ARISTOCRATS AND PROFESSIONALS:
COUNTRY-HOUSE SCIENCE IN LATE-VICTORIAN BRITAIN

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

DONALD LUKE OPITZ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

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DECEMBER, 2004

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Acknowledgments

The Victorian biologist Francis Maitland Balfour once explained to a lifelong friend why he remained devoted to his work at his alma mater, the University of Cambridge, when facing alternative attractions elsewhere. He explained, "It is my child, you know, and I cannot well leave it."[1] My own devotion to the work which has kept me at the University of Minnesota for longer than I care to admit may be explained in the same terms. The stimulating and supportive environment I have found at Minnesota, more than anything else, has enabled me to endure the characteristic hardships of graduate student life and accomplish my life's greatest challenge to date, writing this doctoral thesis. According to a well-known African proverb, "It takes a village to raise a child." In this case, the village extends across the globe and deserves my deepest appreciation.

I begin with Minnesota's History of Science and Technology community. In one of my first graduate courses, Roger Stuewer guided my interest in the physics work of John William Strutt, third Baron Rayleigh. A year later, in her seminar on women in science, Sally Kohlstedt further encouraged my desire to learn more about Rayleigh, particularly his social context. My idea on what constitutes the history of science expanded dramatically as I mined this topic. Along the way I benefitted from lessons in the methodology of social history from Allen Isaacman, (the late) Susan Geiger, and MJ Maynes of the History Department. Many classmates also promoted my learning through

[1] Quoted in Rev. J. Robertson, "The Late Professor F.M. Balfour," *Supplement for Whittingehame Parish*, August 1882, GC433/2/101, BP, NAS. See my bibliography for abbreviations of archive collections.

discussion and debate, especially Kai-Henrik Barth, Rene Burmeister, Joe Cain, Juan Ilerbaig, John Jackson, Natalie McIntire, and Michael Reidy. The program's administrative associate, Barbara Eastwold, guided me through bureaucratic steps at different stages and always showed interest in my progress.

Even when tempted by other topics, my interest in Rayleigh and his family context never waned. A dissertation topic crystallized during my exploration, and it required me to travel to British and Irish archives. When I returned, Nicolas Bergeron, Juliet Burba, Margot Iverson, Ron Frazzini, Susan Rensing, and Michael Ziomko invited me into their dissertation writing group (affectionately known as DaWGs), and all generously read and commented on chapter drafts in their embryonic stages. Other graduate colleagues, especially Erika Dirkse, Tom Haakenson, Piers Hale, and James Satter, engaged me in conversations that also shaped my views on my topic. But I owe special gratitude to Juliet and Susan, who urged me forward during my most trying moments.

During my travels to archives, I must thank the Department of History and Philosophy of Science at the University of Cambridge for welcoming me as a visiting student. The intellectual stimulation, sense of history, and legacies of my dissertation's *dramatis personae* at Cambridge were singular in bringing my topic to maturity. Jim Secord and Simon Schaffer generously gave their time to reading my work, discussing my interests, and providing feedback on a paper I presented in the department's Natural History Cabinet. Other members of the vibrant Cambridge HPS community who extended their hospitality and advice include Jim Endersby, Hjalmar Fors, Christopher

Haley, Karen Haugland, Nicholas Jardine, (the late) Joan and Stephen Mason, Helen McDonald, Greta Peterson (also a Minnesota alum), Greg Radick, Anne Secord, and Sujit Sivasundaram. Departmental staff Tamara Hug and David Thompson arranged provisions that created hospitality and an identity for me within the department.

Surviving members of the families to which my *dramatis personae* belonged provided valuable recollections and family stories that were critical in orienting me to the character of Victorian country-house society. For their hospitality and interest, I thank Ms. Elisabeth Belsey, Mr. Andrew Brander, Mr. Michael and Lady Evelyn Brander, the late fourth Earl of Balfour, Mrs. Elizabeth Parker, Lord and Lady Rayleigh, Lord and Lady Rosse, the Hon. Guy Strutt, and the Hon. Jean Strutt. In addition, other researchers working on related topics generously shared information and insights: Mr. David Affleck, Dr. John Howard, Mr. Paul Harris, Dr. Joan Huffman, and Mr. Robin Hartcourt Williams.

Friends both in England and the United States supported my work in still other ways, such as providing a bed during a research trip, or simply encouraging me to keep at it. Their support, which I can acknowledge only in brief, carried me through in ways they may not realize: Kathy Ahlers, Sam Alberti, David Allington, Janet al'Azar, Mike Albert, Valerie Amar, Jennifer Bielefeld, Karen Beavers, LaShunda Cross, Jonathan Davis, Lucy Delap, Anna Fedyshyn, Natasha Georgia, Stephanie Glaros, Rob Goddard, Gina Honkala, Kim Johnson, Mary Ellen Johnson, Iroo and Insuk Joo, Marcelline Kamunga, Clive Lawson, Ben Mathews, Jessica Morgan, René Raoul, Pamela Smith, Chris Stray, John Swedell, Char Voight, and Jenn Young.

During most of my doctoral candidacy, I supported myself financially through

positions I held at the University of Minnesota's General College (GC) and Office for Multicultural and Academic Affairs (in the Office for University Women). The social-justice missions and wonderfully supportive work environments of both places made my times away from writing times of renewal rather than of exhaustion. I am especially thankful to GC colleagues who urged my dissertation work along, even when they knew it would be at the expense of my job performance; those folks include Laura Koch, Terry Collins, Irene Duranczyk, Deb Hartley, Suzanne Loch, Doug Robertson, Sue Staats, and Janet Stottlemyer.

My thesis examination committee deserves particular praise for carefully reading the entire manuscript and providing insightful criticism. I am grateful to Jennifer Alexander, Anna Clark, John Eyler, Jennifer Gunn, Sally Kohlstedt, and Bernie Lightman. I especially appreciate Bernie's willingness to come from Toronto to join the committee as an external examiner. In showing interest in my work over the years, he provided unusual guidance and encouragement. A few readers external to my committee also generously offered excellent advice. Chris Stray read and offered comments on Chapters 4 and 6. Rich Bellon and Helen Blackman similarly provided feedback on Chapter 6, and Marsha Richmond, Jim Secord, and Helen, again, on Chapter 8. Anne Secord's and Jane Camerini's advice on gender and class issues shaped the outcome of various sections.

My adviser, Sally Kohlstedt, provided unparalleled advice and encouragement. She never hesitated to ground me in realities nor to urge me to set realizable benchmarks. She critically read every draft, every chapter, and the final result, and while we may not have always agreed, her insights always moved my writing to a new plateau. Perhaps more importantly, she nurtured a sense of community among her advisees during critical stages; a well-timed retreat to her cabin on the Gunflint Trail provided a small group of us a memorable opportunity for work and play. Sally is a wonderful mentor who has sacrificed more than what is reasonable to my personal and professional development, and I am honored to have her as a colleague. I also thank David Kohlstedt for his frequent hospitality.

I owe my deepest gratitude to the members of my family. Over the years, they provided me more support than I can possibly summarize here. During the many times that I was absent because of my work or travels, they always understood. Their constant encouragement and believing in me gave me endless inspiration. When grant agency after grant agency denied my requests for funding to conduct research in Britain, my Mom, Angie Opitz, sister, Dawn Opitz, and brother, Nick Opitz, pooled money from their own pockets to send me for my first research endeavor. During my travels, my father, Don Opitz, and stepmother, Toni Opitz (both of whom also financially contributed), spent many hours on the phone giving their counsel from Chicago while their son adjusted to the shock of living in Cambridge and Edinburgh. They did the same for my life partner, Gregg Albrecht, who changed his own plans to accompany me during the longer of my two Cambridge stays. Gregg's parents, Jack and Nancy Albrecht, provided me unbridled encouragement and space in their home to study over the years.

I must single Gregg out for special appreciation. Without his support of my work over the years, this dissertation would not have been possible. His interest in my work, readiness to relieve me of household responsibilities, and continual encouragement sustained me from day to day. He is a real trooper, and I am blessed to have him in my life.

For a dissertation that has depended on primary source materials in numerous archives and libraries, and a few country seats, I must acknowledge the many individuals that granted access to sites and collections and permission to quote from manuscripts: Mr. David Anderson, East Lothian Museums Service; the late fourth Earl of Balfour, Whittingehame Tower; Ms. Anne Barrett, Imperial College Archives; Dr. Keith Bland, Pelham-Clinton Fellow of Entomology, National Museums of Scotland; the Hon. Mrs. Melissa Bradley, Whittingehame House; Mr. Michael and Lady Evelyn Brander, Whittingehame Mains, Whittingehame; Mr. Andrew Brander, Whittingehame Tower; Ms. Stella Brecknell, Hope Library, Oxford University Museum of Natural History; Mr. Stephen Bunyan, Honorary President, East Lothian Antiquarian and Field Naturalists' Society; Ms. Clair M. Castle and Ms. Jane Acred, Balfour & Newton Library, Cambridge; Ms. Eleanor Gildersleeve, former Archivist, and Mr. John Griffin, Director, Air Force Research Library, Hanscom Field; Mr. Ken Hall, County Archivist, Essex Record Office; Ms. Sonia Hollins, Whipple Library; Dr. Frank James, The Royal Institution, London; Mr. Allen Packwood, Director, Churchill Archives Center; Ms. Karen Peters, Royal Society of London Archives; Ms. Christine Ratcliff, Librarian, Department of Physiology, Cambridge; the Rt. Hon. Baron Rayleigh, Terling Place; Ms. Sheila Noble, Librarian, Special Collections, University of Edinburgh Library; Ms. Kate Perry, Girton College Archives; the Rt. Hon. Earl and Countess of Rosse, Birr Castle, Birr; Mr. Jonathan Smith,

Archivist, Wren Library, Trinity College, Cambridge; the Hon. Guy Strutt, Terling Place, Terling; Dr, John Thoday, Department of Genetics, Cambridge; Ms. Anne Thomson, Archivist, Newnham College Library, Cambridge; Ms. Veronica Wallace, Librarian, Local History Centre, Haddington Library; Mr. Godfrey Waller, Manuscripts Room, Cambridge University Library; Dr. Andrew E. Whittington, Curator, Entomology Department, National Museums of Scotland; and Mr. Robin Hartcourt Williams, Librarian, Hatfield House. Figure credits appear in the captions.

I received a generous dissertation enrichment grant from the National Science Foundation, SES-00994442 (2001) that allowed me the time and resources needed to return for an extended research trip to British and Irish archives and the extant country seats analyzed in the pages that follow.

