted his character, but because it would have been financially disastrous for him for legal reasons.[32] It was true nevertheless, and in 1917 he married Jane Frodi, the daughter of a chief executive of the Swedish Lloyd shipping company. Svedberg described her as Andreen's opposite: 'bizarre, flighty, feminine'.[33] She would assume the role of homemaker and seems to have taken no part in Svedberg's scientific work, other than by providing breast milk for early experimentation with the ultracentrifuge.

The social costs of a divorce at this time could be high. When Astrid Cleve was abandoned for another woman, her supporters organized a (failed) campaign against von Euler's election to the Royal Swedish Academy of Sciences. When Svedberg and Andreen divorced, he claimed their friends formed camps divided by political and religious affiliation, so that he now became even more firmly associated with the left-wing modernizing camp than he already was. His mentor Oskar Widman was quoted as saying: 'At Stockholm University they have had divorces (Svante Arrhenius, Hans von Euler), but I thought Uppsala University would be spared such scandals.'[34] These three chemical divorcés were all future Nobel Laureates. The anecdote, told in Svedberg's autobiography, therefore probably reflects a self-conscious acknowledgement that the family life of exceptional men did not have to conform to ordinary social standards.[35] From a historical perspective, the three divorces exemplify the great obstacles against combining scientific and private lives in the pre-welfare era.

After their divorces, Andreen and Cleve resumed their old scientific interests, medicine and biology, whereas Rudbeck carved out a career as a photographer. Cleve would become a prominent expert on diatoms and politically active on the far right (where her former husband von Euler also belonged). Andreen's politics went leftwards, and she became a leading spokesperson for women's rights to a professional career and equality inside and outside of the family. In 1933 she earned a doctorate in medical chemistry. The feminist movement to which Andreen belonged would work ardently during the interwar period to promote policy changes that aimed to make the companionship model of marriage a practical possibility, which it had not really been when she had had a stab at it around 1910.

All this time, the question of women's career possibilities in scientific research was largely an academic one. Between 1900 and 1950 the number of woman PhDs relative to the total number grew at an unsteady pace, from 1 per cent to 5 per cent. But this was not true of the natural sciences, where the absolute number hardly increased at all (about one every two years throughout the period).[36] That women PhDs did not make careers in university science before the mid-twentieth century was the result of a vicious circle: the prospect of almost no career opportunities apparently lured only a small number of women to the sciences. It was not until 1925 that women got the right of employment in 'higher' public offices, including at the university. After that, other obstacles remained, for instance the practical difficulties of combining family and scientific career-making, and outright discrimination.

Feminist family policy between the wars

After World War I, when female suffrage had been won, and other related reforms (taxation, divorce law) had been implemented, the feminist movement in Sweden focused on women's right to work.[37] A case in point was Andreen, who steadily moved leftward politically and who would eventually join the Social Democratic Party (and later receive the Stalin Peace Prize). In the early 1920s, with her medical education finished, she became active in the feminist network around the 'Fogelstad group', which ran a private school for the adult education of women, focusing on social issues, and she frequently wrote in the group's magazine *Tidevarvet*.[38]

When women did gain the formal right to seek higher public offices, the immediate result was a political backlash from mainly social democratic members of parliament, who thought married women should be excluded from this part of the labour market.[39] The discussion concerning married women's right to work would continue until 1939, when it was guaranteed by law. For academic women like Andreen this was a central feminist issue. She used the common argument of inevitable modernization: 'All factors tend in this direction.'[40] 'Every day', she proclaimed, 'a new history' was written as the 'barriers surrounding women's lives' were being eroded.[41] The Fogelstad group used the term 'companionship society' to describe their ideal, where, according to Andreen, differences between the sexes should be seen as too insignificant to merit practical consideration. There was no reason, she claimed, that husbands and wives should not share responsibility for their offspring on equal terms.[42] As Alva Myrdal put it in 1932: it should be possible for married women to work and for working couples to have children.[43]

Thus defined, the question of the family was placed centre stage in the political discussion in 1934 when Alva Myrdal and her husband Gunnar, both social democrats, published an influential book on the presumed nativity crisis in Sweden – with low birth rates being seen as a major political problem and interpreted by many as an argument against women entering the labour market.[44] The Myrdals turned this interpretation of the nativity crisis on its head by arguing that women's right to work was inevitable and that birth rates should be kept up through welfare reforms that would make it possible to combine work and childbearing. In short, they and other progressives, such as Andreen, presented the problem of family life and female labour as one of decommodification: welfare provisions should empower women economically *and* preserve the family as a fundamental unit of society. The discussion was framed by a rhetoric of historical inevitability, for example, describing the family as a function of 'the development of society as a whole, which in the last analysis is driven by technology'.[45] The Myrdals and likeminded reformers saw the patriarchal family model as a historical parenthesis, and the broad entry of women into the labour market as historically inevitable as well as ideologically desirable.[46] As Alva Myrdal put it: 'Feminism is not engaging in a war of aggression in order to lay claim to new areas previously belonging to the men, but engages in a defense in order to recapture tasks that industrialization has deprived women of.'[47]

The Myrdals thus cleverly argued that everything about the family had to change in order to preserve it, and to increase birth rates. They saw the problem of family policy as solvable through rationalization and the application of cutting-edge social science, looking mainly to American examples for inspiration. They used the American sociologist William Ogburn as a guide for identifying the problem if not the solution: modern society had to be adjusted to the cumulative effects of technological development; not least the fact that the family was rapidly losing traditional functions, thus becoming 'maladjusted'.[48] At the same time, women's right to work was mainly discussed from a labour market point of view. Women's right to join the academic elite was barely prioritized by this academic elite couple, who had just decided to join the Social Democratic Workers' Party.

By the mid-1930s, family reform and gender relations were becoming recognized goals for welfare policy in the social laboratory of Sweden. Several government commissions were now launched that set the agenda for policy developments in the decades to come. In one report from 1938 by a 'committee on women's work' (with Alva Myrdal as secretary and a number of other prominent feminists participating), it was claimed that political attempts to exclude married women from the labour market would '*undermine marriage as a social institution*'.[49] Another government committee that included Andrea Andreen and Gunnar Myrdal was appointed in 1935 to investigate the nativity crisis. It also argued that the preservation of the family demanded policies that facilitated the combination of work and procreation for women.[50] Another important argument was that female human capital was needed: society could not afford *not* to utilize the economically productive potential of women.[51]

Measures proposed by the Myrdals and others could thus be described in terms of PRT modified by gender concerns. By providing services that encouraged egalitarian family arrangements, government should make it possible for women to join the labour market *and* keep up high birth rates (four children was thought to be the ideal); family policy would thus facilitate female liberation in the economic sense as well as within the family, and also provide the labour market with new resources. The economic aspects hence received much attention – in a typical social democratic fashion – whereas the power resource of (academic) knowledge did not. Alva Myrdal proudly presented this model to a foreign audience as a 'Swedish Experiment in Democratic Family and Population Policy' carried out through 'constructive social engineering'.[52]

Technology-oriented research policy during the war

As his ex-wife joined the movement promoting sexual equality and rationalized family living, The Svedberg became a figurehead for modernization in laboratory research. His institute for physical chemistry at Uppsala University was idealized in the early research policy of the welfare state as an example of a new laboratory ideal of how science–industry relations should be organized, and in the popular press as an example of progressive family values. Svedberg transformed laboratory research through the introduction of systematic teamwork, flexible design, and intimate collaboration with industry. As with the progressive social scientists, much of the inspiration was derived from the

United States, where he spent a sabbatical in 1923.[53] When he was awarded a Nobel Prize in 1926, monies for building and equipping a new and hypermodern scientific laboratory were provided by the Swedish government and the Rockefeller Foundation. From the mid-1930s, collaboration with industry became intense, helping to finance a growing technical and academic staff and Svedberg's second divorce that, according to him, was financially disastrous.[54] When a modern research policy, with vastly increased government support for science, was negotiated during the war years, Svedberg would be a key player and his laboratory would be held up as exemplary.

Like family policy, the emerging research policy was described as a necessary consequence of historical forces that could not be controlled but rather demanded political and social adaptation. The main ambitions were to make research more economically productive and to encourage collaboration between government-funded science and industry. The goal was a commodification of academic research. Plans for such policies were laid down in the early 1940s in an ambitious multi-volume report concerning technological research that set the stage for further policy initiatives in the coming years, much like the reports on family policy did. Immediate results included the founding of a technological research council and a number of industrial research institutes.[55] Svedberg and several of his associates were involved in the production of the policy report, but it is nevertheless surprising that it portrayed Svedberg's *university* laboratory as an ideal *technological* research organization. The report differentiated between two kinds of research institutes: the vertical and the horizontal. The former was discipline-oriented, like traditional university departments. The latter was multidisciplinary, using technologies and methodologies from many sciences. Few such institutions existed, the report explained, as this kind of organization demanded particularly expensive equipment and prominent leadership in several disciplines. Indeed, the only example mentioned was Svedberg's institute in Uppsala. This, said the report, was the preferable form of organization: flexible, versatile, and efficient.[56]

The two kinds of organizations demanded different forms of leadership. The vertical variety was described as a benign patriarchy, a small-scale operation with a director who was involved in all activities and where scientific freedom reigned, for the director at least. The horizontal organization was envisaged as much larger. Rather than disciplinary leadership it demanded a managerial structure with a director in charge of a system of divisions, committees, and so forth – in short, something similar to a large industrial enterprise, where diverging interests among division leaders were kept in check by a strong 'impartial central leadership'.[57] The need for such an organization was explained with reference to modernization: 'progress' had meant that laboratories had 'changed radically'. This was due to the greatly increased demands for advanced technology; to let researchers work with anything but the best equipment would be 'a waste of the intellectual resources of the country that we cannot afford'.[58] Not only advanced technology was needed: an array of auxiliary functions – for routine analytical work, photographic work, technological maintenance, and so on – was demanded as well. Under such a regime, the report optimistically predicted, 'sufficient autonomy' for the researchers could still be guaranteed; in particular, heads of various divisions would be given great autonomy as long as they stuck to prescribed research programmes.[59] Thus, the exploitation of research would be sustained by government policies that simultaneously preserved traditional core values; in the idiom of PRT, commodification would be counterbalanced through state-supported academic freedom.[60] Another extensive report concerning research in the natural sciences followed in 1945, leading to the creation of a science research council. The importance of fundamental research was again defined in technological and economic terms, and academic freedom was also emphasized, now with reference to Vannevar Bush's US presidential report, *Science: The Endless Frontier*.[61]

The careers of women scientists were not, however, a concern in research policy any more than in family policy. It was noted that the low salaries of assistant professors (*docenter*) was a problem from the point of view of family formation – an echo of the concerns of the 1930s about nativity.[62] But women were mentioned only in connection with the assisting functions implicitly reserved for them.[63] Of the gender-equality ambitions also belonging to the welfare project there was little or no sign in early research policy. It is in fact likely that the heavy emphasis on engineering aspects of science helped brand the natural sciences as even more of a manly pursuit than they had been before the war. If family policy, including reforms securing women's right to work, aimed to create an interface between the nuclear family and the labour market that included both sexes, and science policy aimed to create an interface between academic research and industry, there was precious little interest in establishing a female bridgehead in male-dominated 'hard' science and engineering. For a long time, technically oriented expertise would continue to be encoded as a male power resource.

'Young man's road to Minerva'

Around 1940, women were nevertheless making inroads into academic science with the prospect of pursuing a professional career – including at Svedberg's laboratory. By then he had assembled a large team of young researchers working under circumstances that were in line with emerging policy ideals (that he himself helped define). Unlike at a traditional university department, his students would not necessarily hurry to finish a PhD and then try to find a job; they could remain in the laboratory year after year without graduating, doing project-based cross-disciplinary research supported by external funding – from Rockefeller, from chemical industries, or from the government. A string of these male disciples would nevertheless make splendid careers, none more so than Arne Tiselius, whom Svedberg helped get a personal chair in biochemistry in 1938, and who ten years later received a Nobel Prize for work on electrophoresis.[64]

Svedberg's institute exemplified the 'horizontal' organization advocated in the research policy report discussed in the previous section. There were several scientific leaders involved in the work: Svedberg and Tiselius were the two tenured professors representing physical chemistry and biochemistry respectively, but there were also guest professors. Furthermore, the traditional top-down power structure was broken up by the existence of a variety of projects run by Svedberg, Tiselius, and their lieutenants. As activities were centred on technological development, Svedberg established a mechanical workshop and hired several skilled technicians. Scientific work was further rationalized through the creation of a calculation department for handling the masses of computation work produced by staff and guest researchers.

Through its various projects, the institute established a many-faceted interface with government and private enterprises that made the internal organization fluid (including the intellectual structure, which became pronouncedly interdisciplinary). In an organogram of the institute made around 1940, there was a list of providers of funding: beside the university, six private funding agencies and eight industrial enterprises were involved.[65] Government provided basic funding for the institute but also commissioned work leading to a new research unit being created during the war for the development of synthetic rubber: the so-called rubber band (*gummibandet*). By the 1940s, Svedberg's lab was not only described as paradigmatic in policy but emulated by industry.[66] The shape of things to come, it seemed, was visible there, with regard to organization as well as research directions.