All final interpretation and errors, of course, remain the sole responsibility of the author.

Dedicated to Ruth Ann (née Arnold) Rispoli
(January 27, 1928 - November 6, 2004)
whose inspiring humor and perseverance
endures in the lives she touched

Abstract

The historiography of late-Victorian and Edwardian science has overwhelmingly emphasized the importance of new institutional arrangements and the professional growth of the scientific disciplines, largely owing to the initiatives of the British middle-class and the increasing support of research by the British government. While historians consistently acknowledged the agency of gentlemen of science and domestic sites for research in the background to these developments, few have analyzed the tenacity and influence of the individuals, their activities, and the domestic social contexts in which they worked beyond the mid-nineteenth century. This dissertation considers the status of country-house science and "professionalization" from roughly 1850 to 1920. I argue that, enabled by a familial social infrastructure, an extensive aristocratic network – consisting of the Balfour, Campbell, Cavendish, Darwin, Gascoyne-Cecil, Parsons, and Strutt families – contributed to the intellectual and professional advancement of scientific fields in ways that applied, generally, politically-Conservative, yet liberally intellectual, theistic beliefs. Their perspectives, which contrasted with agnosticism, scientific naturalism, and middle-class professionalism, emphasized the respectability of the amateur study of nature at home as a means for personal atonement and the promotion of social good – an outlook consistent with the evangelical, aristocratic values in which their society came of age. Country-house science thus provided a model for the study of science at home as well as within purpose-built sites; it was a distinct vision and an enterprise that, amid social hierarchies governed by class and gender, encouraged broad participation within a dynamic intellectual milieu.

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Chapter 1

Introduction: Bringing Victorian Science Home

In Rosina Maria Zornlin's children's book, *What is the Voltaic Battery?* (1842), Mr. Compton taught his nephew Edward about "the leading phenomena presented by *ordinary electricity*."[1] In the tradition of Jane Marcet's character, Mrs. B., from the extraordinarily popular *Conversations on Chemistry*, Mr. Compton quickly moved from explanation to an experimental demonstration of "the attractive power possessed by a non-conducting substance, when excited by friction" (or, in later terms, static electricity).[2] Naming familiar household items, Mr. Compton instructed his nephew in the experiment:

> Having first torn up a piece of paper into small fragments, and placed them on the table: if you now take a stick of sealing-wax and rub it briskly against the sleeve of your coat, or a piece of flannel, and then immediately hold it near the fragments of paper, you will find that it attracts the latter, which will remain suspended, so long as the electrical excitement lasts; when they will become detached, and fall by their natural gravity, or weight, to the table.[3]

Mr. Compton's experiment posed no obvious danger, but other experiments, like one described in Samuel Parke's *Chemical Catechism* (1806), as Aileen Fyfe has pointed out,

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[1] Rosina M. Zornlin, *What is a Voltaic Battery?* [1842], rpt. with an intro. by James A. Secord in *Science Writing by Women*, ed. Bernard Lightman, vol. 4 of 7 vols. (Bristol: Thoemmes Continuum, 2004), p. 4.

[2] Zornlin, *What is the Voltaic Battery?* p. 6; Jane Marcet, *Conversations on Chemistry* [1806], rpt. with an intro. by Aileen Fyfe in *Science Writing by Women*, vols. 1 and 2.

[3] Zornlin, *What is the Voltaic Battery?* p. 6.

were criticized for "too frequently" introducing "explosive or detonating substances."[4] Popular manuals such as these indeed inspired various home experiments, some more dangerous than others, among the middling and upper classes.

The young John Strutt, for example, sent for ingredients from the local chemist after reading in *The Family Friend* that "Fine sawdust or rasped wood, steeped in a mixture of concentrated sulphuric and nitric acids, and afterwards washed and dried, will explode similar to common gunpowder."[5] Strutt's sister recalled the concern this request produced: "The chemist when filling the order sent a warning to the authorities of the dangerous nature of the goods he was supplying, and poor John was severely taken to task and the chemicals confiscated."[6] Gender proprieties also guided the prescriptions; in natural history Charles Kingsley emphasized, "Entomology ... is the study most fit for boys (as Botany is for girls)," referring to the cruelty involved in collecting specimens that contemporaries viewed as inappropriate for girls.[7] For this very reason, as David Allen has pointed out, contemporary literature also prescribed conchology as "a study peculiarly suited to ladies; there is no cruelty in the pursuit, as the subjects are so brightly

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[4] [Anon.], [Review of S. Parkes, *A Chemical Catechism for the Use of Young* People (1806)], *Monthly Review* 53 (1807): 64-67, on 66; Aileen Fyfe, "Introduction," in Marcet, *Conversations on Chemistry*, pp. xxi-xxvii, on xxiv.

[5] [Anon.], "Wooden Gunpowder," *The Family Friend* 1 (1849): 24.

[6] Robert John Strutt, Fourth Baron Rayleigh, *Life of John William Strutt, Third Baron Rayleigh* [1924], aug. ed. with an intro. by John N. Howard (Madison: The University of Wisconsin Press, 1968), p. 11.

[7] Charles Kingsley, *Glaucus: or, the Wonders of the Shore* [1855], 5th ed. (London: Macmillan, 1873), p. 220.

clean, so ornamental to the boudoir."[8]

The explosion of popular science books by the middle of the nineteenth century suggested not only a growing cultural interest in scientific learning but also the dissemination of instructions by which families turned the spaces of their homes into miniature laboratories or museums.[9] Eliza Brightwen so relished her creation of a home museum that she repeatedly encouraged her readers to create their own:

> My little museum had, like many other things, a very small beginning. As there was plenty of space on the walls of the billiard-room, I had a case made to contain specimens of nuts and seeds which had been stored up in various cupboards and boxes about the house. These objects, neatly arranged and named, were hung up in a wall-case, and formed the nucleus of the further collection.[10]

Scientific biographies, also widely circulating, emphasized genius, self-application and industriousness as the ingredients to an exemplar life in science. Perhaps more importantly than the characteristics of individuals, the popular science publishing phenomenon, which explicitly recruited readers for participation in the scientific life, created a cultural vogue for home science.[11]

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[8] David Elliston Allen, *The Naturalist in Britain: A Social History* (London: Allen Lane, 1976), p. 127. On contemporary concerns for cruelty to animals during the early-nineteenth century collecting craze, Anne Larsen Hollerbach, "Of Sangfroid and Sphinx Moths: Cruelty, Public Relations, and the Growth of Entomology in England, 1800-1840," *Osiris* 11 (1996): 201-220.

[9] Bernard Lightman, "'The Voices of Nature': Popularizing Victorian Science," in *Victorian Science in Context*, ed. Bernard Lightman (Chicago: The University of Chicago Press, 1997), pp. 187-211.

[10] Mrs. Brightwen, *More about Wild Nature* [1892], rpt. with an intro. by Barbara Gates in *Science Writing by Women*, 7: 188.

[11] Geoffrey N. Cantor, "The Scientist as Hero: Public Images of Michael Faraday," in Michael Shortland and Richard Yeo, eds., *Telling Lives in Science: Essays*

Curiously, nineteenth-century domestic sites for scientific practice and their role within broader social and intellectual trends remain largely unexamined. During a period that historians generally recognize to be defined by the want of public laboratory institutions, it is ironic that the primary context for scientific work – the home – is all but absent from the historical narratives. More generally, in science historiography, public lives are privileged over private, reflecting both a presentist orientation toward professional venues and the methodological challenges involved in chronicling the private.[12] Thus, intellectual trends, institution-building, eminent personalities, and social contexts reconstructed from readily accessible publications or archived collections of unpublished – yet still "public" – materials tell the familiar stories of science. How would these stories appear, we might ask, if the spaces, familial relations, and routines of private

on Scientific Biography (Cambridge: Cambridge University Press, 1996), pp. 171-193; Anne Secord, "'Be What You Would Seem to Be': Samuel Smiles, Thomas Edward, and the Making of a Working-class Hero," *Science in Context* 16 (2003): 147-173; Secord, "Botany on a Plate: Pleasure and the Power of Pictures in Promoting Early Nineteenth-Century Scientific Knowledge," *Isis* 93 (2002): 28-57.

[12] The pioneering statement of this situation by way of explaining the "incidental concomitant exclusion of women," from the historiography of science is Pnina Abir-Am and Dorinda Outram, "Introduction," in *Uneasy Careers and Intimate Lives: Women in Science, 1789-1979*, ed. Abir-Am and Outram (New Brunswick, NJ: Rutgers University Press, 1987), pp. 1-16. The authors argue for a progressive exclusion of the domestic realm from science over the course of the nineteenth century. Their argument rests, however, on an assumption of the separation of spheres (private and public) that more recent women's history has taken to task; for example, Amanda Vickery, "Golden Age to Separate Spheres? A Review of the Categories and Chronology of English Women's Histsory," *The Historical Journal* 36 (1993): 383-414. My present study poses a challenge to the assumption of separate spheres as well as the exclusion of women from the institutions of science, as will become clearer further in this dissertation. Pointing out the challenge of reconstructing private lives from limited or inaccessible primary sources, Leonore Davidoff and Catherine Hall, *Family Fortunes: Men and Women of the English Middle Class, 1780-1850* [1987] (Chicago: University of Chicago Press, 1991), p. 34.

households were also considered? By what means can we access the private side to scientific lives?