In 1941 the Finnish-Swedish physiologist and later Nobel Prize winner Ragnar Granit published a collection of essays called *Young Man's Road to Minerva*, presenting a vivid image of the scientific life aimed at young men who contemplated going into research. The title essay of the book emphasized the collective nature of research and the importance of research environments, of which Granit painted a rose-tinted homosocial picture:

> It is not so easy to define the strange atmospheric condition called a scientific milieu. It consists of many simple as well as subtle elements: a leading man's dedication to research, solid problems, open criticism, the readiness of a few young men to take on their share of work, their enthusiasm. The fruit of all this is noble rivalry between peers, advanced individual training and self-criticism, undying loyalty to common ideals.[67]

Granit argued that the common idealization of the individual researcher, not least in literary fiction, gave a false image of research, which was essentially collectivistic.[68] The implicit challenge to depict science thus, as a collective enterprise, was accepted at Svedberg's institute. In 1942, a photographic album with the same title as Granit's book was produced there; it held a group portrait of nearly a hundred individuals (all identified by name and occupation) who worked with research and technological development or who did maintenance work connected with such activities.[69] The album's portraits, most of them with brief and sometimes jocular remarks, give a key to understanding social relations at a lab that was considered an epitome of modern science. Gender relations were changing, though still not in a dramatic way; in some senses they were actually modelled on the situation of four decades earlier, when Svedberg and Andreen were about to embark on their failed companionship marriage.

The album depicted each and every co-worker, from Svedberg – 'our teacher, our friend, and our chief' – to the cleaning ladies. The professors were portrayed first; then came those who ranked below them in the academic hierarchy: (untenured) *docents*, PhD candidates, and students. The *docent* Sven Brohult had taken about ten years to finish his PhD, and would go on to lead an instrument company founded by Svedberg and others, and then to become CEO of the Swedish Engineering Academy and a central figure in science–industry relations in post-war Sweden. He was described as the institute's 'factotum' and as the 'ladies' dedicated knight'.[70] The style of portraiture and a comment to the effect that Brohult was never present at the lab indicate that he was, by this time, entering a managerial career path, exemplifying what has been indicated about the permeability of the institute.

The first, and therefore academically highest-ranking, woman appearing in the album was Ingrid Moring, portrayed with her fiancé Stig Claesson (Figure 10.1). They later married (and divorced) and both pursued academic careers. He would succeed Svedberg. According to the caption, the couple represented 'the department's official breeze of romance'.[71] Lower down on the academic ladder more women appeared.

Figure 10.1 Ingrid Moring and Stig Claesson (surname misspelt in the album's caption) from *Ung mans väg till Minerva* University Archive, Uppsala University Library, Archives of the Department of Physical Chemistry, The Svedberg Papers, F4, E:6.

They were mostly bachelors of science doing less qualified research work, but perhaps aiming to do a PhD. The gendered structure of the lab is obvious just by glancing through this album. Not only were the women in a minority (about 10 per cent), but their position in the hierarchy was low, most of them being assistants of some kind (the position presumed for women in the government reports). The gendered choice of title for the album of course illustrated, and perhaps reinforced, this state of affairs.

In the album, after the academic staff came, in order of appearance: the rubber band, the calculating office, and finally technical support – the workshop and maintenance. The only female member of the rubber band was Ingrid Svedberg, née Blomqvist, a chemistry student. The fact that she was also, as of four years, Svedberg's (third) wife is not mentioned directly in the caption. Instead she is presented with these slightly equivocal words:

> Ingrid Svedberg. Student, prematurely abducted from classes and studies to investigate the structure of the rubber molecule and other dark secrets. Comrade and the cohesive force between the feuding elements of the rubber band.[72]

The women were often presented with mildly risqué or otherwise gendered comments: one was said to appreciate 'equivocal' stories, another to be married and to like being scratched on her back. As some of the young men were also described using mild sexual innuendo, the impression given is that of a workplace with some sexual tensions and social interactions that went beyond work relations.

The album presented the organization of research in a way that Ragnar Granit had described as typical of modern science, as a collaborative *Gemeinschaft*, though its inclusiveness made female participation visible in a way that Granit's literary presentation of budding career scientists had not. This community was organized hierarchically, though not autocratically, with academic staff on top, with the rubber band as a government-sponsored sideshow, and with the calculating office, the workshop, and maintenance as service departments. The organization was gendered but there were cracks in the male dominance. The impression given by the photo album as a whole is that of collective hard work and play and also comradeship between men, women, and even children (apprentices in the workshop).

Elsewhere I have discussed the media image of Svedberg during the war: he was portrayed as a scientific genius, a great inventor, a one-man force of modernization, and a morally exemplary character to boot.[73] The media image thus projected included portraits of the thoroughly modern Svedberg *couple* (Figure 10.2): two scientists working side by side, both helping with running the lab as well as their private household. If one were to believe the magazines that printed such stories, Svedberg had finally accomplished what he attempted but failed to achieve with Andrea Andreen, namely a working professional relationship within a true companionship marriage (with children). The

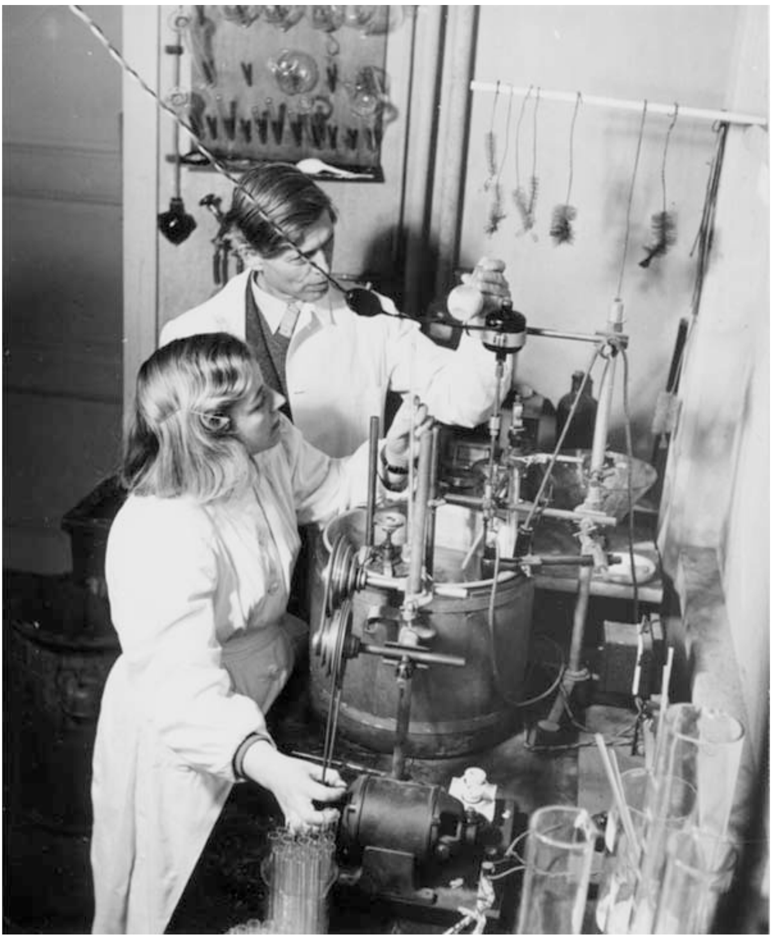

Figure 10.2 The Svedberg and Ingrid Svedberg as presented in the media from *Allers*, 22 August 1944 (34). Photo by Sweden's premiere photojournalist, K.W. Gullers, ©Nordiska museet.

Svedberg couple were presented as a realization of what progressive family policies attempted to achieve at the time.

But this was far from the truth. According to Svedberg's unpublished autobiography, as well as contemporary documentation, the marriage was an unmitigated disaster. Svedberg claimed that he had not intended that the relationship with Ingrid would amount to anything more than 'an erotically coloured friendship'. But he had fallen in love with 'Lillan' – this was her nickname, a female diminutive ('little one') – and had been particularly impressed with the fact that 'she seemed to devote herself entirely to me'.[74]

When the two met, Ingrid Blomqvist was a law student, but she quickly switched to chemistry, thus repeating the pattern from Svedberg's first marriage. She then joined the rubber band unit, a move that, according to Svedberg, was catastrophic. Blomqvist started to meddle in the running of the institute, and she 'became too intimate with her colleagues'. During one of the 'rubber parties' that she organized, the participants practised archery, firing away at trees in the park outside of the institute without opening the windows first, breaking more than 30 panes.[75] In another context Svedberg described the free and easy atmosphere in the rubber band unit as a distinct advantage, promoting dedication and energetic work.[76] But when it came to his wife's exploits, the unconventional ways of the group's young members threatened the morale of the institute as a whole – not least because of her status as the director's wife. Several scandals ensued, and eventually Svedberg arranged for Blomqvist to get a job at a laboratory in Cambridge so that they could fulfil the prescribed one-year separation legally required before their divorce could become final. As she did not return to Sweden, Svedberg got custody of their three children. Ingrid Blomqvist later changed both her first and her second names, as she remarried in England.[77]

Blomqvist's position at the lab was ambiguous to say the least. Svedberg was the master of the scientific household, regarded as 'a god' according to his wife, whose term of endearment for him was actually 'master' (*husse*) – in Swedish denoting a male dog owner.[78] She enjoyed a role not as her husband's unpaid assistant but rather as an employed subordinate in one of several ongoing projects, a regular team member. As we have seen earlier in this section, that is how she was portrayed in the photographic album. Nevertheless – in her capacity of wife to the director, and despite the fact that she lacked academic credentials – she seems to have tried to take an active part in running the institute, causing her husband much embarrassment (according to himself at least).

But she was not a peer among the aspiring young research workers either, as she was indeed the director's wife, causing further embarrassment by associating too freely with her rubber band colleagues. She seems to have tried to play the role of privileged director's wife and teammate simultaneously, with dire consequences.

Svedberg's testimony before the Church Council in 1914, in connection with his first divorce, had been misleading, because the law more or less forced divorcing couples to bend the truth about extramarital affairs in order to toe the line of Lutheran morality and its legal manifestations. The cheerful journalistic representations of him and his third wife were similarly misleading. They presupposed that a modern scientific hero would have a modern marriage in tune with progressive values, whereas in reality this ideal, too, was far from being realized. Svedberg's attempt to make his first wife a chemist may have been misdirected. But the masquerading of Ingrid Blomqvist as her husband's scientific collaborator was a more sinister business. By agreeing to have himself and his spouse presented as partners in science, Svedberg indicated that he fulfilled expectations surrounding his science, media, and policy personae, namely that he represented progressive values associated with the ambitions of the welfare state. In reality, however, his laboratory, marriage, or policies he helped forge took no more than minimal steps towards decommodification in the gendered sense discussed in this chapter, a process by which women supposedly gained greater autonomy by entering the labour market. If anything, he used his wife as a commodity for enhancing his own progressive image.

Concluding remarks

Family policy and research policy in mid-twentieth-century Sweden both expressed the ambitions of an emerging welfare state in the process of erecting an institutional framework for economic development and the furthering of equality and democratic values. In both cases, the goal to utilize human capital – women and scientists – to its full potential was central. This was described as a necessary remedy against the cultural lag produced by rapid technological advances.

Family policy and research policy both exemplify the interplay between commodification and decommodification, between the social democrats' ambition to collaborate with capital in order to provide economic growth and jobs (also for women and scientists) and to provide power resources for employees (including women and scientists). In PRT, citizenship has been seen as the most important power resource. Feminist researchers have pointed out that economic autonomy, achievable when women entered the middle-class labour market, should be seen as a power resource as well. I claim that 'knowledge' may be viewed similarly. Changes in the organization of families and concomitant changes in the organization of laboratories would not only open up these institutions to the market but provide a measure of autonomy, for instance through tax-funded childcare and support for academic freedom. In this period there was, however, slight interest in utilizing women as human capital in the *sciences*, at least in the short run, and the two welfare projects would remain on parallel tracks for a in the long run. For a long time the power resource of knowledge – at least in technically oriented academic science – was gendered so as to exclude women.

To explain in detail why this was so is beyond the scope of this chapter. I suggest two reasons that were probably important around mid-century. First, the Swedish social democrats were labour-oriented whereas academic science was an elite occupation. Promoting women's entry into the labour market was one thing; to help them join the academic elite was probably of minor concern. Second, the science policy forged in the 1940s was oriented towards engineering and industry – two areas that were even more male-dominated than the university. If 'academic freedom' helped balance the commodification of research it did precious little for those who had not gained a foothold in science.

The case of Svedberg illustrates successful modernization in science but not in family living or sexual politics. Maybe the attempt to embrace the companionship model with Andreen was a sign of progressive ambitions. His (second) marriage with Jane Frodi seems to have been wholly 'traditional', whereas his return to something like the companionship model in his (third) marriage with Ingrid Blomqvist must be described as a sign of bad judgement. The fact that Svedberg was depicted as a dangerous libertine by the Church in 1914, and as a modern man with a modern marriage in the 1940s, showed that times had changed. Alas he had not.

Notes

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11

Research Cooperation, Learning Processes, and Trust among Plant Scientists: Fictive Kinship, Academic Mobility, and Scientists' Careers

Helena Pettersson

Family are the ones you find along the road.[1]

Introduction

Career paths among academics and the construction of academic research communities are central topics in current research politics at a global as well as local level. The discourse about the research society as a cosmopolitan community puts forward a 'taken for granted' perspective that mobility is good for its own cause. On the other hand, ideas concerning stability, 'home', and 'roots', having a geographical focal point in life, are still valued as life quality factors. These contradictory ideals and values make the combination of transnational mobility with family life and the feeling of being at home complicated.[2]

This chapter analyses fictive kinship in research cooperation and scientific careers among scientists. Its focus is to describe how junior scientists engage in the fictive kinship process: how they understand the importance of scientific networking, develop scientific collaborations, and form close bonds with researchers while conducting international postdoctoral research. The junior scientists must learn and gain new scientific skills and achievements. How do scientists form relationships with lab members in the labs they are visiting, and what do those relationships mean as they acquire seniority within their careers?

Academic mobility across global networks is crucial in the contemporary discourse and practice of the circulation of knowledge and its economy. Research migration across national boundaries is a central topic in the discourse of 'brain circulation' and its intellectual and economic consequences. With an increasing competitiveness between knowledge-intensive countries, it is important to analyse how researchers form such collaborations, as well as the social and cultural imperatives to move between the different research sites.[3] Late modernity, according to Zygmunt Bauman, is characterized by nomadism. Traditional roles, values, and identities are tested: they become 'liquid'. Nomadism in this context is not merely a geographic migration of bodies; it is more of a fluid state, where long-established infrastructures of support no longer define a stable working-place security or a given framework for identities.[4] This is also the case with family relations as well as definitions of the family concept. How can we understand kinship and academic family relations in contemporary knowledge communities and today's demands regarding mobility, research internationalization, and competitiveness? In this chapter, I problematize how junior scientists must learn and gain new scientific skills and achievements. They also form strong relationships with the peer and the fellow lab members, especially at a similar career stage. Gained scientific skills and an extended scientific family are central resources for the junior scientist's career development. The concept 'fictive kinship' is used to analyse power and loyalty relations between people and groups that are bound to each other not by blood, but by power relations, material goods, and close research cooperation.

Data collection and method

The argument of this chapter is based on my analysis of transcripts and field notes from my ethnographic fieldwork, conducted between autumn 2009 and spring 2011, consisting of interviews and following/descriptive observations of 12 informants at a plant science centre in Sweden. These are well-established methods in ethnology for studying complex cultural contexts.[5] As an ethnologist, I study cultural practices and meaning-making processes. The advantage of ethnographic fieldwork is that it produces a comprehensive understanding of the scientific environments under investigation.

Before starting my fieldwork, I disclosed the purpose of the project to my informants, and I used the field notes and interviews with their consent. Through the interviews I aimed at capturing each individual's perspective on his or her work practices and culture. In most interview situations, I recorded the interviews with a digital recording device with the informants' consent; in a few cases I took notes in lieu of recordings. In my analysis of the interviews, I categorized their content by themes and topics. I matched these topics with other data collected from the observations, and I then analysed the data together. The informants are given pseudonyms in this chapter to protect their identity, both regarding their names and their specific academic institution.

Owing to my lack of training in my informants' scientific field, plant science, I chose the following/descriptive observation technique instead of participant observation; to have really participated, a professional background would have been required. In following/descriptive observation, I followed the plant scientists to observe the daily conditions under which they work, asked questions about their work, and regularly took field notes. My observations served as a foundation upon which to conduct my interviews.

Research environments such as laboratories are complex environments, constituted of a combination of humans and machines.[6] The ethnographer performs a translational act when analysing the lab as a cultural phenomenon. The lab has to be described so that outsiders can understand it. There is a balance between an insider and an outsider perspective where the ethnographer becomes 'the professional stranger'.[7] Estrangement or defamiliarization remains the distinctive trigger of ethnographic work, giving it the sense that there is something to be figured out or discovered by fieldwork.[8] I would also argue that academic mobility is a part of a research field called 'studying up'.[9] By 'studying up', we conceptualize knowledge and power-making processes within academic research communities on local and global levels.

Cultural and social studies of science and the academy are complex fields. The academy has been studied as a territory with tribes, and as a culture with its internal rules regarding social relationships, logic, and socializations into disciplines and research identities.[10] Sharon Traweek's anthropological study of particle physicists is a pioneering work that is unique in its analysis of the physicists' socialization into their research identity and the gendered construction of research practices.[11] Part of the socialization process is to recognize the necessity of different stages of scientific training. Such an activity may be the building of fictive kinships within a scientific network through academic mobility.

Family, internationalization, and academic mobility

A couple of years ago I encountered the dictum, 'Family are the ones you find along the road', on a wall plaque in the home of a nomadic researcher. The person, let us call her Deborah, had spent her time between the United States, Europe, and Japan, conducting research as a visiting professor at different universities. She emphasized the importance of fictive kinship she had established over the years in different academic settings. Fictive kinship, she said, was equally important as blood-based kinship. As an academician who travelled all over the world, she found it important to know that she had a basis for forming fictive kinships in academia.

Academic mobility can be analysed as cultural, gendered values and practices. These values are articulated at an early educational stage as one enters higher education and progresses through the educational system. It includes presupposed training in formal methods, experimental practices, and disciplinary, scholarly knowledge.[12]

Family and kinship relations are a condition for and a consequence of academic research. Changes on the level of family structure and family norms are correlated with changes in scientific practice and epistemology.[13] The life as a scientist is intertwined with a life outside of the lab group and the lab. Analyses regarding academic career and family have studied how scientists balance academic mobility in relation to their partners and family. Among the issues that need to be addressed is how both partners can fulfil their ambitions despite the migratory requirements that both might have. A common concern is whether a partner is willing to co-migrate or whether the career and the relationship are sufficiently important to maintain across long distances. The employment situation forces scientists to negotiate with a partner/family to be able to move between research sites.[14] A person with higher education tends to have a partner with higher education. This is especially true when it comes to female researchers. A 1998 American study of 30,000 faculty members showed that 44 per cent of the female physicists in the USA were married to other physicists and an additional 25 per cent to other scientists.[15]

Gendered identities may challenge how relationships and careers are valued. Among my informants, there are, for example, female researchers who chose not to form relationships or to start a family. They define their lab space and colleagues as their home and kin. Fictive kinship is formed as a central part of building trust, cooperation, and career choices. Hence, we might reflect on the level of importance between family-like relations, bearing in mind that scientists spend at least 40 hours per week at their labs and may form long-term or even lifetime scientific relations – if not collaborations.

Kinship and academic contexts

Sociologists and anthropologists like Émile Durkheim, Claude Lévi-Strauss, and Bronisław Malinowski problematized the concept of kinship.[16] To study the role of blood relatives is a well-established way of understanding relatedness among different ethnic groups and social and cultural organizations of humans.[17] According to Marshall Sahlins, the idea of kinship is a 'mutuality of being'. He aims at human relations where people are 'intrinsic to one another's existence – thus "mutual person(s)", "life itself", "intersubjective belonging"'. Sahlins argued that the 'mutuality of being' covers a variety of ethnographically documented ways kinship is locally constituted, whether by procreation, social construction, or some combination. Kinship can also be an interpersonal relation, based on consanguinity or on affinity. Sahlins further pointed out group arrangements of descent as a possible basis for defining kinship. The 'mutuality of being' will, according to Sahlins, also motivate the otherwise inscrutable effects of kinship bonds – of the kind often called 'mystical' – whereby what one person does or suffers also happens to others, like inherited virtues or misfortunes in religious narratives.[18]

A common understanding of kinship is the idea of a biological relation: a blood descendant or blood-based relative. Examples of ways to organize and extend kinship is through marriage, a lineage of descendants, and certain structures and organizations. During the 1980s, there was a critique towards the use of kinship terminology, since concepts like 'mother', 'father', and 'cousin' do not have the same meaning in different cultural contexts. The critique had been preceded by an understanding of kinship systems as symbolic relationships with different meanings.[19]

Kinship can thus not only be understood as a blood-based relation. Fictive kinship is a symbolic relationship not forged by legal family ties or blood lineage. Adoption is one example where parenthood is defined through a legal process. The non-biological and non-racial relationships in legal kinship becomes visible especially in international overseas adoption.[20] Parenthood and fictive kinship has been studied through a phenomena called *compadrazgo* in Mexico, where parenthood is considered to be shared. Manuel Carlos's and Robert Kemper's studies argue that the *compadrazgo* system is more flexible than a biological kinship and yet deeper than friendship. There are norms about how to use the fictive kinship to build social and economic alliances. Neighbours, fellow migrants, and kinsmen are common choices as *compadres*. Through a multiple structure of intensive and extensive relations, fictive kinship is built through sponsorship and mutual assistance, from patron to client and from client to patron.[21]

Kinship can also be understood as a relationship where individuals are accorded status through the level of their fellowship relations. A person with more alliances is a person with more power. People with kin are people who are enmeshed within networks through their kinship. Pedigree is a biological concept often associated with domesticated animals like horses and dogs. Pedigree charts are used to document ancestry and family trees. As problematized by Marilyn Strathern, biological facts have played a central role in the interpretation of kinship in Western societies. Kinship is thus a conceptual meeting place for nature and culture, and it has a critical role in shifts of knowledge production.[22] With the development of reproductive technology and international adoptions, traditional biological kinship, formed through nature and biological mechanisms, is challenged.[23]

Scientists who participate in academic mobility can be defined as contemporary nomads. Nomadic scientists are bound to certain spaces, like successful research groups and laboratories with state-of-the-art equipment, and, through them, to social relations and power structures. Other individuals are also bound to the nomads, such as partners and families, who, in turn, are also affected by and participate in the globalized, academic culture.[24] Nomads are dependent on a form of 'tribe culture', or in this case, a tribalized research culture. Such a culture provides for a scientific, professional identity much like a national identity.[25] Within the nomadic groups, certain norms are articulated concerning expected career paths and career priorities, providing incentives for how research is conducted. Experimental practices also affect how a group organizes its research, thus explaining a research agenda's point of departure.[26]

Transformations of communication and of the global economy have changed our conceptions of territory and its bounds. Within an international research community in which the researcher must make transitions between countries, workplaces, groups of colleagues, and modes of cooperation, the identity-making process becomes critical for enabling the individual to function autonomously on an everyday basis. The development of fictive kinships serves as a strategy.

Playing the game and settling in with kin

In an academic discourse about globalization and nomadism, migration and mobility can be described as movements of people without roots or any close relations.[27] Researchers who travel between different research sites are separated from both blood relatives and colleagues. Migrating from one university to another means a separation from former colleagues, but sometimes from family and friends, too. Among the majority of my informants, mobility is itself described as part of the academic life. A career in research therefore requires a certain willingness to migrate. This is especially important for researchers from small countries, like several of the plant scientists. However, to be able to pursue a successful career within plant science, there is an unspoken demand: if you are in plant science and want to continue to work as an academic, you need to go abroad – preferably to the USA – and work as a junior researcher. The very act of moving to another university and entering a postdoc position are critical steps, explained John, a senior plant scientist. Besides expected gains in knowledge and method, mobility as a professional activity is in itself an indication of research interest. According to John, 'It shows that you really are serious, that you are willing to work towards a career as a plant scientist.'[28]

To calculate risks is considered essential. To become a mobile scientist, to change one's university or research institute, to work in different countries, could be defined as risk-taking situations, as described by many of my informants.[29] Within many European university systems, scientists are not obliged to change universities or research institutes when going through different career steps (compared to the US academic system). It is not uncommon within the Swedish system to continue one's academic career at the same university where one completed the PhD. If you decide to work as a scientist in the academy, you need to learn to 'play the game', said Anne, a junior researcher. That is, you need to develop a strategy to know how to make the 'right decisions'. You need to show that you are willing to take the risks, to be serious with your career, and, by that, willing to participate in international mobility.

National or ethnic communities are important groups when an individual is trying to establish oneself in a new context in a foreign country. Andreas, a researcher from central Europe, went to the USA after finishing his PhD to take up a postdoc position. The transition – from a context with blood kinship, family, and friends – to an environment in another country was a hard transition. The career step, to start a postdoc position, was a necessity for him, although he was not able to bring his family with him to the USA. To be separated from his social context and native language created a situation that would potentially affect his professional life negatively. Relationships that substitute blood kinships are defined as social and cultural parachutes. For Andreas, the correlation between being socially isolated outside of work and the ability to develop as a scientist, as well as the quality of that development, was strong. It was impossible for him, he stated, to be a part of a research community if he was not able to feel socially secure through a community of countrymen.