Bearing these question in mind, in this dissertation I pay visits to a set of Victorian scientific households in which a particular aristocratic society of relatives and friends spent the greater part of their lives. I observe how the children gained their initial exposure to science from tutors, governesses, and estate staff who taught them lessons in their homes and gardens. I consider the stimuli of their home surroundings – libraries of books; collections of apparatus; the domesticated natural habitats of gardens, aquaria, and terrariums; natural history cabinets and museums; excursions to nearby fields and seashores; and meditations on God's design through prayer. I consider the pervasiveness of religion infusing their homes, from the conduct of "family prayers" in the mornings to Bible readings in the evenings.[13] I watch how brothers and sisters shared in a common stock of scientific knowledge, only interrupted when they followed their predestined paths to separate boarding schools and distinct calls to public or domestic duty that involved gender-differentiated means for pursuing higher learning. I discover their intellectual lives as fundamentally social, their work as collaborative, and their scientific pursuits as deeply interwoven with religious and social concerns. Moreover, I find how their lives often contradicted various popularized expectations and stereotypes,

[13] Commenting on the contemporary practice of "family prayers" in distinction from more rigorous evangelical practices, Edmund Gosse, *Father and Son: A Study of Two Temperaments* [1907] (London: Penguin Books, 1989), p. 108.

transgressing the boundaries constructed by class, gender, and professionalism.[14] I observe how the home environments shaped and supported the public works of their inhabitants. By stepping into their homes, I enter a space in which public and private, society and family, science and domesticity commingled. Their science emerges as a coherent set of diverse experiences in thinking and writing, experimenting and demonstrating, conversing and debating, promoting and lobbying, proselytizing and politicking. To borrow the title of a forthcoming anthology, rather than viewing these activities as the stuff of "sidelined sciences," I examine them from their center – within the Victorian home.[15]

With this reorientation in perspective, in my analysis I move outward from the home and follow individuals into the other spaces that also mattered. Their movements bring me to Cambridge college rooms, dining halls and tennis courts; the country seats and London townhouses of relatives and friends; ships navigating seas; newly-built physics laboratories, marine zoological stations; and genetics breeding farms; and the meeting rooms of clubs, scientific societies, and government scientific committees. In following their public engagements, I find how the private and public became blurred to the extent that what was usually considered private and domestic became at once public

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[14] This approach is much in the spirit of M. Jeanne Peterson, *Family, Love, and Work in the Lives of Victorian Gentlewomen* (Bloomington: Indiana University Press, 1989).

[15] A forthcoming collection of essays challenges a presentist view of nineteenth-century science by emphasizing an intellectual and spatial context in which sciences later judged as pseudosciences or otherwise peripheral are central; David Clifford, Elisabeth Wadge, Alex Warwick, and Martin Willis (eds.), *Sidelined Sciences? Shifting Centres in Nineteenth-Century Scientific Thinking* (Cambridge: Anthem Press, forthcoming).

and political; often the reverse was also true. Of course, gradations existed between these dichotomies, and spaces were regularly transformed from sites of solitary speculation to forums for public action. But the patterns more often than not resembled W.L. Burn's observation of how, for politically-active upper-class Victorians, "the home was less a place for cultivating family affections than a base for action, where policies could be worked out and influence obtained by means of hospitality."[16]

To embark on this journey, I have chosen as my focus the extensive aristocratic family network comprised of the Balfours of Whittingehame, Gascoyne-Cecils of Hatfield, Strutts of Terling, Sidgwicks of Hillside, Campbells of Inveraray, and Parsons' of Birr. It must be borne in mind that these families only gradually became associated through interactions made possible by aristocratic society and guided by various interests related to marriage, politics, intellect, and sheer fancy. A family network of aristocratic status interests me for a number of reasons. In science historiography, aristocrats have fallen out of favor, leaving their roles in science at the end of the nineteenth and beginning of the twentieth century also understudied.[17] Moreover, despite the general assumption that power, wealth, and prestige accompanied aristocratic status, within the period of my concern these characteristics were by no means certain or predestined.[18]

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[16] W.L. Burns, *The Age of Equipoise: A Study of the Mid-Victorian Generation* (New York: W.W. Norton, 1964), p. 247.

[17] Summarizing this historiographical trend, Bernard Lightman, "Introduction," in *Victorian Science in Context*, pp. 1-12.

[18] David Cannadine, *The Decline and Fall of the British Aristocracy*, rev. ed. [1992] (New York: Vintage Books, 1999).

Most interesting to me is the prevalence of science infusing their lives, beyond commonplace participation in popular science culture. From their families derived the most eminent men and women of science of their times, and only the celebrated names of the zoologist Francis Maitland Balfour, physicist John William Strutt (Lord Rayleigh), astronomer William Parsons (Lord Rosse), and mathematician Eleanor Mildred Sidgwick need be mentioned to illustrate this.[19] Also characteristic is the admixture of their beliefs and daily routines that tended to emphasize evangelical simplicity, cultivation of the intellect, professional engagement for public good, and pursuit of science alongside the pursuit of theology. Their perspectives and practices, even when allowing for important individual differences, tended to produce a unified position within the reigning contemporary debates: these aristocrats were sympathetic to spiritualism, advocates of women's rights, reformers of higher education, supporters of professionalizing movements, champions of amateur practice, skeptics of natural selection, theists reconciling religion and science, and unionists on the question of Irish Home Rule.

Considering the individuals constituting this loose family network as a single social unit urges certain reinterpretations of their individual histories. Whereas a wealth of historical analysis exists for most of the individuals (the exceptions being the women), those analyses uniformly divorce their subjects from their family contexts.[20] Resituating

[19] This is not to mention the many examples of eminence populating the younger generations, including Lady Eve Balfour, Robert John Strutt (Lord Rayleigh), Laurence Parsons (Lord Rosse), Sir Charles Algernon Parsons, and Nevil Sidgwick. I provide examples of the accomplishments further in this dissertation.

[20] The exceptions being domestic biographies, identified in my bibliography and discussed further in this dissertation. (Generally, I refer to the biographies, when authored

the subjects within a common family context exposes important continuities, influences, and shared perspectives that go much further in explaining their intellectual orientations and contributions than the apparently disjointed influences that result from tracing influences internal to their specialized disciplines. To give one striking example, the eminent statesman Arthur Balfour's philosophy on the relation between science and religion takes on a much different character than a purely philosophical or political agenda when seen as one manifestation of his family's involvement in a sea of public debate.[21] A trinity of responses, appearing in the successive presidential addresses made before the British Association for the Advancement of Science, by Rayleigh in 1884, Salisbury in 1894, and Balfour in 1904, reiterated in different terms the same criticism of scientific naturalism and defense of theism across two decades. Their perspectives, as I will argue, fed into an important defense of a professional scientific morality within the broader movement to professionalize science characteristic of the last third of the nineteenth century. A defining feature of their shared perspective is a reiteration of

by their relatives, as "domestic biographies.") There are numerous scholarly studies of the individuals, also identified in my bibliography.

[21] The standard interpretations of Balfour's philosophy, which differ in their emphasis on intellectual and political debts are John David Root, "The Philosophical and Religious Thought of Arthur James Balfour (1848-1930)," *Journal of British Studies* 19 (1980): 120-141; and L.S. Jacyna, "Science and Social Order in the Thought of A.J. Balfour," *Isis* 71 (1980): 11-34. A recent analysis of Balfour's debate with Thomas Henry Huxley moves in the direction of emphasizing the importance of Balfour's aristocratic status and family connections; Bernard Lightman, "'Fighting Even with Death': Balfour, Scientific Naturalism, and Thomas Henry Huxley's Final Battle," in *Thomas Henry Huxley's Place in Science and Letters: Centenary Essays*, ed. Alan P. Barr (Athens, GA: University of Georgia Press, 1997), pp. 323-350.

evangelical values which infused the country homes of their upbringing.[22]

A second, related outcome from this focus on the family is a notable tenacity of the country house as a primary site for scientific research, across disciplines, throughout this entire period.[23] It was within the homes of the principal actors, as opposed to the newly-built laboratories, that an opus of work, significant both in its quantity and quality, was produced. This situation defies the common assumption embedded in historical master narratives that have emphasized the importance of new professional institutions.[24] When this interrelated set of domestic scientific sites is considered among other cases, we are forced to consider redrawing our institutional maps of late-Victorian and Edwardian science to more accurately reflect the prominent position of private, domestic sites.[25]

A final point emerging from my study is the importance of the country house for

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[22] This argument is developed further in Chapter 7.

[23] A similar argument for the case of physics may be found in Simon Schaffer, "Physics Laboratories and the Victorian Country House," in *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, ed. Crosbie Smith and Jon Agar (Basingstoke: Macmillan, 1998), pp. 149-180.

[24] For a general example, Thomas William Heyck, *The Transformation of Intellectual Life in Victorian England* (London: Croom Helm, 1982). For the biological sciences, Adrian Desmond, *The Politics of Evolution: Morphology, Medicine, and Reform in Radical London* (Chicago: University of Chicago Press, 1989). For the physical sciences, Mary Jo Nye, *Before Big Science: The Pursuit of Modern Chemistry and Physics, 1800-1940* (London: Prentice Hall, 1996).

[25] The strongest example of a study that has moved in this direction is Allan Chapman, *The Victorian Amateur Astronomer: Independent Astronomical Research in Britain, 1820-1920* (New York: John Wiley & Sons, 1998).

providing opportunities to women in science.[26] If we consider the case of Terling Place, which the historiography has rendered as an exemplar of private laboratories where men of science worked in solitude, even here we find, when considering the familial context, the importance of collaboration in the scientific work conducted both within and beyond the domestic laboratory.[27] Again, the reorientation begs the question of women's exclusion from the heart of scientific culture; from a perspective that expands the contemporary nature of science as something broader and more encompassing than elite professional science, gentlewomen's roles reappear as centrally important.

Turning to the second question I posed above – by what means can we access the private side to scientific lives? – I consider the issue of sources. Unlike the situation often afflicting historians of the families of the middling and laboring classes, primary documentary evidence pertaining to upper-class family life is abundant.[28] For the family network examined here, its members' roles within the highest departments of government and university administration have ensured the preservation of their private papers within national and university archives. Their participation in a multitude of professional

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[26] For other examples, Peterson, *Family, Love, and Work*, passim; Barbara T. Gates, *Kindred Nature: Victorian and Edwardian Women Embrace the Living World* (Chicago: University of Chicago Press, 1998), esp pp. 222-224; Donald L. Opitz, "'Behind folding shutters in Whittingehame House': Alice Blanche Balfour (1850-1936) and Amateur Natural History," *Archives of Natural History* 31 (2004): 330-348.

[27] On the rhetoric of solitude in science, Steven Shapin, "'The Mind Is Its Own Place': Science and Solitude in Seventeenth-Century England," *Science in Context* 4 (3) (1990): 191-218.

[28] On this point, compare Jessica Gerard, *Country House Life: Family and Servants, 1815-1914* (Oxford: Blackwell, 1994), pp. 12-13.

societies has also produced an abundance of materials preserved in societies' archives. Moreover, the younger generations' senses of their forbears' importance have led the survivors to carefully preserve diaries, letters, and household account books either at the country seats remaining in their possession or at local archives. For aristocrats, the preservation of family records held legal and practical significance as well; heirs to estates inherited not only land and houses but wills, deeds, genealogical data, insurance and tax valuations, expense records, and architectural plans.

Despite this wealth of primary manuscript documents, notable omissions exist, however. Nearly nothing is extant concerning the outfitting, design, and cost of the original laboratories at Terling Place; these presumably burned in the fire afflicting the laboratory wing in 1930.[29] Another noticeable gap exists in the surviving papers of Eleanor Sidgwick (elder sister of Arthur Balfour). Her biographer, a niece, referenced Sidgwick's diaries and travel journal, but none can be traced.[30] Similarly, the late historian Janet Oppenheim encountered only one extant letter between Eleanor and Henry Sidgwick, and my own searches produced no others.[31] Fortunately several letters

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[29] The only extant records I have discovered relate to renovations made to the laboratory by the fourth Baron in the early 1920s. While much of the library in the adjoining study was saved, photographs show damaged records appearing in the reckage; [Anon.], "Fire at Terling Place: Lord Rayleigh's Laboratory Destroyed," *The Essex Chronicle*, Chelmsford, 14 March 1930: 2; also [Anon.], "The Fire at Terling," *Nature* 125 (1930): 420.

[30] Ethel Sidgwick, *Mrs. Henry Sidgwick: A Memoir* (London: Sidgwick and Jackson, 1938), pp. 5-6.

[31] Janet Oppenheim, "Academic Partners: Henry and Eleanor Sidgwick and the Growth of Newnham College," *The Cambridge Review* (May 1996): 17-24, on 23 (n. 17). The dearth is curious given the abundance of extant letters between the Sidgwicks and

exchanged between the couple were reprinted in their domestic biographies.[32] Despite the biases that published life-and-letters and domestic biographies bear, when used critically they offer valuable sources of information. A striking paucity of materials also exists for Mary Parsons, Countess of Rosse, in the Birr Castle Archives where the Parsons family muniments are kept.[33]

The generous access granted me by holders of private muniments have made possible my study of previously untapped primary materials. In some cases, the result has been a deeper understanding of aspects to their home environment than available in the printed biographies or publicly-available archived letters. As an example (further discussed in Chapter 5), the scientific ability of Lady Rayleigh is underestimated by her biographers, but letters between her and her husband tell a story in which she engaged in serious discussions of scientific publications and contributed to her husband's own work. She assisted in a variety of experiments and helped in calculations. Moreover, the private side to the families' religious practices are revealed more strongly in the manuscript diaries and letters, than in published documents. Nevertheless, as valuable as the private

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other family members in most of the relevant archives.

[32] Sidgwick, *Mrs. Henry Sidgwick*; A.S[idgwick] and E.M.S[idgwick], *Henry Sidgwick: A Memoir* (London: Macmillan, 1906).

[33] Mary Rosse was born in Heaton Hall, near Bradford in Yorkshire. After her husband's death in 1867, she moved from Birr to London. In her old age, she often returned to Heaton Hall and contributed to the development of the parish there. I have searched in vain for further primary materials pertaining to her. Horace Hird, "Mary Wilmer Field: The Girl from Heaton," in *Bradford Remembrancer: Twenty-Six Essays on People, Or Incidents in their Lives which are Worthy of Remembrance*, (Bradford: McDonald, 1972), pp. 44-53.

documents are for reconstructing private lives, I use them in conjunction with published sources that often portray a subtly different perspective concerning the same historical details. Both kinds of sources are critical for reconstructing the meaning and character of science in these familial contexts.

To execute my themes and arguments, the structure of my dissertation generally begins with the domestic context and proceeds to the public arena. The chronology roughly follows the life cycle of the generation of family members constituting this aristocratic network. Rather than detailing all facets to their enterprise and all of their activities, I have elected to focus strategically on particular instances that illustrate broader patterns. Thus, while I may have justifiably chosen the continuity of country house science as practiced at Birr Castle throughout the Victorian period, I focus instead on Rayleigh's Terling Place, particularly because it had a more intimate connection to the key actors in the network. Sensitive to the wealth of scholarship that has already illuminated certain famous scientific episodes connected with this family (such as Rayleigh's Nobel-prize-winning discovery of argon), I have tried, when possible, to highlight lesser-known discoveries and experiments that captivated broader family interest and that better illustrates the character of their country-house scientific enterprise. Interwoven throughout all chapters are defining social, religious, and intellectual aspects of the most relevant local contexts.

In Chapter 2, I consider the historiography of Victorian science and the historical background to this particular family network, particularly their status and wealth, religious orientation, and pursuit of country-house science. To explain how science entered households and inspired gentlemen and gentlewomen to follow scientific avocations, in Chapter 3 I analyze patterns in private education within aristocratic homes. Challenging prior historical conceptions of early scientific learning as a largely autodidact phenomenon, I emphasize the way in which formal tutoring, libraries, and religious teachings framed the education of brothers and sisters. Carrying the theme of education forward, in Chapter 4 I examine the role of higher learning at Cambridge that enabled the formation of this familial network and their devotion to science. While this subject departs, somewhat, from the spaces of their homes, as I explain further in the chapter, family and home preserved a continuity for the network even when several of its members were resident at the university. Within this period at Cambridge, between 1865 and 1873, scientific reform shaped the critical intellectual milieu.

Chapter 5 returns home, as it were, to analyze in detail one case of country-house science, at Terling Place. Here I argue for the importance of family and religion to the domestic production of scientific knowledge, which leads to a reinterpretation of Terling as a site for a family enterprise in science as opposed to a solitary retreat for the gentleman amateur. Within the domestic context, the management of private science critically depended on the varied roles carried out by gentlewomen. Within the life cycle of the network's members, at this stage their professional engagement became particularly important. For this reason, in Chapter 6, with a focus on Frank Balfour and Rayleigh, I interpret their professional positions as strategic means by which they pursued personal scientific interests while leading aristocratic, grass-roots lobbies for Cambridge reform. Rather than view this Cambridge period in terms of separation from home and family, I show instead how they recreated their domestic institution at Cambridge in ways that both buttressed and enabled their professional influence.

Intimately connected with the development of professional identities, members of this network, especially Rayleigh, Salisbury, and Arthur Balfour, assumed public stances in the religion and science debates then raging in the post-Darwinian world. Chapter 7 considers their participation in the debates as part of a unified discourse that challenged the naturalism creed of the professional middle class. Their theistic view of nature explains, in part, the ways in which they selectively lobbied for endowments in science. To illustrate, in Chapter 8 I analyze Arthur Balfour's role in founding Britain's first chair in genetics at Cambridge, in which he aimed to promote the growth of the Mendelian program, then at war with the biometrician school. Although Balfour's support of this project can be cast as simply another means by which he challenged the threat of scientific naturalism, I show that he recognized the promise of Mendelian genetics for the nation's welfare and Cambridge's accelerating scientific reform. While these themes may appear, at first glance, remote from my main concern with domestic sites, I reveal that a country-house perspective in fact pervades the genetics episode. Private correspondence reveals the importance of private politicking behind the public's gaze. Moreover, the very design of Cambridge's genetics research station as a country cottage, owing much to Balfour's lobbying efforts, wedded science and domesticity beneath one roof. The irony, which I explore in the conclusion, is that well into the twentieth century, as private sites for science were indeed eclipsed by newly built professional institutions, ventures in which members of the aristocracy took leading roles bore the mark of a distinct, country-house vision for the future of science.

Returning to my introduction's opening theme of the pervasiveness of home science, my dissertation will thus show how members of these families engaged in popular and public science as intimately as they did with what Barbara Gates termed "high" science, "that is, the science of the laboratory or museum or scientific journal."[34] Thus, their consumption of scientific culture, as described in my initial chapters, was marked by an engagement in all sorts of media – "popular," "amateur," and "professional" – defying the rigid categorization arising from twentieth-century positivistic applications of these terms.[35] As the network's own activities and writings reveal, they influenced a multitude of genres and audiences, making them, in effect, at once amateurs and professionals, lobbyists and practitioners, popularizers and experts. This dissertation is a journey through the "common context" of private and public, Victorian and Edwardian science culture as experienced and ultimately shaped by an extended network of British aristocrats.[36]

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[34] Gates, *Kindred Nature*, p. 34.

[35] Lightman, "'The Voices of Nature'," pp. 188-189; Roger Cooter and Stephen Pumfrey, "Separate Spheres and Public Places: Reflections on the History of Science Popularization and Science in Popular Culture," *History of Science* 32 (1991): 237-267, esp. 249-251.

[36] Robert M. Young, *Darwin's Metaphor: Nature's Place in Victorian Culture* (Cambridge: Cambridge University Press, 1985), p. 24.

Chapter 2

The Victorian Scientific Aristocracy

> In a solitary chamber, or rather cell, at the top of the house, and separated from all other apartments by a gallery and staircase, I kept my workshop of filthy creation.[1]

In 1908, late in his scientific career, John William Strutt, third Baron Rayleigh, memorialized his friend, the physicist Henry Clifton Sorby, a pioneer of microscopic petrography. He observed how Sorby, "belonged to a class on whom England has special reason to congratulate herself – men who pursue science unprofessionally." "Specialization and the increasing cost and complication of experimental appliances are having a prejudicial effect," Rayleigh complained. "On the other hand, the amateur is not without advantages which compensate to a certain extant....[T]he example of Sorby suffices to show how much is open to ingenuity unaided by elaborate appliances."[2] Embedded in Rayleigh's remarks are hints of the tensions that developed between "professional" and "amateur" science in late-Victorian and Edwardian Britain. Those tensions also played out within Rayleigh's own scientific career, which began with his avocation in the physical sciences that he pursued exclusively at his private country house, but he later succumbed to professional claims that required him at times to transfer his research to public and academic laboratories. Despite these changing venues, he

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[1] Mary Shelley, *Frankenstein; or, the Modern Prometheus* [1818], 3 vols. in 1 (London: J.M. Dent, 1992), p. 38.

[2] Robert John Strutt, Fourth Baron Rayleigh, *Life of John William Strutt, Third Baron Rayleigh* [1924], aug. ed. by John N. Howard (Madison: University of Wisconsin Press, 1968), p. 319; on Sorby, Norman Higham, *A Very Scientific Gentleman: The Major Achievements of Henry Clifton Sorby* (Oxford: Pergammon Press, 1963).

performed his final researches in 1919 at home. He entered and departed the scientific world as an "amateur" man of science, though contemporaries and historians have justifiably classified him as a "professional." One of my objectives in this dissertation is to establish that he and the other scientific aristocrats within his familial network were, in fact, both.