As a comparison, Traweek analysed physicists in Big Science, and the 'extended family', which is a type of relationship that is not represented by the informant's current conception of family. The idea of 'family' undergoes a transformation due to labour migration or the formation of cultural communities. Such communities are most often based on concrete work goals or identity work based on gender and nationality. In the absence of a stable social environment among mobile academics, a sense of stability can be achieved through an extended family network, which fulfils the nomadic researcher's need for human relations.[30]

A social environment is, for most humans, central to their ability to function as individuals. To go abroad, work in a new environment, and advance to the next career step, for example by taking up a postdoc position, makes junior scientists vulnerable. They need to orient themselves among new teams, laboratory equipment, and work projects. The lack of blood kin and closer relations must be filled by new colleagues – and perhaps fellow countrymen.[31]

Creating fictive kinship through work

> You meet people in the lab on an everyday basis, and you observe their work, and *how* they work. You get to know them pretty well as both professionals and as persons.[32]

In plant science, the scientific work is organized through research groups. Compared to some disciplines within the arts and humanities, where one person singlehandedly runs a research project, including the entire data collection and all the writing up, the plant scientists work in large collaborative teams. Each group typically consists of a principal investigator (PI) who leads the group, senior co-PIs, mid-career junior scientists, postdoc researchers, PhD students, and other research assistants and staff. The work typically consists of controlling and measuring the plants, analysing proteins, running proteomic machines, analysing data, and writing up the results for publication. All members in the group have their tasks, some more specific than others. Some members, like the senior researchers, may not be practically involved in the data collection or the experiment, but instead in the data analysis and writing with the assistance of postdocs and PhD students.

The practical experience of cooperating is central: actually seeing what co-workers do, how they handle samples, and how they use machines to measure or analyse DNA and proteins. When entering a collaboration, you really need to gain knowledge of the other participants, my informants explained. This includes how they define the research question, know the specific experimental procedure, analyse the data, write a reliable lab protocol, sort out what can be published, and, finally, write a consistent and good story for publication in a high-ranking journal.

According to one of the informants, regardless of the stage of your career, you assume at least one role within the research group that involves tasks important for the project. You therefore need to rely on your co-workers. 'It is through your own everyday observations of your co-workers' skills that you are able to form an opinion on their reliability and trustworthiness', explained another informant. The postdoctoral period is a period when the junior scientist starts to be more observant of other people's skills and knowledge, how different people organize their work, and how they are able to transform data into results and, in the end, publications.

There was a strong consciousness among the informants of the importance of recruiting junior scientists with international experience. For example, at the plant science centre in Sweden, the junior scientists were a part of a conscious growth programme for the centre, both in terms of extending its network and achieving research excellence. The postdoctoral period involves not only the cultivation of new skills but also learning about other co-workers' expertise within the research field. For my informants, their relationship to the lab, during both the PhD and postdoc periods, was important. In my informants' cases, there are several examples of people being recruited back to Sweden after their international postdocs abroad. As senior research leaders pointed out at my field site, this was a conscious, managerial strategy of the very head of the entire research centre.

New networks may continue to be built over a period of 20 to 30 years or more. A senior lab leader is a key figure for researchers during their postdoc periods. Afterwards, however, new postdocs and others in the same career cohort become co-workers, labouring in parallel for many years. They will be generational colleagues and the participants of scientific conversations for decades.

Building fictive kinship: Extending the scientific family

Aside from international mobility reasons, building close relationships is also significant for junior researchers' future development into senior researchers with the ability to develop research collaborations. Because PhD students also work closely with their supervisors, analogous to the children of families they are nurtured and raised within their academic disciplines, socialized into values, and introduced into their supervisors' networks. As shown by Anna Peixoto, the supervisors are considered to be crucial to the PhD students' own network and potential career trajectory consisting of a postdoc and faculty position.[33] But also, the senior researchers are dependent on the PhD students who are conducting a large part of the practical work in the laboratory.

Building a network starts at the PhD level, the informants generally said. They held that it is important to start going to conferences at an early stage. For the junior researcher, the supervisor becomes the key person through whom to develop and expand a research network and form contacts for future professional relations. One informant elaborated on the role of conferences in this process:

> Going to conferences is very important. You're meeting a lot of people central to your research and you'll be able to network. It is really important! And it might affect your possibility to develop further contacts and then, perhaps, also job opportunities, postdocs and other things.[34]

A common theme among my informants is the importance of exposing oneself as a PhD student, that is, both by soliciting from external audiences critical questions about one's research and by sharing research results. Doing this can be defined as a profound task, something that is a part of being a PhD student. But as my informants emphasized, at conferences, they also build their contacts, many of which are introduced through their supervisors.

When discussing the criticalness of networking, the informants also mentioned 'the failed postdoc', where a researcher might have been at a lab that was not very productive, but also failed to manage maintaining good relationships with his or her lab group, fellow postdocs, and senior lab members. As a postdoc, stated one of my informants, you enter a new domain with knowledge and skills, but also people. You need to get yourself established within the group and show the others what you have to offer.

A long-term goal that many postdocs are not aware of, said one of my informants, is the need to build research relations within one's generation, and continues: 'You yourself belong to a generation, or an age group'. There are senior researchers who are extremely important in the current research field; however, the researchers of one's own age group are more important to connect to, to start to form collaborations with, and to plan future research with. 'It is so easy to just see the senior researchers who are in the limelight', said one informant, that you would rather miss the crucial point of finding the interesting and rising academics in your own age, the future colleagues that will be around for another 30 to 40 years in the profession. With those, you can form sustainable relations built on a kin relation, which demands trust and scientific virtue.

Trust among fictive kin in cooperative research

Cooperation, specifically within international research, is a question of trust, said one of my senior informants. 'You just can't start a cooperation without that trust. The trust is gained during the shared time in the laboratory'. After defending her thesis in Sweden, Kim went to a lab in the USA. While there, she established a good relationship with the other postdocs, professionally and socially. After returning to Sweden, she maintained contact with her former co-postdoc fellows and started to cooperate, both when it came to sharing data and exchanging postgraduate students between labs.

Kim described a situation where she and her Canadian colleague ran parallel experiments and started to compare and share data to carry out a larger set of similar experiments, following the same lab protocol. The matter of trust not only is limited to the single senior scientist but it also involves the co-workers in that group leader's lab. A collaborator needs to be in control of every step in the experimental process. If you are able to share data from another lab, she explained, you need great confidence in that person's experimental practice, given that you lack the opportunity to conduct the collaborator's original, controlled experiment yourself. Even so, it is possible to replicate the experiments – a necessary but time-consuming task. It is therefore important to have close knowledge about the collaborators' test conditions, for example, and, thereby, knowledge on what actually can and cannot be tested and controlled.

Kim described a situation in which her trust was extremely central. Kim's partner, a PI at a lab in Canada, had a PhD student working with an experimental setting, taking raw data to be analysed and processed. The data looked very interesting, promising to be an important basis for a series of publications. However, when Kim wanted access to the raw data to go over the analysis, the PhD student refused to share it with Kim and her group in Sweden. Kim was therefore unable to control the experimental setting herself, and she had to rely on her Canadian colleague, who had been supervising the PhD student in the experiment and therefore was very likely to have a deep insight into how the data had been collected. Moreover, Kim and the Canadian colleague had developed an exchange system, with master's students and PhD students visiting in each other's lab. The Canadian PhD student came to visit the lab in Sweden. Kim could then watch the student conduct experiments, observe the lab skills, and discuss the design of the experiments and interpretation of the data.

Having insights from the visit and everyday experience of interacting with the visiting PhD student, Kim concluded that the collected data were reliable. From a scientific point of view, the data seemed to be correct, and she detected no flaws in the experimental setting. From a social perspective, Kim considered the PhD student as not yet socialized into the system of lab groups, in which members have the right to access and share data – a kind of act of intimacy.

As Karin Knorr-Cetina pointed out, there are different conditions and epistemic cultures for scientists in small-scale life sciences in contrast to scientists in Big Science disciplines like particle physics.[35] The situation Kim described in the case mentioned is a part of daily work when cooperating with colleagues at other universities and especially overseas. The entire setting, consisting of labs with their experimental benches and research groups, is infused with confidence and trust.

For those researchers who are trying to acquire seniority, these relations become important. The research group becomes the core environment in which they are dependent on close work relationships. The dependency of PhD students in the sciences on their supervisors and lab leaders can be represented by the kinship metaphor. As Catherine Hasse and Stine Trentemøller showed in a study of physicists, there are senior lab leaders who promote the development of a strong caretaker culture, in which the leader cultivates and maintains the group's overall effectiveness as well as that of individuals within the group. Scientists' loyalty is to the group, not the individual.[36]

The fictive kin as a substitute for the biological

> Work becomes so central to you. I have my work. And my pets. Why do people always ask questions about a 'real family?' and having kids? ... And, no, my husband never receives that type of question![37]

Academic workplaces are typically not domestic realms, but there are indeed situations in which they resemble them, as fictive kinships resemble biological ones. There are close bonds between the lab members and the foreign labs with which they are cooperating, constituting a fictive kinship. Their relations can replace blood kin relations and serve as the very kin system within which scientists associate and interact.

The image of the lonely genius in the lab is still a strongly gendered ideal.[38] As one informant opined, if you are a woman, to be fully engaged in and devoted to science, you still get considered with suspicion. As the epigraph for this chapter indicates, there are assumptions that take for granted a relationship between an acceptable level of dedication to work and the scientist's gender. Several of my informants gave voice to the fact that the overriding assumption is that being a devoted researcher remains a masculine role. The informants did not embrace a romantic idea is of science as a vocation, but they were critical of the assumption that only men can practise and distinguish themselves through the strong social bonds that accompany scientific work.

'Yes, I have been thinking of it, family. But no. I have not had the time', said one of the senior female informants. 'Perhaps I could adopt a child, but ....' For her, the scientific relations have always been more central than forming family relations. As shown in this chapter, both countrymen and colleagues can take the place of kin, and the formation of close relationships between individual researchers and their groups are considered central to forming a professional life. Still, it is controversial for women to choose against having children. The ideal of the male scientist, sacrificing one's private life in devotion to science, as my female informants pointed out, is not unproblematic in contemporary research culture, but it is less provocative than a women's pursuit of that ideal.

Kinship through scientific practice: Concluding remarks

This chapter aimed to analyse fictive kinship in research cooperation and scientific careers among scientists, with a focus on how junior scientists understand the importance of scientific networking and forming scientific collaborations, acts of the fictive kinship process. The junior scientists must learn and gain new scientific skills and achievements. They also form strong relationships with peers and fellow lab members, especially those who are at similar career stages. Gained scientific skills and an extended scientific family are central resources for the junior scientist's career development.

Kinship in this context is a 'mutuality of being' relationship, as described by Sahlins. It is locally constituted within the laboratory, but it is also an interpersonal relationship, based on consanguinity or other affinity. The creation of fictive kinships provides one critical strategy for individuals to function effectively when transitioning from one international research context to another. Researchers who travel between different sites are often separated from both blood relatives and colleagues. Mobility is itself understood to be part of the academic life. A career in research therefore requires a certain willingness to migrate.

The postdoc period is both professional and social. It is important that a postdoc establishes good relationships with other postdocs, especially those within one's own generation, not only professionally but also socially. By carrying out experimental work alongside each other in the lab, researchers learn about each other's skills and knowledge, and this familiarity becomes a foundation for research cooperation. International research cooperation is a question of trust with regard to sharing data and laboratory methods. Trust is based not only on scientific measures, but also on social relations, such as a kinship-like propinquity.

Fictive kinship as an analytical concept can be used to understand structuring factors within the academy, beside economy, systems of meritocracy, and formal organizational principles. With a fictive kinship analysis, we can further analyse how informal relations shape and maintain cooperation, hiring processes, and power relations at the individual as well as group level. This becomes even more central at a time when international research cooperation and academic mobility is put forth as a basis for knowledge production.

Notes

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12

Vasudhaiva Kutumbakam: Family in the Knowledge Economy

Aalok Khandekar

Introduction

Scholarship on migration and transnationalism has documented the central place of familial ties and kinship networks in enabling transnational migration and ethnic enclave-based economies.[1] Even migrations of the highly skilled, as AnnaLee Saxenian demonstrates, build on and bolster ethnic, regional, and national ties. A dominant framework for understanding transnational migrations of the highly skilled, and the social and cultural transformations that these entail, has been that of the 'knowledge economy': a set of interrelationships between knowledge, experts, and mobility under contemporary capitalist configurations.[2] The knowledge economy, Aihwa Ong argues, must necessarily be understood as a 'new ecology of belonging' in which the very bases of social citizenship are rearticulated, such that intellectual capital and technomanagerial skills increasingly replace political and ethnic loyalty as its key attributes.[3] Against this backdrop, I ask, what is the everyday experience of such profound sociocultural shifts? What kinds of anxieties and disruptions do they provoke? How are they organized and managed in everyday life? And, most directly relevant to the themes of this volume, how does the family, a fundamental organizing unit of modern societies, shape these transnational mobilities? In what ways do the contours of the family shift in the process?