Rayleigh's portrayal of Sorby touches on a well-documented transformation of the nineteenth-century sciences into professions characterized by credentialed experts, paid positions, and formal institutions devoted to teaching and research.[3] The theme of "professionalization" has captured a variety of processes within specific local contexts, including the advocacy of science lobbyists, relationship between science and government, academic reforms serving new educational needs within a rapidly

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[3] On Britain, Roy MacLeod, "The Support of Victorian Science: The Endowment of Research Movement in Great Britain, 1868-1900," *Minerva* 4 (1971): 197-230, reprinted in MacLeod, *Public Science and Public Policy in Victorian England* (Aldershot: Variorum, 1996); D.S.L. Cardwell, *The Organisation of Science in Britain*, rev. ed. (London: Heinemann Educational, 1972); Mary Jo Nye, *Before Big Science: The Pursuit of Modern Chemistry and Physics, 1800-1940* (London: Prentice Hall, 1996), pp. 12-13; Lynn Nyhart, "Natural History and the 'New' Biology," in *Cultures of Natural History*, ed. N. Jardine, J.A. Secord, and E.C. Spary (Cambridge: Cambridge University Press, 1996), pp. 426-443. On the historiography, J.B. Morrell, "Professionalisation," in *Companion to the History of Modern Science*, ed. R.C. Olby, G.N. Cantor, J.R.R. Christie, and M.J.S. Hodge (London: Routledge, 1996), pp. 980-989, and Adrian Desmond, "Redefining the X Axis: 'Professionals,' 'Amateurs' and the Making of Mid-Victorian Biology—A Progress Report," *Journal of the History of Biology* 34 (2001): 3-50. For the American context, George H. Daniels, "The Process of Professionalization in American Science: The Emergent Period, 1820-1860" [1967], in *Science in American Since 1820*, ed. Nathan Reingold (New York: Science History Publications, 1976), pp. 63-78; Sally Gregory Kohstedt, "The Nineteenth-Century Amateur Tradition: The Case of the Boston Society of Natural History," in *Science and its Public: The Changing Relationship*, ed. Gerald Holton and William A. Blanpied (Dordrecht: D. Reidel, 1976), pp. 173-190.

industrializing society, and the growth of industrial research within the private business sector.[4] Intellectual and experimental developments within the sciences added to the array of factors motivating a tendency toward professionalization, which has, admittedly, served as a useful historical category. There is a danger, however, in overemphasizing the effects of this broad trend on local practices, and particularly in concluding that "professional" science simply and inevitably sidelined "amateur" practice.[5] In particular, if we are to bring domestic practices in science to the center of our historical inquiry, we must first deconstruct the rubric of professionalization that has otherwise obscured rich domestic traditions.

Several scholars have encouraged this deconstruction by reconsidering the status of the professional identity in relation to the amateur, noting the durable respectability of amateurs throughout the nineteenth century.[6] An important conclusion emerging from

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[4] Michael Sanderson, "Research and the Firm in British Industry, 1919-1939," *Science Studies* 3 (1972): 107-151; Sanderson, "The English Civic Universities and the 'Industrial Spirit,' 1870-1914," *Historical Research* 61 (1988): 90-104.

[5] Stefan Collini, *Public Moralists: Public Thought and Intellectual Life in Britain* [1991], rpt. (Oxford: Clarendon Press, 2003), p. 203; Donald L. Opitz, "'This House is a Temple of Research': Country-House Centres for Late-Victorian Science," in *Sidelined Sciences? Shifting Centres in Nineteenth-Century Scientific Thinking*, ed. David Clifford, Elisabeth Wadge, Alex Warwick, and Martin Willis (Cambridge: Anthem, forthcoming).

[6] For example, in the biological sciences, Desmond, "Redefining the X Axis"; Richard Bellon, "Joseph Dalton Hooker's Ideals for a Professional Man of Science," *Journal of the History of Biology* 34 (2001): 51-82; John C. Waller, "Gentlemanly Men of Science: Sir Francis Galton and the Professionalization of the British Life-Sciences," *ibid.*, 83-114; and Samuel J.M.M. Alberti, "Amateurs and Professionals in One County: Biology and Natural History in Late Victorian Yorkshire," *ibid.*, 115-147. On the social categories, D.C. Coleman, "Gentlemen and Players," *Economic History Review* 26 (1973): 92-116.

their work is that traditions of amateur science continued to flourish and, within local contexts, lacked the connotation of inferiority implicated by contemporary professional, often urban, pundits. Moreover, historians have increasingly reclaimed the roles and contributions of popular science writers, women in science, and artisan naturalists previously sidelined by an historiographic emphasis on professional men. This scholarly work has demonstrated how these and other groups contributed to contemporary understandings of nature both among popular audiences and experts within "high" science.[7] As a result of the revisionist studies, new narratives summarizing the character of nineteenth century science now emphasize the diversity of scientific communities and practices, ranging from science in the parlor to science in Grub Street.[8]

Yet a further need continues to exist in our historical revisions. While "gentlemen of science" claimed a central place in the early historiography of Victorian science, scholars have usually considered them as a displaced sector by the end of the nineteenth century.[9] Based on the foregoing analysis of a particular network of gentlemen and

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[7] Important examples in this rich literature include Anne Secord, "Science in the Pub: Artisan Botanists in Early Nineteenth-Century Lancashire," *British Journal for the History of Science* 27 (1994): 383-408; Bernard Lightman, "'The Voices of Nature': Popularizing Victorian Science," in *Victorian Science in Context*, ed. Lightman (Chicago: University of Chicago Press, 1997), pp. 187-211; Barbara T. Gates, *Kindred Nature: Victorian and Edwardian Women Embrace the Living World* (Chicago: University of Chicago Press, 1998). Gates defines "high" science as "the science of the laboratory or museum or scientific journal" (p. 34).

[8] For example, James A. Secord, *Victorian Sensation: The Extraordinary Publication, Reception and Secret Authorship of* Vestiges of the Natural History of Creation (Chicago: University of Chicago Press, 2000), pp. 403-405, 524-525.

[9] Bernard Lightman, "Introduction," in *Victorian Science in Context*, ed. Lightman (Chicago: University of Chicago Press, 1997), pp. 7-8; Morris Berman, "'Hegemony' and

gentlewomen who remained powerful players in science into the early decades of the twentieth century, I argue for the persistence of the aristocracy's influence. Even amid social and political transformations that gradually curtailed the aristocracy's power, as I will show in later chapters, cases of aristocratic agency demonstrate the continued importance of this class as central stakeholders and influential voices beyond the period of their supposed demise.[10] My analysis reveals that important alliances formed between the aristocratic community and the rising middle professional classes, rather than factions divided by class divisions and professional interests.[11] The aristocratic men and women of science examined here often aligned their interests with diverse groups in the name of advancing science while continuing to promote the respectability of amateur practices.

This chapter explicates the social, economic, religious, and intellectual backgrounds to the network consisting of the Balfour, Campbell, Gascoyne-Cecil, Parsons, and Strutt families, drawing comparisons, when relevant, to other aristocratic families. I conclude with a reflection on the scope of nineteenth-century private, domestic-based scientific enterprise, as distinct from academic, industrial, and

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the Amateur Tradition in British Science," *Journal of Social History* 8 (1974-75), 30-50.

[10] On aristocratic decline, David Cannadine, *The Decline and Fall of the British Aristocracy*, rev. ed. [1992] (New York: Vintage, 1999).

[11] An influential source for this characterization of antagonism is Adrian Desmond, *The Politics of Evolution: Morphology, Medicine, and Reform in Radical London* (Chicago: University of Chicago Press, 1989), esp. pp. 1-24; 25-41, 101-151, 373-397. Martin J. Wiener, by contrast, argued for an "accommodation" between the upper and middle classes that, he claimed (problematically, in my view), contributed to the decline of British industry and economic strength; Wiener, *English Culture and the Decline of the Industrial Spirit, 1850-1980* [1984], 2nd ed. (Cambridge: Cambridge University Press, 2004), p. 8.

government-sponsored research. This background situates this particular aristocratic network within the broader context of late-Victorian science.

The Aristocratic Familial Context

In her memoirs, Lady Frances Balfour acknowledged the critical importance of the family as the foundation upon which all other institutions – the parish, county, and nation – rested. Arthur Balfour regarded the households in which he lived as paramount influences for the continuity they gave to his life.[12] Other memoirs, especially those reflecting the influence of evangelical religious beliefs, written by his family members and in-laws are typical in positioning the home and family as cherished institutions.[13] The high value the authors placed upon domesticity suggest its importance to their activities in science, which depended upon the country-house institution for the necessary physical, economic, and social infrastructure.[14] For this reason, I begin with the context that mattered most to my *dramatis personae*, the aristocratic family.

"Family" as a Victorian institution, as several historians have analyzed, underwent a transition during the nineteenth century. Generally, over the course of the century, particularly with the development of a self-acknowledged middle-class identity, the

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[12] Lady Frances Balfour, *Ne Obliviscaris: Dinna Forget*, 2 vols. (London: Hodder and Stoughton, 1930), I: 54; Arthur James, first Earl of Balfour, *Chapters of Autobiography*, ed. Mrs. Edgar Dugdale (London: Cassell, 1930), pp. 3-4.

[13] See the Domestic Biography section of my bibliography. More generally on this theme, Christopher Tolley, *Domestic Biography: The Legacy of Evangelicalism in Four Nineteenth-Century Families* (Oxford: Clarendon Press, 1997).

[14] I give substance to this point in Chapter 5. For the background to the Victorian country house, Mark Girouard, *The Victorian Country House* [1971], rev. enl. ed. (New Haven: Yale University Press, 1979).

meaning of family became more specialized in its application. In the eighteenth and early nineteenth centuries, the "household" was generally understood to include the members of the biological, nuclear family; the servants who typically lived in the same household and in cottages located on the estate; and a range of relatives who often stayed for seasons at a time, even though their own families were housed on other estates. In addition, friends who stayed with the family also counted as members of the household.[15] Georgians and Victorians frequently referenced this comprehensive identity of the household, inclusive of their biologically-related and non-related members, in their writings. Consistently, census takers counted all members present at the moment of their calling. In short, nineteenth-century senses of "family" were much broader than later definitions that restricted the term to the biological, nuclear family.[16]

Intimately involved in the development of this new meaning was a shift in Victorian values that placed increasing emphasis on marriage as a companionate arrangement as opposed to marriage as simply a strategy for extending and preserving aristocratic power networks and primogeniture, the typical passage of a gentleman's title

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[15] Leonore Davidoff and Catherine Hall, *Family Fortunes: Men and Women of the English Middle-Class, 1780-1850* (Chicago: University of Chicago Press, 1987), pp. 31-33; Lawrence Stone and Jeanne C. Fawtier Stone, *An Open Elite? England, 1540-1880* (Oxford: Clarendon Press, 1984), pp. 308-310; Jessica Gerard, *Country House Life: Family and Servants, 1815-1914* (Oxford: Blackwell, 1994), pp. 21-37: Chapter 1, "The Demography of the Family."

[16] On the interface between biomedical and cultural definitions of family and kinship, Ludmilla Jordanova, *Nature Displayed: Gender, Science and Medicine, 1760-1820* (London: Longman, 1999), pp. 161-227: "Part III: Family Values."

and estate through the male line.[17] In the writings of the figures belonging to the aristocratic network examined here, the more common designation they continued to use was that of "family circle," reflecting the expansive definition of the household. Yet their marital engagements displayed new emphases on affection, companionship, and intellectual interests shared among the betrothed above and beyond traditional aristocratic power considerations. Without his father's blessing, Robert Gascoyne-Cecil (as Viscount Cranborne) married Georgina Alderson in 1857. According to Andrew Roberts, "She was something of a blue-stocking.... He fell in love with [her]."[18] Georgina's family could boast academic accolades but no riches, prompting Cranborne's father to oppose the betrothal on the grounds that a marriage to the middle-classes would strain the estate, which Cranborne stood to inherit. Throwing all cautions to the wind (and risking his inheritance), he married Georgina without the presence of his father, stepmother, and brothers, who refused to attend the wedding. Temporarily cut off from his father's purse, until the latter died, Cranborne wrote hundreds of articles for serial publications like the *Saturday Review* and *Quarterly Review* to earn his own living.[19]

For analytical purposes, I shall refer to the interconnected families whose perspectives and actions that I will analyze as a loose familial "network." This network evolved over the century, displaying closer intimacies during certain periods and greater

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[17] M. Jeanne Peterson, *Family, Love, and Work in the Lives of Victorian Gentlewomen* (Bloomington: Indiana University Press, 1989), pp. 74-84, 186, 188-191.

[18] Andrew Roberts, *Salisbury: Victorian Titan* (London: Phoenix, 2000), p 30.

[19] Roberts, *Salisbury*, pp. 33, 37-67.

separation in others. Branches of this network, which enjoyed the usual range of affiliations made possible by the various institutions of aristocratic society, became more intimately linked at different stages through friendship and intermarriage.[20] My interest in the membership and extent of this broad network, which should be distinguished from Noel Annan's extensive genealogical analysis of the Clapham sect, is limited to only those sections that shared common social and intellectual contexts concerned with the sciences.[21] In the spirit of the broader, nineteenth-century application of the terms "household" and "family," I include among this network relatives, colleagues, friends, and estate staff.

The central scientific figures spanned three generations, centering on the associations formed between Robert Arthur Talbot Gascoyne-Cecil (third Marquis of Salisbury) (1830-1903), landlord, statesman, and amateur physical scientist; Arthur James Balfour (first Earl of Balfour) (1848-1930), laird, statesman, and philosopher; Francis Maitland Balfour (1851-1882), animal morphologist; Gerald William Balfour (second Earl of Balfour) (1853-1945), classicist and psychical researcher; Eleanor Mildred Sidgwick (nee Balfour) (1845-1934), feminist education reformer and psychical researcher; Henry Sidgwick (1838-1900), philosopher; and John William Strutt (third Baron Rayleigh) (1842-1919), landlord and amateur physicist. Peripheral to varying

[20] Leonore Davidoff, *The Best Circles: Society, Etiquette, and the Season* (London: Croon Helm, 1973).

[21] N.G. Annan, "The Intellectual Aristocracy," in *Studies in Social History: A Tribute to G.M. Trevelyan*, ed. J.H. Plumb (London: Longmans, Green and Company, 1955), pp. 243-287.

degrees were further members: William Cavendish (seventh Duke of Devonshire) (1808-1891), landlord, science patron, and amateur botanist; George John Douglas Campbell (eight Duke of Argyll) (1823-1900), landlord, amateur geologist, and science popularizer; Laurence Parsons (fourth Earl of Rosse) (1840-1929), landlord and amateur astronomer; Sir Charles Algernon Parsons (1854-1931), engineer; Robert John Strutt (fourth Baron Rayleigh) (1875-1947), landlord and physicist; and Lady Evelyn Barbara Balfour (1898-1990), agricultural scientist. Other scientific intimates included Charles Darwin and his sons, Horace, engineer; Francis (Frank), botanist; and George, physicist. Intermarriage linked the Darwins and Sidgwicks, illustrating the characteristic marital bonds existing among the various families. In 1883, after the death of his first wife, Frank Darwin married Henry Sidgwick's cousin Ellen Wordsworth Crofts, a Fellow and lecturer of Newnham College.[22] Other marital links existed between the Parsons and the Strutts and between the Gascoyne-Cecils and the Cavendishes. Figure 2.1 provides a schematic of the geographical distribution of this network's families and identifies the marital relations. My appendix gives the most important family trees.

Properties and Country Houses

While variations existed in the socioeconomic positions of the members of this network, as a whole they could boast the highest degree of power and wealth to be found among the British aristocracy. With the exception of the Darwins and Sidgwicks, the

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[22] Henry Sidgwick's mother, Mary Crofts, was Ellen Croft's aunt; A. S[idgwick] and E.M. S[idgwick], *Henry Sidgwick: A Memoir* (London: Macmillan, 1906), p. 2; Gwen Raverat, *Period Piece: A Cambridge Childhood* (London: Faber and Faber, 1952), p. 192; Annan, "The Intellectual Aristocracy," p. 264.

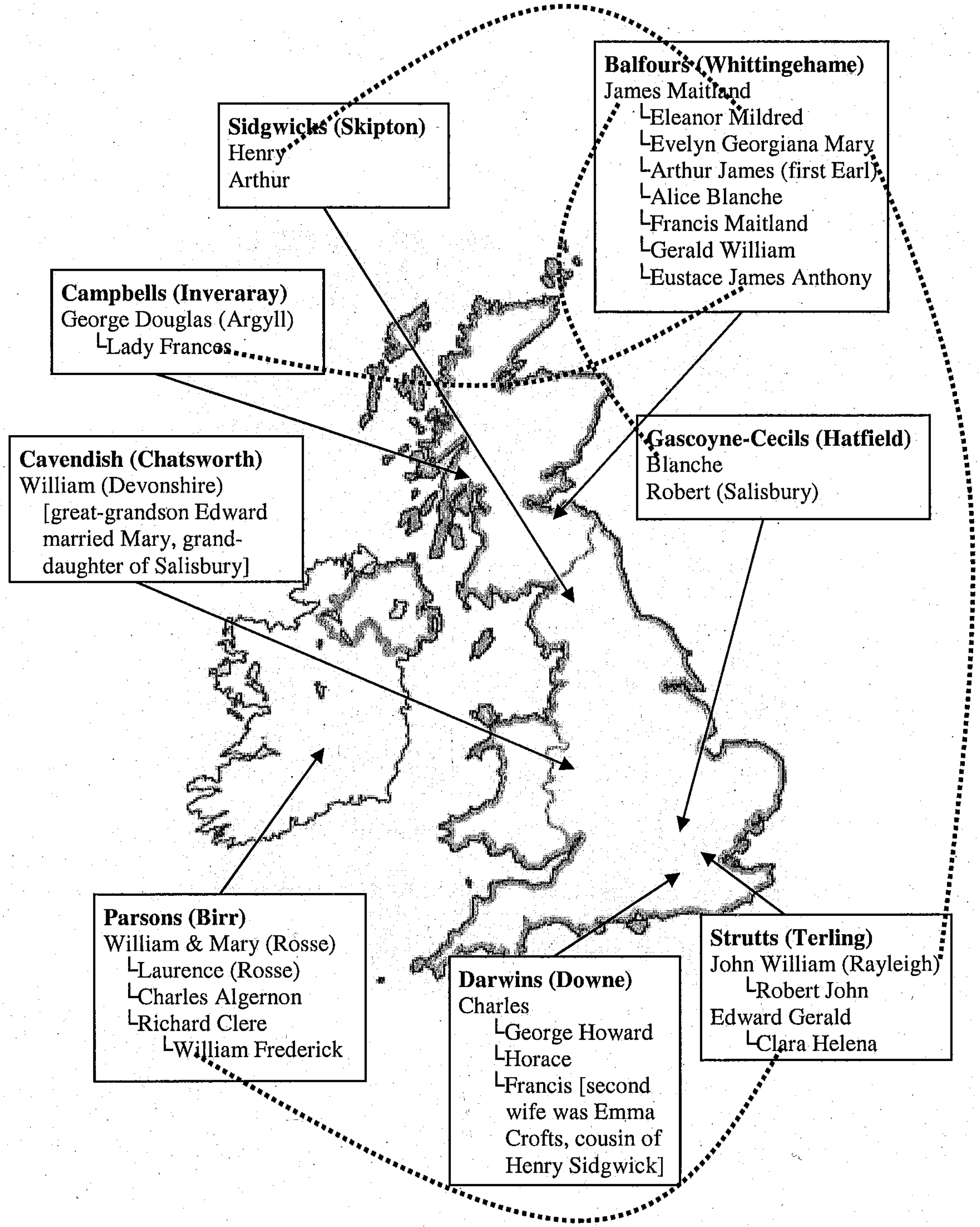

Figure 2.1. Geographic distribution of selected members of the scientific aristocracy. Marriages are indicated with dotted lines. Arrows indicate the location of country seats. Village or town names are given in parentheses. See Appendix for more detailed family trees. (The map is a modified version of the original, ©National Geographic.)

first-born members of all these families inherited titles of nobility or were created nobles within their lifetimes. Except for Lord Rayleigh, the titled gentlemen generally held multiple titles, acquired through a combination of inheritances and creations of nobility in distinct parts of the kingdom, for example Scotland or Ireland as well as England. At the extreme, Lord Argyll held some 13 titles (though not all simultaneously): 11th Lord of Kintyre, 18th Lord Campbell, 17th Lord Lorne, 10th Baronet Campbell, 5th Baron Hamilton of Hameldon, 4th Baron Sundridge, 8th Earl of Campbell and Cowall, 8th Marquess of Kintyre and Lorne, 8th Duke of Argyll, 17th Earl of Argyll, 8th Lord of Inverary, Mull, Movern and Tirie, 8th Viscount of Lochow and Glenyla, and 1st Duke of Argyll (United Kingdom).[23] More modestly, Lord Devonshire held two titles, the 7th Duke of Devonshire and 2nd Earl of Burlington. Arthur Balfour held no titles until his creation as first Earl of Balfour and Viscount Traprain in 1922.