Answers to these questions are many and change alongside the specificities of the groups and politico-legal milieus under consideration. Here, I focus on one set of answers drawing on my ethnographic research conducted between 2007 and 2010 among Indian technomigrants to the United States, comprised of engineering students and professionals migrating for higher education and employment. In my research, I conducted in-depth interviews with Indian technomigrants both in India and the USA, as well as a wide range of participant observations at various events involving Indian diasporic communities. The research also draws on a range of documentary sources, including graduate-school application essays and biographical narratives authored by Indian technomigrants, that provide windows into their lived experiences and the strategies through which they navigate the demands of the knowledge economy. In this chapter, I foreground a paraphrased version of an autobiographical essay by an Indian technomigrant, Abhay Patil. I also draw on data collected through participant observation, ethnographic interviews, and primary and secondary documents to supplement my analysis of Patil's autobiographical essay.

My argument is twofold. First, a discourse of Indian family and family values is key to enabling and managing the anxieties and disruptions that migrant life in the knowledge economy engenders. Second, then, contrary to Ong's argument that ethnic loyalties are replaced by entrepreneurial and technomanagerial modes of citizenship, I demonstrate here that a heightened sense of ethnic belonging, mediated through a discourse of family values, is crucially important in enabling the transnational mobilities that are at the core of the knowledge economy. In this respect, my argument parallels Biao Xiang's work on 'body-shopping' in the international information technology (IT) sector, whereby he identifies ethnicization as central to the functioning of the system of flexibilized labour management in that sector.[4] However, unlike Xiang, ethnicization in the present case of Indian technomigration is not so much a strategy of immediate survival under precarious labour regimes. Instead, mediated by a discourse of family values, ethnicization here occurs primarily as a means to articulate notions of cosmopolitan selfhood and belonging among an otherwise professional, successful social group.

My argument is structured as follows. In the next section, I present key analytical constructs; in particular, drawing on Aihwa Ong's work, I further explicate the idea of the 'knowledge economy'. Then, drawing on South Asianist scholarship, I develop the idea of 'global Indianness', and the place of the family therein, in order to explain how new notions of belonging are articulated among Indian technomigrants as a response to their increased transnational mobilities. Next, I present ethnographic material that draws out the salience of the construct of the family in technomigrant narratives. Finally, in conclusion, I return to my core argument about the centrality of the discourse of Indian family and family values in enabling and managing the high degree of transnational mobility that characterizes the lives of contemporary Indian technomigrants. It is my contention throughout that new notions of a global Indianness are articulated in order for Indian technomigrants to be able to participate in the knowledge economy; these rearticulations occur from within a discursive space that is parameterized by notions of the Indian family and Indian family values.

Knowledge economy, global Indianness, and the transnational Indian family

The knowledge economy

Following Aihwa Ong, I understand the 'knowledge economy' as a certain 'ecology of expertise': a 'deliberate orchestration of technical flows and interactions between global and local institutions, actors, and values' that establishes 'new forms of linkages, exchanges, and feedback loops . . . between the distribution of knowledge flows[,] . . . technical resources, and techniques of management'.[5] For Ong, the knowledge economy is a particular instantiation of late capitalism that is definitively characterized by certain deliberately managed relationships between experts, knowledge, and (often transnational) mobility. Mobile knowledge, multinational corporations, and educational and research institutions are brought into alignment through premeditated governmental calculations in the name of regional and national economic growth – as evidenced by the creation of special economic zones (SEZs), relaxed immigration requirements, and selective tax breaks, for example. Moreover, it is usually, though not exclusively, technoscientific expertise that is at stake in discussions involving the knowledge economy, as it is the high-technology sectors, such as those generated through bio-info-nano-technologies, that are often considered to be key to sustaining national competitiveness in contemporary configurations of global capitalism.

However, this new ecology of expertise, argues Ong, is necessarily also a 'new ecology of belonging'. If the knowledge economy works through deliberate governmental interventions, the effectiveness of such actions depends on their ability to engender a shift whereby 'expertise and entrepreneurial values . . . replac[e] ethnicity and political loyalty' as the key terms of social citizenship. In other words, the knowledge economy functions by instituting 'new regimes of moral worthiness' which champion 'intellectual capital and risk-taking behaviour' as its quintessential virtues.[6] Thus, on the one hand, the knowledge economy is articulated as a novel set of interrelationships between various institutional actors. At the same time, such institutional reconfigurations are effective only insofar as they are accompanied by shifting subject positions that rearticulate the very bases of belonging and social citizenship. The knowledge economy thus signifies nothing short of a transformation of some of the most basic categories of contemporary social life such as selfhood, belonging, and community.

For Indian technomigrants, such reformulations of personhood and life-worlds take form by reworking already existing notions of Indianness. As I outline below, contemporary articulations of identity among transnationally mobile Indian professionals can be understood through the notion of 'global Indianness': the idea of maintaining an essential Indian core even as these technomigrants continue being ever more globally dispersed. The construct of the 'family', as the locus of this essential Indianness, is at the crux of emergent articulations of global Indianness. The idea of global Indianness, as I demonstrate, itself figures as the continuation of ongoing historical processes set into motion as part of the cultural politics of the 'new middle class' that was constituted during the colonial period.[7] Thus, following Ong, I demonstrate in this chapter the new notions of belonging that the knowledge economy engenders; however, in contrast to Ong, I also argue that these new notions of belonging continue rather than undermine historically salient notions of kinship and ethnicity, mediated through a discourse of familial belonging.

A few caveats are in order before proceeding further. First, the notion of the middle class at play here is less a sociologically accurate descriptor and more a discursive and performative category. Indeed, given its staggering diversity, both in socioeconomic and cultural terms, several commentators have noted the futility of any attempts to measure the actual size of this social group (estimates range anywhere from 30 million to 300 million).[8] The (new) middle class, as a discursive construct – a 'marker of identification, aspiration and critique in contemporary Indian public culture' – then, is interesting precisely because of the vast heterogeneity that it is able to effectively manage and represent.[9] Second, as the following section will demonstrate, the middle class in question here is fundamentally transnational in nature. Recent South Asianist scholarship has noted that the density of interconnections between the middle class in India and the Indian diasporic community at large renders a rigid distinction between the two analytically inadequate.[10] Lastly, the technomigrants that are my research subjects can be squarely located within this discourse of the middle class. Like the larger category of the middle class, there is significant diversity – in terms of socioeconomic and linguistic backgrounds, for example – among these migrant professionals, too. However, a historic investment in technoscience-related professions in India's pursuit of modernity and an ongoing emphasis on professions such as those related to IT imply that these Indian technomigrants have come to exemplify the very promise of modernity, middle-class lifestyles and respectability that captivate the popular imagination.[11]

Global Indianness and the Indian family

Global Indianness is a notion that is fundamentally structured by an essentialized binary opposition between a spiritual India and a materialist West; it serves to manage and render compatible the differences between these binaries. In this 'auto-orientalist' scheme of thinking, 'India' figures as a land of spiritual and moral richness, but one that is equally characterized by material lack and disorderliness: poor, dirty, and lagging behind in scientific and technological progress.[12] The 'West' (especially the USA), on the other hand, figures as a 'land of opportunity': technologically advanced and materially affluent, but nonetheless characterized by excessive hedonism that indexes a certain moral and spiritual bankruptcy. The discourse of global Indianness bridges such wide chasms between these oppositional categories, primarily by defining the moral limits to westernized habits and lifestyles: individualist, but circumscribed by family values, consumerist, but in ways that can be readily coded as being Indian and which, above all, remains strongly underpinned by an Indian spiritual character. Global Indianness, in other words, articulates ways of being 'appropriately Indian', particularly at a moment when an ever greater number of Indians are inserting themselves into transnational circuits of professional mobility, and consequently, in ever closer proximity to that which is foundationally 'other'.[13]

These essentialized conceptions of both India and the West result from historical processes in which the colonial Indian middle class sought to articulate its difference from its colonial rulers.[14] It did so by imagining the colonial space as being divided into an 'outer' material domain consisting of entities such as science and technology, statecraft and economy, and an 'inner' spiritual domain that included such cultural entities as language, theatre, literature, and the family. In the outer domain, the supremacy of the West was well established and to be emulated in India's pursuit of modernity. In the inner domain, however, it was India that was all-important; the incursion of Western logics into this sacred domain of essential Indian culture was to be prevented at all costs. Indianness in the space of this middle class was achieved through 'cultural normalization': the process of articulating an Indian identity that was, in its essence, fundamentally different from a Western identity even while it embraced modern Western Enlightenment ideals towards India's development and progress. The task at hand was to articulate a definitively non-Western – or a uniquely Indian – modernity.[15]

Economic slowdown in the 1960s precipitated a wave of professional emigration from India to Western countries, the USA in particular.[16] A second wave of professional emigration from India to the USA was then jumpstarted by the impending Y2K crisis of the 1990s, which generated a sudden demand for vast amounts of IT-related labour – a niche that came to be dominated by Indian software professionals.[17] Transnationalization also took the form of global brands and consumer goods arriving in India: the liberalization of the erstwhile socialist economy, starting in the 1980s, definitively inaugurated an era of consumer-citizenship such that 'aspirational consumption' situated 'betwixt and between' globalization and localization, and modernity and tradition, became the hallmark of Indian middle-class identification.[18] The Indian middle class came to be vastly transnationalized in the process, forcing a further rearticulation of dominant constructions of Indianness.

The impulse for such redefinition came from at least two distinct directions: one from the historically specific internal logics constitutive of the Indian middle class, the other from the context of the Western societies in which the middle class was inserting itself. In the first instance, being powerfully and ubiquitously confronted with Western modes of social organization – either through transnational migration or through the circulation of globally inflected images of commodity consumption and lifestyles at home – reflexively put to question established modes of Indian sociality.[19] On the other hand, however, belonging within the prevailing racial hierarchies in the West was no straightforward exercise to begin with. Vijay Prashad, for example, argues that the diasporic community of professional Indian immigrants in the USA often positions itself at an intermediate location between the extremes of white privilege and black marginality in a twofold manner: it is at once a community that contributes substantially to economic growth while otherwise operating at a social and cultural remove from mainstream society.[20] The emergent diasporic community, thus, integrates fully into the labour market, but remains socially isolated, such that an Indian cultural–national identification continues to be the most salient form of belonging available to the community.[21] What results, consequently, is a strongly interconnected transnational class that remains deeply anchored to its Indian roots irrespective of its global dispersion.

It is at the nexus of these conditions that the notion of global Indianness emerges as a contemporary rearticulation of established notions of Indianness: Indian, but globally so. It corresponds to the fundamentally altered circumstances of Indian middle-class life: globally dispersed yet deeply connected to the Indian nation, inflected by consumerist logics, yet concerned with articulating them within dominant conceptions of Indianness.[22]

The transnational Indian family

Such rearticulations of essential Indianness are centrally enacted within the space of the family. Identified as central to 'Indian tradition', and therefore the nation, the family, Partha Chatterjee argues, has historically been a site where the 'assertion of [Indian] autonomy and difference [from the West]' has been the most dramatic.[23] A key element of claiming such difference, for example, has been through the construct of the 'joint family'. Coded as a distinctly Indian kinship system, the joint family refers to social arrangements whereby multigenerational households consisting of fathers, sons, and their wives and children continue to co-habit the ancestral home, with routine domestic activities such as caring, cooking, and cleaning often being organized at the level of the household. While the actual nature and scope of social relations encompassed under the rubric of the joint family varies, and its lived experiences strongly temper any claims to its efficacy, the narrative of the joint family is nonetheless frequently invoked as definitive proof of a stronger communitarian orientation of Indian social life, and, in such intimate and personal arrangements of caring, also of the moral superiority of a spiritual Indian culture over that of the materialist West.

The onset of modernity, with its individualizing impulse, and its associated geo-spatial dispersion, then, fundamentally challenges this mode of social organization, precipitating, in turn, very basic anxieties over the loss of authentic Indianness.[24] Importantly, in the context of the present volume, it is in the space of the family – in practices of child-bearing and child-rearing, marriage, and caring for the elderly, for example – that apprehensions over the loss of an authentic Indian selfhood, through the potential breakdown of established socialities, most readily manifest themselves; or, as Lawrence Cohen so persuasively argues, challenges to Indianness are first and foremost experienced in the 'familial body'.[25] Such anxieties continue in the circuits of Indian professional migration where prevailing modes of Indian family living are challenged even more severely, given the transnational dispersions involved. Smitha Radhakrishnan's ethnography, for example, documents the strong emphasis that Indian women in IT (based in India, South Africa, and the USA) place on finding the right 'balance' and establishing 'good families' even as they pursue professional lives.[26] And yet, as a newer generation of Indians comes of age, some of these concerns are becoming less pronounced: in part, due to a greater degree of autonomy claimed by Indian seniors, and in part due to a sense of pride in professional achievements globally, which offsets some of those anxieties.[27]

Familial anxieties among Indian technomigrants

Abhay is in his late 40s, currently residing in Pune, India, with his wife and two children.[28] He is an IT professional who went to the United States in the early 1990s and returned to India in 2001. While in the USA, he lived in the San Francisco Bay Area of California where he was an active participant and organizer in the Indian community. Since returning to India, he has continued working in the IT sector, and he also actively engages in theatrical performance and Right to Information activism.

When he first left for the USA in 1993, Abhay says that there was a clear distinction between an Indian life and a Western life in his mind. He aspired to a good job, an even better salary, and an opportunity to live in the most advanced country in the world. But he never wanted to settle in the USA permanently, since he had always viewed people doing that as being traitors to India. But his time in the USA has changed all of that – the reasons for returning to India when he first left the country are very different than from those when he actually returned. He has come to view citizenship of any particular country only as a matter of detail; what is far more important for him are the values one subscribes to, and the ways in which one acts on them. While he initially felt that, no matter what, he was always going to be an outsider in the USA, he has now come to understand that the USA is, at its very core, a country of outsiders (immigrants).

What really propelled Abhay to return to India was what he thinks of as a culture of instant gratification and excessive hedonism in the USA. He was really shaken to his core when, at the peak of the dot-com years, his eight-year-old son asked him, ‘Dad, what is your “net worth”?’ Abhay is very critical of the moral/spiritual bankruptcy that he feels characterizes US culture, and the imperialism that the USA demonstrates on the world stage.

In spite of this, he has had many good experiences of the USA at an interpersonal level. He appreciates the sense of financial security that he could experience there, and the liberal and secular ethos which pervades American society, which he attributes to the US educational system. He has also made many close friendships; even though he was born in Sangli, and grew up in Mumbai, when someone asks him where he is from, the ‘Bay Area’ is his instinctive response. While acknowledging racist tendencies among Indians living in the USA (the use of racial slurs for individuals of various ethnicities is common among many Indians), he feels very heartened when second-generation Indian kids seek to overcome these.

And yet, in spite of all of this, partly propelled by a mid-life crisis, and partly because he started experiencing life in the USA as routine and scripted (a repetitive pattern of domestic life, office life, weekend trips, soccer matches, hanging out at friends’ houses), he found himself longing to return to India. Since his wife shared his feelings, they slowly wrapped up their lives in the USA and about a year-and-a-half later, they relocated to Pune, India.

Coming back, the extreme poverty, uncleanliness, and corruption that he encounters on a daily basis trouble Abhay. But more than poverty itself, it is the desensitization of the more privileged classes to such poverty that bothers him. Having lived away from it for a long time, Abhay is no longer capable of blocking out these elements in his surroundings; he thinks of this as a certain ‘loss of innocence’ for himself. He realizes that this is why many individuals who come back to India decide to go away once again, but feels that he wants to stay put and hopefully effect a positive change. With this in mind, he has begun to live by the motto, ‘think globally, act locally’, in his various professional, artistic, and societal endeavours.

A number of Indians have started returning to their nests. Abhay is hopeful that these individuals will be able leverage their professional successes responsibly. These individuals, who have had a chance to add a global dimension to their thinking, and have subsequently returned to India, are the ‘born again citizens of India’. Transcending narrow conceptions of citizenship, their ambitions are to fulfil a global citizenship. Indeed, these are individuals who are practising *Vasudhaiva Kutumbakam* (‘the world is one family’).

Biographical narratives like those of Abhay are frequently witnessed in the transnational circuits of Indian technomigration, and they index some of the most pervasive anxieties provoked by transnational mobility among these highly skilled migrants. The standard narrative goes something like this: an Indian IT professional, or engineer, travelling abroad (the USA being a predominant destination in recent years) seeks higher education and good career opportunities. Professional success comes to him (relatively) easily. Professional ascendancy is then accompanied by family life in the suburbs, itself often embedded in an extended Indian community. Even so, while achieving financial wellbeing in this altered ecology of expertise is relatively straightforward, figuring out what belonging here means is often less so. Inhabiting contexts that are culturally unfamiliar, in spite of establishing and embedding oneself in social formations that are culturally more immediate and recognizable, inevitably entails renegotiating habitual modes of sociality.

One set of negotiations entails working out perceived tensions between Indian and Western ways of life in everyday practice. Here, perceptions of Western societies as closed households and overly regimented lifestyles are often contrasted with perceptions of more informal modes of Indian hospitality. Abhay's experience of the routine and scripted nature of American suburban existence is one expression of this sensibility. American life, for many technomigrants, is too rigidly structured, driven by an 'appointment culture', which leaves very little room for informal, spontaneous interaction. In contrast to their interactions with their American acquaintances, technomigrants' interactions among their Indian peers are considered to be much more flexible: informal norms of Indian hospitality are said to be such that visiting their Indian peers without prior notice, for instance, does not constitute a social discourtesy.[29]

A different manifestation of the negotiation of the contradictory pulls of Indianness and Westernness in everyday life is the establishment of exclusively Indian student communities around many American university campuses. Srinivas, an Indian graduate student in Mechanical Engineering in Northeastern USA, explains that, in his experience, most Indian graduate students in American universities tend to live together as part of a larger Indian graduate student community. Thus, Indian students share apartments and rooms with each other, in larger apartment complexes which, in turn, are home to many more Indian students. According to Srinivas, in large part, this is because practical arrangements of everyday living are more difficult to negotiate with his

American peers than his Indian ones. Room-sharing, for instance, is a common practice among many Indian students, both as a strategy for saving on rent, given the high level of disparity in the valuation of the Indian rupee and the American dollar, and as a practice to which many are already habituated, given that it is common to ways in which Indian domestic spaces are organized.

However, such arrangements, Srinivas explains, would be nearly impossible to realize with his American peers, given widely disparate understandings of the social norms of personal space and privacy. Srinivas further cites practices such as closed doors within apartments to demarcate private spaces within shared apartments: a practice that he identifies as characteristic of Western modes of living, but alienating for himself given his habituation to more communitarian lifestyles. Diet is another site of such a tension: for example, according to Srinivas, strong smells from Indian kitchens, heavy in their use of spices, do not pose any difficulty when cohabiting with other Indians; they do, however, frequently become a problem with those not accustomed to Indian kitchens. Moreover, dietary taboos, such as the consumption of meat – beef in particular, given that it is proscribed by Hindu custom – also render the negotiation of everyday modes of living as potentially contentious: perceived differences between Indian and American lifestyles that are not necessarily irresolvable, but ones that can be simply sidestepped by living in exclusively Indian communities. Such coding of the domestic space as distinctively Indian exemplifies Partha Chatterjee's distinction between the inner and outer domains of the cultural space as well as the everyday practices through which the boundaries between the these two spheres of activity continue to be reified.

Over the past decades, the family has also emerged as a central locus of financial investment among Indian technomigrants. Alongside increased outmigration, the World Bank reports that India is now among the largest receiver of remittances in the world.[30] Significantly, over 50 per cent of these remittances are deposited in savings accounts at the domestic level, and not in government-sponsored investment projects.[31] This mode of investment, in part, results from a deep-seated distrust among many Indian technomigrants towards the Indian state, while at the same time also a strong commitment to their families and the betterment and the prosperity of the Indian nation.[32] Property investments are a second major avenue of financial investments. Many of my interlocutors in the USA, for example, actively invested in apartments and houses in their hometowns in India. Their logic was twofold: first, the property market in India is considered to be a booming sector whereby the monetary value of their investments is expected to increase significantly. Second, investing in their hometowns often meant that their parents or siblings could serve as their local proxies and could maintain and manage their properties while they continued to live elsewhere.

A different index of the distinctiveness of Indian ways of life that sits uneasily with Western socialities is the continued idealization of joint family living among Indian technomigrants. While, traditionally, joint family households referred to kinship arrangements where extended families shared the familial house, contemporary articulations of joint families often refer to multigenerational households usually restricted to immediate families comprising of sons and daughters, grandchildren, and grandparents. Consider, for example, Rohit Joshi's narration of technomigration.

Like Abhay, Rohit also chose to relocate to India after residing in the USA for several years. Rohit is an Indian Institute of Technology (IIT) trained chemical engineer who has lived in the USA for a long time.[33] After enjoying a very successful career in the USA, he decided to relocate to his birth-city of Pune. Rohit says that he was always keen on going back to India, but both he and his wife had to think through this decision carefully. He had to choose between returning to the motherland and being a small-scale entrepreneur or staying on in the USA and ascending the rungs of upper managerial positions in the corporate world. But he was also always aware of the younger Indian generation coming of age in the USA. Their schools, their system of higher education, their thoughts about India, American family life, tensions that arose between the younger generation and their parents, early expressions of sexuality with the onset of adolescence, girls' quests to look attractive from a very young age – all of these made Rohit anxious over raising his two girls in the USA. He found the prospect of bringing up his girls there to be potentially risky and stressful. In comparison, both he and his wife agreed that their girls would transition into adulthood more smoothly in India. While their residence in Irvine in Southern California was beautiful, they started thinking that their girls would not understand the real world by staying there. Their girls would grow up more 'naturally' by living in the shadow of their motherland and experiencing the joy of living among family, regular exchanges with relations, and the love of their grandparents. With this in mind, they decided to relocate to India, but left the doors open for returning back to the USA.

In addition to reiterating perceived tensions between Indian and Western modes of living, Rohit's narrative also hints at the gendering of the domestic space and the discourse of global Indianness more generally. The prospect of bringing up his girls in American society, structured through very different dynamics of gender and sexuality, becomes Rohit's key concern and what eventually impels him back to India. These concerns are themselves also grounded in a larger history of Indian anti-colonial nationalism, which, Chatterjee argues, centrally vested the 'Indian woman' with particular attributes of cultural purity and authenticity.[34] In negotiating the boundaries and tensions between the inner, spiritual, and feminine Indian essence and the outer, masculine domains of political institutions and statecraft, the Indian woman came to be the keeper of Indian cultural values against the corruptions of Western modernity that Indian men were more susceptible to, given that they were the ones who, for the most part, operated in those outer materialist domains. Thus, articulating modern nationhood demanded that the Indian woman be modern in her ways, but not *too* modern. It was ultimately her clothing and her mannerisms that had to enact the right balance between tradition and modernity. Rohit's anxiety over raising his girls amidst American cultural values, then, can be interpreted as a contemporary manifestation of that historical process. Such negotiations continue in other domains of Indian social life as well: Indian women, for instance, are continually tasked with finding the right 'balance' between participating in the professional workforce while also being the primary keepers of the domestic space.[35]

A still different kind of anxiety voiced by technomigrants relates to caring for ageing parents. Take Sneha's case, for example. Sneha, in her late 20s, is a former graduate of the IIT who was obtaining her doctorate in chemical engineering at a well-known institution in northeastern USA at the time of this research. Both Sneha and her older sister had migrated to the USA in the recent past. Sneha's sister, who had by now started a family of her own, had decided to emigrate permanently to the USA. For Sneha, this posed a dilemma: on the one hand, she was keen on pursuing a research-oriented career. To this end, she thought that being in the USA presented better and more numerous opportunities than she would encounter in India. On the other hand, she also reported feelings of obligation towards caring for her elderly parents who were still in India. Such feelings of filial responsibility are shared by my interlocutors more generally, and are consistent with the South Asianist literature on kinship and ageing whereby caring for parents and elderly relations has traditionally been the responsibility of sons (and sometimes, daughters), and consequently organized within the familial space.[36] Indeed, until recently, there existed little by way of formalized infrastructures for ageing, such as quality managed care facilities. Moreover, the cultural context is one in which the very idea of formal institutionalized care outside of the familial space is frequently associated with both personal and moral failures of children in fulfilling their responsibilities to adequately care for their parents.[37] Caring for parents poses a particularly challenging dilemma: legal regimes make it difficult (though not impossible) for children to bring their parents to the USA in any straightforward and permanent fashion. Moreover, parents themselves are often quite reluctant to relocate to the USA at an old age, given that rehabituating to a very different way of life is deemed all the more challenging for them. Being a migrant and caring for parents thus poses a cultural paradox: anxieties over caring are hence among the most visible of dilemmas in circuits of Indian technomigration.