In addition to noble titles, the families also possessed large tracts of land and, usually, multiple properties in several counties. John Bateman's 1878 compilation of land holdings totaling at least 3,000 acres and worth £3,000 from the official *Return of the Owners of Land* (1876) included the various estates owned by members of this network. Valuations are given in Figure 2.2. In each case, a country seat served as a base for family life. The range of the buildings' ages, architectural and landscaping styles, house staff,

[23] G.E. Cokayne, with Vicary Gibbs, H.A. Doubleday, Geoffrey H. White, Duncan Warrand and Lord Howard de Walden, eds., *The Complete Peerage of England, Scotland, Ireland, Great Britain and the United Kingdom, Extant, Extinct or Dormant*, new ed., 13 vols. in 14, rpt. in 6 vols. (Gloucester: Alan Sutton Publishing, 2000), I: 211.

Figure 2.2. Land holdings and incomes, 1876.[24]

Proprietor	**Counties of Estates**	**Total acres**	**Income (£)**
Argyll, Duke of	Argyll, Dumbarton	175,114	50,842
Balfour, A.J.	Ross., Haddington, Berwick	84,356	16,191
Devonshire, Duke of	14 properties, most in Derbyshire	198,665	180,990
Rayleigh, Baron	Essex	8,302	12,653
Rosse, Earl of	King's Co., Tipperary, York, W.R.	26,486	15,549
Salisbury, Marquis of	Herts., Dorset, Lancashire, Essex, Middlesex, Bedford, Norfolk, Wilts.	20,202	33,413

and parish relations reflect the rich diversity of British country houses that architectural historians have analyzed. I summarize the key features in Figure 2.3. To a modern reading audience, it is important to emphasize the large-scale nature of these stately homes. All still survive, but only a few are solely owned by private owners and still fewer by the biological heirs. They nonetheless are rare exceptions to the general extinction of the English country house in the last half of the twentieth century. Lawrence and Jeanne Fawtier Stone made an apt characterization in likening the splendid houses and parks as "the English equivalent of Disneylands."[25]

The estate values tabulated by Bateman represent the total gross income reported for the year, but these figures do not represent the full extent of the wealth of these

[24] From John Bateman, *The Great Landowners of Great Britain and Ireland* (London: Harrison and Sons, 1878).

[25] Stone and Stone, *An Open Elite*, p. 426. On the demise of the country house, Roy C. Strong, *The Destruction of the Country House, 1875-1975* (London: Thames and Hudson, 1974).

Figure 2.3. The country houses and their 19th-century proprietors.[26]

Proprietor	Country house	Year built	Town	Architects	Style
Argyll	Inverary Castle	1744-88	Inverary, Argyll	Robert Morris; Robert Mylne	Norman/ neo-Gothic
Balfour	Whittingehame House	1818	Haddington, East Lothian	Sir Robert Smirke	Neo- Ionic
Devonshire	Chatsworth House	1687-1707	Chesterfield, Derbyshire	William Talman	Palladian
Rayleigh	Terling Place	1772	Chelmsford, Essex	John Johnson	Neo-Ionic
Rosse	Birr Castle	1620-27; 1803	Birr, Co. Offaly	unknown; Earl of Rosse, John Johnston	Gothic; neo-gothic
Salisbury	Hatfield House	1608-12	Hatfield, Hertfordshire	Robert Lymninge	Elizabethan

families nor the financial hardships from which they never fully recovered following the agricultural depression of the 1870s. Arthur Balfour, for example, inherited estates and investments estimated at £4 million in 1869, but after his death his inheritors were forced to sell much of the property and evacuate the country house.[27] The families' patterns of

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[26] From John Cornforth and George Hughes-Hartman, *Inverary Castle* (Derby: Pilgrim Press, 1978); Paul Harris, *Life in a Scottish Country House: The Story of A.J. Balfour and Whittingehame House* (Whittingehame: Whittingehame House Publishing, 1989); Deborah Devonshire, *Chatsworth – The House* (London: Frances Lincoln, 2002); Strutt, *Life*; Mark Girouard, "Birr Castle, Co. Offaly," *Country Life* 37 (1965): 410-414, 468-471, 526-529; Lord David Cecil, *Hatfield House*, 7th impression (Stockbridge: Gascoyne Holdings, 1997). Parts of Birr and Hatfield date to the 15th century; Inverary, Terling, Birr and Hatfield underwent later repairs owing to damage from fires. This survey does not include later additions and improvements.

[27] Kenneth Young, *Arthur James Balfour: The Happy Life of the Politician, Prime Minister, Statesman and Philosopher, 1848-1930* (London: G. Bell and Sons, 1963), pp. xiii; Harris, *Life in a Scottish Country House*, pp. 98-101, 110-113.

patronage throughout these difficult years nevertheless suggest a certain level of disposable income and a commitment, at any rate, to maintaining a public image of *noblesse oblige*.[28] But given the economic context, their intellectual industry is inseparable from material concerns; the swell in their publications from the 1890s onwards represented not only products of their genius, but also a new source of income.[29]

In comparison with the other great British landowners, only Devonshire could boast a place among the five top income-generators in 1880: the Dukes of Westminster (grossing about £290,000), Buccleuch (£232,000), Bedford (£225,000), Devonshire (£181,000), and Northumberland (£176,000). With respect to estate sizes, none could compare to the Duke of Sutherland's extraordinary 1,358,545 acres, though Devonshire's, Argyll's, and Balfour's estates all ranked respectably among the largest holdings.[30] These numerical comparisons only go so far in indicating the social prestige enjoyed by all these families. While his estates appear modest in comparison to the others, Lord Rayleigh's leadership roles in local village affairs, for example as Lord Lieutenant, provide another means for judging the extent of his aristocratic power.[31]

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[28] I highlight significant instances of their philanthropy in later chapters. As one example, by 1920 Eleanor Sidgwick had cumulatively donated over £30,000 to Newnham College, Cambridge; Ethel Sidgwick, *Mrs. Henry Sidgwick: A Memoir* (London: Sidgwick & Jackson, 1938), p. 182.

[29] Balfour, with characteristic irony, stated after signing a contract with Cassells to write a two-volume autobiography, "I shall now expect the money to come flowing in"; Max Egremont, *Balfour: A Life of Arthur James Balfour* [1980] (London: Phoenix, 1998), p. 337.

[30] Cannadine, *The Decline and Fall of the British Aristocracy*, pp. 710-711.

[31] Strutt, *Life*, pp. 267-269.

Evangelicalism

As parish patrons, communicants, and keepers of family prayers, the family members showed a high degree of concern for religion. Although practicing religion in vastly different localities – the Balfours, for example, as communicants in the Scottish Presbyterian Church when at Whittingehame and communicants of the Church of England when in London – the families all shared a significant debt to the Evangelical Revival of the late-eighteenth and early nineteenth-centuries. As Boyd Hilton has pointed out, even as an imprecise phenomenon, *evangelicalism* inescapably shaped the "mentality" of the nineteenth century. Citing a contemporary estimate, Hilton noted, "By 1850 about one-third of Anglican clergymen, including many of the brightest and the best, may have been designated 'Evangelical' with a capital letter."[32] But among these aristocratic families, the evangelical influences proved to be deeper than a shared milieu.

The evangelical creed was distinguishable by its emphasis on the emotions over reason, the direct relationship between the individual soul and its creator, individual conscience as the organ of redemption and Christ's atonement as the means, and faith in the atonement which sanctifies individuals in preparation for Judgment Day. Evangelical factions included moderates and more extreme millenarians, led by charismatic spokespersons like the Rev. Edward Irving, founder of the Catholic Apostolic Church, and Joanna Southcott. Moderates tended to believe that God's providence worked

[32] Hilton distinguished between self-professed Evangelicalism or the Evangelical party from a broader notion of evangelicalism that he applied to individuals adopting evangelical beliefs though not avowedly professing themselves as Evangelical; Boyd Hilton, *The Age of Atonement: The Influence of Evangelicalism on Social and Economic Thought, 1795-1865* (Oxford: Clarendon Press, 1988), pp. 7, 26.

through physical laws that manifested a permanent, natural moral law. This contrasted with the millenarians' belief that God manifested his judgments through special interventions. Within the scientific aristocracy, individuals tended to follow the moderate stance.[33]

"To begin fearlessly, I am an Evangelical in heart & soul," wrote Rayleigh's Anglican grandmother Marianne Vicars to her daughter. "It is indeed a sect every where spoken against...it is a *sure* sign to me that they hold the *Truth*."[34] The death of her son (Rayleigh's uncle) in the Crimean War produced a potent and popular evangelical martyr under the pen of Catherine Marsh.[35] Her daughter, Clara Vicars (Rayleigh's mother), showed a similar fervor for atonement, chasteness, personal discipline, and familial devotion. After Clara's marriage to John Strutt, second Baron Rayleigh, she implemented a regime of daily family prayer and closely involved herself in her children's upbringing. Her devotion to keeping a religious household reflected the broader emphasis of

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[33] Hilton, *The Age of Atonement*, pp. 8-14. A good entre into the burgeoning scholarship on the relationship between evangelicalism and science is the collection, David N. Livingstone, D.G. Hart, and Mark A. Noll, eds., *Evangelicals and Science in Historical Perspective* (New York: Oxford University Press, 1999); also Geoffrey Cantor, "Quaker Responses to Darwin," *Osiris* 16 (2001): 321-342, and Peter J. Bowler, *Reconciling Science and Religion: The Debate in Early Twentieth-Century Britain* (Chicago: University of Chicago Press, 2001), pp. 289-296.

[34] Marianne Vicars, 'Mother's Thoughts', n.d., Terling.