The continued salience of the practice of 'arranged marriages' represents yet another way in which the family and the notion of Indianness remain deeply intertwined. Arranged marriages (as opposed to 'love marriages') represent a traditional system of organizing marriages among Indians, whereby matrimonial relations between the bride and the groom are facilitated by their respective families. Such arrangements are often formalized between the respective families (rather than the individuals), who frequently have similar linguistic, caste, and class backgrounds. While the nature of such arranged marriages has shifted considerably from its traditional instantiations, the practice, nonetheless, continues to be very salient among Indian technomigrants.[38] Indeed, matrimonial websites that cater exclusively to an Indian clientele are nowadays extremely popular among technomigrants, as also among urban middle-class Indians more generally.[39] Individual profiles on these websites are ordered through indigenous parameters such as language and caste, background information about education and employment, information about the respective families, and, more recently, immigration statuses of the individuals involved. My interlocutors cite an array of reasons for the continued salience of 'arranged marriages' among technomigrants – including the differences between Indian and Western ways of organizing romantic relationships, the differences between Indian and American lifestyles more generally, the difficulty of cross-cultural negotiations involved otherwise, and, sometimes, just the proclivity to stay within established cultural boundaries. As one interlocutor put it, 'Why would I go out of my way to upset my parents?'

Anxieties about family life and about staying true to cultural traditions thus feature prominently in the transnational circuits of Indian technomigration. These take shape both in very mundane activities, such as the organization of the domestic space, as well as through ethical reflections on appropriate personhood – visible especially in key moments of social transition such as child-bearing and child-rearing, an impending marriage, and caring for the elderly – in the face of profoundly altered conditions of living, for which no templates are readily available. Under these circumstances, Indian technomigrants draw on culturally available ways of thinking while also rearticulating them in the altered contexts of global living that they now inhabit. Global Indianness affords them the discursive space from within which they can make sense of these new conditions of being.

Conclusion

In circuits of Indian technomigration, professional success is often assumed to be an assured end. Transnational mobility provokes anxieties not so much over education and employment; rather, anxieties over selfhood and notions of community are those most readily foregrounded among these highly skilled migrants. These concerns are articulated in the idiom of family. Dilemmas over migration such as where to live and work, how to invest, whom to marry, and how to care for family – themselves contemporary manifestations of longer historical processes – are fundamentally decisions about the nature of family life, and, as such, are resolved within the familial space.

In Abhay's case, for example, the decisive moment takes the form of the realization of his children having internalized an apparently Western materialist logic of evaluating even the most immediate of their social relations: the monetary value of their father in terms of his 'net worth'. Others, as in the case of Rohit, are concerned with the divergent norms of gender and sexuality that are said to characterize Indian and Western cultures. Such internationalizations pose an utmost challenge: they imply the incursion of Western individualist logics – often tolerated and sometimes even celebrated in public life – into the sacred realm of the private. The materialist logics of the West threaten to displace the spiritual moorings of India by reordering the private sphere of the family, a key site in which belonging to the Indian nation is conceived of and enacted. Different individuals resolve the ensuing dilemmas differently: some embed themselves even more firmly within local cultural formations, others reject prevailing ideals of community altogether, and still others, such as Abhay, relocate to India, where they seemingly belong in a much more straightforward manner. Of course,

Table 12.1 Binaries of global Indianness

India	'New' India Characterized by Economic Liberalization	United States
Highly Skilled Workers	'Model Minority'	Immigrants as Other
Indian	Global Indian	Western
Poverty	Consuming in an Indian Way	Material Affluence
Informal, Open Hospitality	Reconstituted Indian Communities	Closed Household
Spiritual/Moral	Indian Spiritualism as the Basis of Material Accumulation	Material
Collective/Cultural	Individualism Circumscribed by Family	Individual

as Abhay himself suggests, such 'return' migration is not without its own challenges, and many, finding themselves unable to negotiate local conditions of pollution, poverty, colossal inequality, and messy politics, move back to the West. In each case, however, an Indian cultural essence is summoned forth to circumscribe and parameterize the material successes available to the West. Table 12.1 schematizes the dichotomies that the newly emergent discourse of global Indianness seeks to resolve.

To conclude, if the knowledge economy mobilizes a shift in how belonging is articulated under contemporary conditions of globalization, then such shifts among Indian technomigrants are experienced and managed in the familial space. These emergent notions of self and community are articulated through a discourse of global Indianness – a construct that articulates a middle ground in-between essentialized notions of both India and the West. A discourse of (Indian) family and family values occupies a central position here, and it is through these that the difference between Indiannness and Westernness is primarily articulated. Hence, anxieties over family life, and, consequently, over a continued investment in a strong cultural–national Indian identity, figure as some of the most pervasive anxieties among Indian technomigrants. The family – as a discursive and material construct – is at the very core among the transnational circuits of highly skilled mobility traced by Indian professionals. Or, put more provocatively, it is the family that allows the Indian to globalize.

Notes

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22. The idea of the global Indian has yet another genealogy. Mazzarella, *Shoveling Smoke*, traces the emergence of the global Indian as a brand identity mobilized by many Indian corporations. In the aftermath of economic liberalization enacted in the early 1990s, popular Indian consumer brands suddenly found themselves competing with international brands which were now increasingly available in the Indian market. One way to articulate their uniqueness was through staking claim to an essential (spiritually) Indian identity that was nonetheless global and cosmopolitan in its outlook: A. Khandekar and G.J. Otsuki (2011) 'Remediation and Scaling: The Making of Global Identities', in R. Chopra and R. Gajjala (eds) *Global Media, Culture, and Identity: Theory, Cases, and Approaches* (New York: Routledge), pp. 128–41.
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24. L. Cohen (1998) *No Aging in India: Alzheimer's, the Bad Family, and Other Modern Things* (Berkeley: University of California Press).
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26. Femininity, a construct that has historically mediated the distinction between the public and the private, is a distinct but related domain where the notion of a distinctly modern Indianness has been fiercely debated: P. Chatterjee (1989) 'Colonialism, Nationalism, and Colonialized Woman: The Contest in India', *American Ethnologist, 16*, 622–33. Radhakrishnan's work can be understood as tracing the contemporary manifestation of this dynamic: Radhakrishnan, *Appropriately Indian*.
27. S. Lamb (2010) *Aging and the Indian Diaspora: Cosmopolitan Families in India and Abroad* (Bloomington: Indiana University Press).
28. This essay, part of an edited book titled *Swadesh: Amhi Marathi NRI* ('*My country: We are Marathi NRIs*'), is one such publication. *Swadesh* is a collection of essays published in Marathi comprised of series of narrations of Indians who have lived outside of India for prolonged periods of time before eventually returning. The term NRI here stands for 'Nest Returned Indians' and is a play on the legal-bureaucratic category of 'Non-Resident Indians' that identifies Indian expatriates that have been residing outside of India for more than five years. Several of its authors lived in the United States for many years before eventually returning to India, others have been based in Western European and South East Asian countries. While many of its authors have trained and

worked as scientists and engineers, some of its authors have also been based in fields like graphic design and higher secondary education. While individual narratives vary in their details, a sense of wanting to stay connected with their Indian roots is prominently visible in each of them. While sometimes grounded in a sense of patriotism, more often the authors emphasize their desires to bring up their children within Indian culture. In narrative after narrative, a clear distinction between Indianness and Westernness can be evidenced, and it is this desire for maintaining Indianness that is said to drive many technomigrants homewards. Abhay's is an example of one such narrative: A. Patil (2007) 'Born Again Citizens', in B. Kelkar (ed.) *Swadesh: Amhi Marathi NRI* (Mumbai: Granthali), pp. 1–7. Translated by the author from the original, in Marathi.

29. *Atithi Devobhav*, or 'the (unexpected) guest is equivalent to God', is a commonly invoked Sanskrit phrase to index uniquely Indian norms of hospitality in such contexts.
30. M. Tuck (2008) *India Top Receiver of Migrant Remittances in 2007; Followed by China and Mexico* (Washington, DC: World Bank).
31. Reserve Bank of India (2006) *Invisibles in India's Balance of Payments* (New Delhi: Division of International Finance, Department of Economic Analysis and Policy, Reserve Bank of India).
32. For an overview of the historical evolution of the relationship between the new middle class and the Indian state, see A. Khandekar and D.S. Reddy (2015) 'An Indian Summer: Corruption, Class, and the Lokpal Protests', *Journal of Consumer Culture, 15*, 221–47. For a more comprehensive overview, see Fernandes, *India's New Middle Class*.
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34. Chatterjee, 'Colonialism, Nationalism, and Colonialized Woman'.
35. Radhakrishnan, *Appropriately Indian*.
36. Cohen, *No Aging in India*; Lamb, *Aging and the Indian Diaspora*; C.J. Fuller and H. Narasimhan (2007) 'Information Technology Professionals and the New-Rich Middle Class in Chennai (Madras)', *Modern Asian Studies, 41*, 121–50.
37. In a particularly poignant reading of the image of *Ghar Kali* (The End of the World), for example, Lawrence Cohen, *No Aging in India*, p. 159, writes: 'Old-mother narratives . . . are unforgiving in stressing the meanness of the daughter-in-law who abuses the old mother and the weakness of the son who lets her. In nineteenth-century Calcutta, this . . . narrative was visually represented in the art of the *patua* school of painters and woodcut printers as Ghar Kali, the End of the World: a wife riding on her husband's shoulders while his mendicant mother is dragged along on a leash held by her son. . . . Ghar Kali . . . bespeaks an apocalyptic consciousness. The young couple in the image neglecting their mother are not universal but located: the babu – the parvenu Indian government servant under the British – and his wife. The neglect of the old mother, the foppishness of the son, and the selfish disrespect of the modern wife together constitute a central image satirizing the emerging urban elite as emblematic of Kali Yuga, of the most corrupt last moments of the most corrupt age of humanity.'

38. See D.J. Johnson and J.E. Johnson (1992) *Through Indian Eyes* (New York: Apex Press), for a detailed description of the institution of arranged marriages.
39. Shaadi.com Matrimonials (2015) *Shaadi.com: The World's No. 1 Matchmaking Service*, http://www.shaadi.com, date accessed 21 February 2015; Bharat Matrinony.com (2015) *Bharat Matrimony: For Happy Marriages*, http://www.bharatmatrimony.com, date accessed 21 February 2015.

Part IV

Afterword

13
Afterword: Science and the Domestic Sphere in the *Longue Durée*

Alix Cooper

Domestic settings have a long history as sites for science. The chapters in this volume have focused primarily on the modern period, from the eighteenth century through to the present day. They have shown the degree to which, in the modern world, household and family contexts have been extremely productive in the generation of new knowledge about nature, offering opportunities for individuals of all kinds to engage with science. Even as new sites for science, like modern laboratories, have emerged amid rapid technological change, domestic settings, with all their ambiguities and contradictions, have proved crucial to the scientific enterprise.

Yet if we look back to earlier periods, we see that the location of natural knowledge within the domestic sphere was by no means restricted to the modern world. In the early modern period, for example, households and families likewise served as important contexts for the pursuit of science.[1] Over the past several decades, historians of early modern science have begun to comment more and more frequently on, and to analyse, this phenomenon. Some, for example, have called attention to the ways in which, during the sixteenth and seventeenth centuries in particular, many experiments with natural substances were carried out at home, whether in a housewife's kitchen or a purpose-built (al)chemical laboratory elsewhere in the house.[2] Others have noted how certain kinds of empirical observations, for example in astronomy and natural history, were frequently made not only by the person whom historians have usually considered the 'scientist' in the family, but by other family members, such as by wives, sons, and daughters, or by domestic servants, assistants, or other household members.[3] Still others have observed the ways in which natural knowledge was handed down within families through generations, whether from father to son or through some other pattern of inheritance.[4] Perhaps most strikingly, it has been shown that, in at least some cases, the household setting was crucial in mediating the flow of scientific information. As Deborah Harkness, for example, has convincingly argued, access to the busy mathematician and astrologer John Dee was contingent on his hard-working wife Jane, who managed the flow of visitors into his study.[5] In short, the early modern period, like and perhaps even more than the modern one, seems to have been one in which domestic settings were where much of the work of science was actually done.

Yet these settings seem also to have been fruitful for science in still earlier periods, despite the relative paucity of evidence we have for them. We do know for certain, though, that it was during the High Middle Ages that European universities first emerged. This might not at first seem significant for our purposes, given the common perception of universities as 'ivory towers' far removed from the domestic sphere. Yet one of the basic structures of the medieval university was in fact the professor's household. University students frequently paid for room and board in the professor's home and, eating meals with the professor and his family, shared in conversation which might well touch on scientific or medical topics.[6] Nor was this the only way in which discussions of the natural world might take place in a medieval home. The High Middle Ages saw not only the origins of the medieval university, but also of the guild system, which organized artisanal activities well into the early modern period. And many activities we might nowadays see as related to science, such as experimentation with medicinal substances, were often carried out in artisanal contexts, like that of medicine, in which occupations were typically overseen by guilds, and/or passed down from one family member to another, while homes and workshops usually shared the same roof.[7] In these various ways, then, the Middle Ages likewise saw at least some domestic settings prove hospitable to the pursuit of natural knowledge.

And one can find evidence of this kind even earlier, for example, in ancient Mediterranean settings like Egypt, Greece, and Rome, despite the paucity of surviving information about most individuals' daily lives. The mathematician Hypatia of Alexandria, for example, who lived in Greco-Roman Egypt during the first century CE, is perhaps best known today as one of the earliest women of science.[8] Regarded as an icon of female achievement, she has lent her name to a feminist scholarly journal and a history of women in science, as well as to all sorts of other cultural artefacts.[9] But she can also be viewed in a different way, as an example of an individual whose scientific abilities and talents may have first been developed in a domestic setting; her father was himself a mathematician at the renowned Library of Alexandria, and in many ways she seems to have followed in his stead, working on the same kinds of mathematical problems and eventually herself teaching at that same institution.[10] Her case suggests that, in the ancient world, occupations and interests, including ones related to science, might likewise be inherited and passed down within a family or domestic setting. Other cases in which women in the ancient world seem to have acquired scientific or medical knowledge from family members provide some support for this claim.[11]

Hypatia's case thus reflects a more general pattern that we can observe in the ancient Mediterranean world, one of familial inheritance of scientific interests. Another instance in which this can be seen is in the case of the Roman naturalist usually referred to in English as Pliny the Elder and his nephew, Pliny the Younger. From the names of these two individuals alone, we see a pattern that appears again and again in the science of later periods, in which natural enquirers from the same families but different generations were given labels like 'Elder' and 'Younger' to distinguish them from each other.[12] Both Plinys, the uncle and the nephew, are reported to have been living together in the same household on the fateful day that the elder Pliny left the house to investigate the eruption of Vesuvius, a venture in which he perished.[13] Pliny the Elder's will expressly left his entire estate, including his manuscripts and collection of naturalia, to his nephew, while also officially adopting the younger man as his son.[14] Though Pliny the Younger, who was only 19 at the time, did not end up pursuing his adoptive father's natural-historical interests any further – the circumstances of Pliny the Elder's death could scarcely have encouraged him to do so – and his own writings ended up discussing different topics, nonetheless here, too, we can see some of the patterns by which learned careers and their products might be inherited within domestic settings.

Nor do these patterns of the familial or domestic siting of science seem to have been limited only to Europe or 'the West'. Scholars of East Asian science, for example, have pointed out the degree to which certain professions, like medicine, ran in families. In China during the Sung and Yuan dynasties, as one researcher has shown, the profession of physician seems often to have been a hereditary one, with four or five generations of doctors documented in some families.[15] Furthermore, recent work has pointed to the importance of the household more generally as a site for

Chinese women's medicine in particular.[16] Such patterns are unlikely to have been confined to East Asia, and interested researchers may well end up being able to locate them in other areas of the globe.

Given the long history of domestic-based science which the evidence seems to suggest, it is perhaps not surprising that it continues to thrive into the present day, even despite the advent of new spaces of science, like laboratories, that have come to be constructed separately, and often far away, from residential areas. Many of the chapters in this volume attest to the enduring power of household-based natural knowledge. Indeed, in some ways it may have even increased, due to new technologies. For example, with the rise of telecommuting in recent decades, many tasks that previously required a person's physical presence in a workplace can now be performed from home, using 'personal' and/or, increasingly, 'mobile' devices. And these advances in computer technology, letting people conveniently enter the results of backyard observations from home, have spurred new kinds of 'citizen science'.[17] We seem to stand on the verge of a new era of domestic-based science.

This makes it all the more important to understand the history of this domestic-based science in all of its chronological, geographical, and social complexity. This volume has explored many of the changes that took place over the past several centuries in a range of countries, but further research into earlier periods, and other continents, drawing on the new global history of science, may allow us to discern even broader patterns. How, for example, has the pursuit of science in domestic settings changed from era to era, from place to place? Are there certain continuities that have endured, even amidst epochal societal and technological changes? Or have these changes led to new conceptions of and/or uses for domestic settings in science?

Other research directions beckon as well. For example, how have changing perceptions of 'public' and 'private' affected the practice of science in domestic contexts? This may well be a challenging question to answer, given the difficulty of untangling these highly charged concepts – but the chapters of this volume show that it can be done. Other questions that remain to be resolved include: How have changes in the composition of households, with full-time live-in domestic staff now available only to the very few, affected the kinds of science done in them? What about changing ideas of gender within the family, with male heads of households no longer necessarily the norm? Likewise, what about changing ideas of gender within the fictive kinships of more official scientific workplaces like laboratories? More broadly, how have individuals worked within the constraints of (and opportunities enabled by) social as well as intimate concerns to pursue knowledge of the natural world? Despite the accomplishments of the chapters in this volume, albeit with their assistance, much remains to be explored.

Notes

1. During this and earlier periods, of course, the term 'science' and its cognates meant something rather different from what it means today; it was used primarily to refer to 'certain knowledge' such as mathematics and theology, while much of what we might today call 'science' was referred to by terms such as 'natural history', 'natural philosophy', and so forth. For the sake of simplicity, though, I will use the word 'science' with its modern meaning.
2. See S. Shapin (1988) 'The House of Experiment in Seventeenth-Century England', *Isis, 79*, 373–404. Scholars who have studied the history of women in science have played a crucial role here; to cite just a few of many useful sources on the use of household spaces for science, see, for example, L. Schiebinger (1989) *The Mind Has No Sex? Women in the Origins of Modern Science* (Cambridge, MA: Harvard University Press); many of the articles in L. Hunter and S. Hutton (eds) (1997) *Women, Science and Medicine 1500–1700: Mothers and Sisters of the Royal Society* (Stroud: Sutton); A. Rankin (2013) *Panaceia's Daughters: Noblewomen as Healers in Early Modern Germany* (Chicago: University of Chicago Press); and A. Cooper (2012) 'Women and Science', in M. King (ed.) *Oxford Bibliographies: Renaissance and Reformation* (New York: Oxford University Press), http://www.oxfordbibliographies.com/ (home page), date accessed 24 October 2014. On the topic more generally, see A. Cooper (2006) 'Homes and Households', in K. Park and L. Daston (eds) *The Cambridge History of Science*, Vol. 3: *Early Modern Science* (Cambridge: Cambridge University Press), pp. 224–37.
3. On family members making observations, see, for example, R. Iliffe and F. Willmoth, 'Astronomy and the Domestic Sphere: Margaret Flamsteed and Caroline Herschel as Assistant-Astronomers', in Hunter and Hutton, *Women, Science and Medicine 1500–1700*, pp. 235–65; and E. Reitsma (2008) *Maria Sibylla Merian and Daughters: Women of Art and Science* (Zwolle: Waanders). On servants and assistants in the early modern scientific household, see S. Shapin (1989) 'The Invisible Technician', *American Scientist, 77*, pp. 554–63; and J.R. Christianson (2000) *On Tycho's Island: Tycho Brahe and His Assistants, 1570–1601* (Cambridge: Cambridge University Press).
4. On the inheritance of scientific and medical knowledge within families, see G. Algazi (2003) 'Scholars in Households: Refiguring the Learned Habitus, 1400–1600', *Science in Context, 16*, 9–42: 25; F.W. Euler (1970) 'Entstehung und Entwicklung deutscher Gelehrtengeschlechter', in H. Rössler and G. Franz (eds) *Universität und Gelehrtenstand 1400–1800* (Limburg: C.A. Starke Verlag), pp. 183–232; and Cooper, 'Homes and Households', pp. 232–3. The following provide case studies of particular families: D. Harkness (2001) 'Tulips, Maps, and Spiders: The Cole-Ortelius-Lobel Family and the Practice of Natural Philosophy in Early Modern London', in R. Vigne and Charles Littleton (2001) *From Strangers to Citizens: Foreigners and the Metropolis, 1500–1800* (Eastbourne: Huguenot Society and Sussex Academic Press),

pp. 184–96; and A. Cooper (2013) 'Picturing Nature: Gender and the Politics of Natural-Historical Description in Eighteenth-Century Gdańsk/Danzig', *Journal of Eighteenth-Century Studies, 36*, 519–29.

5. D. Harkness (1997) 'Managing an Experimental Household: The Dees of Mortlake and the Practice of Natural Philosophy', *Isis, 88*, 247–62.
6. R. Müller (1996) 'Student Education, Student Life', in H. de Ridder-Symoens (ed.) *Universities in Early Modern Europe, 1500–1800* (Cambridge: Cambridge University Press), 345–6; Cooper, 'Homes and Households', pp. 230–1. This was, of course, also true for what one might term 'itinerant households', like those of the original wandering scholars who helped to create the university movement (such as Peter Abelard in France), or travelling humanists (such as Erasmus), or itinerant alchemists; I am grateful to Brigitte Van Tiggelen for this point.
7. J. Farr (2000) *Artisans in Europe, 1300–1914* (Cambridge: Cambridge University Press); M. Kowaleski and J.M. Bennett (1989) 'Crafts, Gilds, and Women in the Middle Ages', in J. M. Bennett, E.A. Clark, J. F. O'Barr, B.A. Vilen, and S. Westphal-Wihl (eds) *Sisters and Workers in the Middle Ages* (Chicago: University of Chicago Press), pp. 11–38; and M. Cabré (2008) 'Women or Healers? Household Practices and the Categories of Health Care in Late Medieval Iberia', *Bulletin of the History of Medicine, 82*, 18–51. First established earlier in the Middle Ages, monasteries might also be seen as organized around household models.
8. 'Hypatia of Alexandria' (2000), in M.B. Ogilvie and J. Harvey (eds) *Biographical Dictionary of Women in Science: Pioneering Lives from Ancient Times to the Mid-Twentieth Century*, Vol. 1 (New York: Routledge), pp. 637–9; M. Dzielska (1995) *Hypatia of Alexandria*, trans. F. Lyra (Cambridge, MA: Harvard University Press).
9. The scholarly journal *Hypatia*, for example, focuses on feminist philosophy, while the title of the following book on women in science clearly attests to Hypatia's iconic status: M. Alic (1986) *Hypatia's Heritage: A History of Women in Science from Antiquity to the Late Nineteenth Century* (London: The Women's Press). As is often the case, the Wikipedia entry on her serves as an excellent entry point into popular-cultural appropriations of the history of science, and lists an astonishing array of novels and other works based on her life story; Wikipedia contributors (2014) 'Hypatia', in *Wikipedia: The Free Encyclopedia*, http://www.wikipedia.org/ (home page), date accessed 24 October 2014.
10. See Farr, *Artisans in Europe, 1300–1914*; Kowaleski and Bennett, 'Crafts, Gilds, and Women in the Middle Ages'; and Cabré, 'Women or Healers?'
11. For example, Arete of Cyrene, whose father Aristippus taught her philosophy, which she then in turn taught to her son Aristippus the Younger, and Aemilia, who 'studied medicine in order to assist her physician brother'. The cases of Pythias, Aristotle's wife, who is said to have helped him collect marine specimens for his *Historia animalium*, and Damo, the supposed daughter of Pythagoras, are more likely to be apocryphal. See Ogilvie and Harvey, *Biographical Dictionary of Women in Science*, Vol. 1, pp. 50, 11; Vol. 2, p. 1062; and Vol. 1, pp. 323–4.
12. On the tendency of scientific and medical occupations to 'run in the family', necessitating the frequent use by contemporaries as well as historians of

science of labels like Elder, Younger, Senior, Junior, and even I, II, III, and IV, see Cooper, 'Homes and Households', p. 232.

13. See Pliny the Younger (1915) *Letters*, trans. W. Melmoth (London: Heinemann), pp. 474–83, 489–97 (letters VI.16 and VI.20), which discuss the volcanic eruption.
14. J.F. Healy (1999) *Pliny the Elder on Science and Technology* (Oxford: Oxford University Press); R.K. Gibson and R. Morello (eds) (2011) *Pliny the Elder: Themes and Contexts* (Leiden: Brill).
15. R.P. Hymes (1987) 'Not Quite Gentlemen? Doctors in Sung and Yuan', *Chinese Science, 8*, 9–76: 15–16, 21, 38, 53. I am indebted to Carla Nappi for this reference.
16. See, for example, C. Furth (1999) *A Flourishing Yin: Gender in China's Medical History, 960–1665* (Berkeley: University of California Press); and F. Bray (1997) *Technology and Power: Fabrics of Power in Late Imperial China* (Berkeley: University of California Press).
17. C. Franzoni and H. Sauermann (2014) 'Crowd Science: The Organization of Scientific Research in Open Collaborative Projects', *Research Policy, 43*, 1–20; A.I.T. Tulloch, H.P. Possingham, L.N. Joseph, J. Szabo and T.G. Martin (2013) 'Realising the Full Potential of Citizen Science Monitoring Programs', *Biological Conservation, 165*, 128–38; and G. Cook (2011) 'How Crowdsourcing is Changing Science', *Boston Globe*, 1 November 2011, http://www.bostonglobe.com (home page), date accessed 24 October 2014.

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Index

Note: Locators in bold type indicate figures or tables.