[35] Catherine Marsh, *Memorials of Captain Hedley Vicars, Ninety-Seventh Regiment* (London: J. Nisbet, 1856); James R. Moore, *The Post-Darwinian Controversies: A Study of the Protestant Struggle to Come to Terms with Darwin in Great Britain and America, 1870-1900* (Cambridge: Cambridge University Press, 1979), p. 51.

evangelicalism on maternal authority within the domestic sphere.[36] The evangelical couple educated their children in a home-based system in which science and theology commingled. Evelyn Lady Rayleigh later observed, "[John] R[ayleigh] was brought up in a country home where both parents were strongly religious. Their religion was what is called evangelical in type, & the Vicar of Terling, afterwards Canon Bernard of Salisbury, shared their views. His was no doubt a strong influence."[37] The family's "book-room" housed both the prayer books and Rayleigh's first experimental apparatus. In his more mature years it also served as the site of his first private laboratory.[38]

Lady Blanche Balfour displayed a similar evangelical zeal in the upbringing of her children, her direction of local parish affairs, and her family's practice of daily prayer and Bible readings. "Teach me to use my influence over each and all," she often recited in prayer, "that I may guide with the love and wisdom which are from above the religious education of my children." She directed her children's home education in religion and science, viewing each as a means for understanding God's providence in the world. She hand-picked the Rev. James Robertson as Whittingehame's presbyterian minister; she was generally "Broad-Church" in her attitude toward the Church. After her death, Robertson presented her life as an exemplar in the evangelical magazine, *Good Words*.[39]

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[36] Gerard, *Country House Life*, pp. 278-279.

[37] Evelyn Rayleigh, "Notes," Terling.

[38] Strutt, *Life*, pp. 15-16, 408-409.

[39] James Robertson, *Lady Blanche Balfour: A Reminiscence* (Edinburgh: Oliphant, Anderson and Ferrier, 1897), pp. 5-7, 62-63; Janet Oppenheim, "A Mother's Role, A Daughter's Duty: Lady Blanche Balfour, Eleanor Sidgwick, and Feminist Perspectives,"

Similar evangelical perspectives may be observed in the lives of Laurence Parsons, second Earl of Rosse, Mary Parsons, Countess of Rosse, and Georgina, Marchioness of Salisbury.[40] Like Lady Rayleigh and Lady Balfour, these individuals directed their children's education. The impressions made on subsequent generations' religious beliefs inescapably owed their character to the older generations' evangelicalism. Some, like the third Marquis of Salisbury and Henry Sidgwick explicitly criticized the evangelical doctrine, yet their religiousness and public service founded on moral principles only underlined the effect of evangelicalism upon their lives.[41]

Science in the Country House

As characteristic as their religiousness was the unusual seriousness with which these families pursued scientific avocations. To a certain extent, like many aristocratic landowners of the nineteenth century, they engaged in a common scientific culture, particularly given its infusion within horticulture and agriculture. The Stones highlighted the role of the country seat as a means for aristocratic families to display their power, and

Journal of British Studies 34 (1995): 196-232.

[40] N.D. Atkinson, "Sir Laurence Parsons, 2nd Earl of Rosse, 1758-1841," Ph.D. thesis: University of Dublin, 1961; Donald L. Opitz, "'So Clever a Photographer': Mary Countess of Rosse and Victorian Photographic Science," *Women Scholars and Institutions, Studies in the History of Sciences and Humanities*, 13, ed. Sona Strbanova, Ida H. Stamhuis and Katerina Mojsejova (Prague: Research Center for History of Science and Humanities, 2004), pp. 545-564; Roberts, *Salisbury*, p. 30.

[41] G.M. Young, *Portrait of an Age: Victorian England*, ann. ed. G. Kitson Clark (London: Oxford University Press, 1977), p. 29; Roberts, *Salisbury*, p. 25; Sheldon Rothblatt, *The Revolution of the Dons: Cambridge and Society in Victorian England* (Cambridge: Cambridge University Press, 1968), pp. 133-141; 217-219; Bart Schultz, *Henry Sidgwick: Eye of the Universe: An Intellectual Biography* (Cambridge: Cambridge University Press, 2004), pp. 43, 82, 247-248.

also for this purpose they cultivated parks and ornamental gardens on the estates. Consistent with Judaeo-Christian traditions, the garden possessed a spiritual character that marked it as an earthly paradise where the occupant contemplated peace, reflected spiritual well-being, and refreshed his or her soul.[42] Among the estate's hired staff, head gardeners held an esteemed place; they received higher pay, enjoyed more latitude in defining their work, and supervised an entire cadre of garden staff.[43] The discovery and traffic of new exotic species from overseas fueled various collecting crazes that inspired country gentlemen to sponsor collecting expeditions, new hothouse technologies, and the botanical study of new specimens. In addition, many landlords hoped to increase agricultural production and maximize the nutritive value of soils, and they sponsored chemical study to realize these ends.[44]

Commentators on the background to modern British science often note its early character as a scattering of amateur practices, its debt to gentlemanly codes, and its struggle to professionalize through societies devoted to providing opportunities for distant

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[42] Andrew Cunningham, "The Culture of Gardens," in *Cultures of Natural History*, pp. 38-56.

[43] Stone and Stone, *An Open Elite*, pp. 299-307; Kate Coloquhoun, *A Thing in Disguise: The Visionary Life of Joseph Paxton* (London: Harper Perennial, 2004), p. 36, 43-45, 86.

[44] David Allen, *The Victorian Fern Craze: A History of Pteridomania* (London: Hutchinson, 1969); Allen, "Tastes and Crazes," in *Cultures of Natural History*, pp. 394-407; Coloquhoun, *A Thing in Disguise*; Sir E. John Russell, *A History of Agricultural Science in Great Britain, 1620-1954* (London: George Allen & Unwin, 1966); Donald L. Opitz, "Russell, John, Sixth Duke of Bedford," in *The Dictionary of Nineteenth-Century British Scientists*, ed. Bernard Lightman, 4 vols. (Bristol: Thoemmes Continuum, 2004), IV: 1749-1750.

members to associate.[45] Participants in serious scientific study spanned the British social hierarchy, and while social conventions governed the relations of its members, artisans and gentlemen alike added to the production of scientific knowledge.[46] The popularity of Mary Shelley's Gothic novel, *Frankenstein*, quoted at the beginning of this chapter, reflected the popular fascination for experimentation, particularly with electricity. Shelley represented Victor Frankenstein's investigation into nature as occurring in the recesses of his home; this reflected a well-known truth about the actual places of research – they were by and large based at domestic sites.[47]

Histories of science routinely acknowledge the domestic context of laboratory science prior to the period of professionalization, but usually apologetically. Speaking for medicine, Nicholas Jardine wrote, "In the 1840s the only laboratory of which the average European or American man would be likely to have a direct acquaintance was that of the pharmacist."[48] More optimistically, Frank James declared, "Laboratories did not exist in

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[45] Berman, "Hegemony"; Jack Morrell and Arnold Thackray, *Gentlemen of Science: Early Years of the British Association for the Advancement of Science* (Oxford: Oxford University Press, 1981); Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994).

[46] Anne Secord, "Corresponding Interests: Artisans and Gentlemen in Natural History Exchange Networks," *British Journal for the History of Science* 27 (1994): 383-408.

[47] On Gothic literature's treatment of domesticity, Kate Ferguson Ellis, *The Contested Castle: Gothic Novels and the Subversion of Domestic Ideology* (Urbana: University of Illinois Press, 1989). For a pioneering account of British home science, Steven Shapin, "The House of Experiment in Seventeenth-Century England," *Isis* 79 (1988): 373-404.

[48] Nicholas Jardine, "The Laboratory Revolution in Medicine as Rhetorical and Aesthetic Accomplishment," in *The Laboratory Revolution in Medicine*, ed. Andrew

the pre-industrial age," but, in the nineteenth century, "much experimental physics at this time was done in private laboratories."[49] By contrast, a century ago the noted physician William Henry Welch weighed in, "Private laboratories for investigation must have existed from the earliest times. Doubtless Aristotle had his laboratory."[50] An interesting essay by the American physicist Florian Cajori dated the origin of laboratories with "the advent of the experimentalist," a designation he applied to the Medieval alchemists and astrologists. Cajori articulated the well-known truth about early research sites: "Previous to the nineteenth century all of them, with hardly and exception, were private laboratories owned by individual investigators or their patrons."[51]

The history of private laboratories clearly presents difficulties. Definitions of "laboratory" widely differ in both meaning and application. In its most restricted sense, early in the nineteenth century the term corresponded to the German "Laboratorium," meaning a chemical laboratory.[52] It was this meaning that the *London Encyclopædia*

Cunningham and Perry Williams (Cambridge: Cambridge University Press, 1992), p. 304.

[49] Frank A.J.L. James, ed., *The Development of the Laboratory: Essays on the Place of Experiment in Industrial Civilisation* (New York: American Institute of Physics, 1989), pp. 1, 3. For a similar view, Melba Philips, "Laboratories and the Rise of the Physics Profession in the Nineteenth Century," *American Journal of Physics* 51 (1983): 497-503.

[50] William H. Welch, "The Evolution of Modern Scientific Laboratories," in *Annual Report of the Board of Regents of the Smithsonian Institution* (Washington: Government Printing Office, 1896), p. 495.

[51] Florian Cajori, *A History of Physics in its Elementary Branches, including the Evolution of Physical Laboratories* (New York: Macmillan, 1899), p. 287.

[52] Cajori, *A History of Physics*, p. 287.

highlighted in its lengthy entry on the "Laboratory" in 1829: "The operating room or apartment of a chemist."[53] "Workshop" in fact enjoyed wider applicability closer in meaning to a more modern definition of "laboratory," as reflected in Shelley's portrayal of Frankenstein's "workshop of filthy creation." Yet the workshop and laboratory were distinct, as indicated in C.L. Brightwell's popular science title, *Heroes of the Laboratory and the Workshop*.[54] Similarly, in his reminiscences of his family's scientific activities at Birr Castle, Randal Parsons distinguished between his father's "large workshop...at the South West angle," his brother's "chemical laboratory" at the gatehouse, his mother's "photographic room...adjoining the workroom," and the "Telescopes and Observatory," where his father "was constantly out at night."[55] By the last third of the nineteenth century, however, further types of laboratories sprung into being, requiring that the term previously restricted to chemistry be extended to other disciplines. When Rayleigh desired to build a private "laboratory" and sought James Clerk Maxwell's advice in 1871, Clerk Maxwell offered an expansive definition of "laboratory": "The word denotes a place to work at experiments and connotes a place full of articles not marked at present and liable to noxious fumes."[56]

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[53] [Anon.], "Laboratory," in *The London Encyclopædia*, 22 vols. (London: Thomas Tegg, 1829), XII: 392.

[54] C.L. Brightwell, *Heroes of the Laboratory and the Workshop* (London: Routledge, Warnes, & Routledge, 1859).

[55] Randal Parsons, *Reminiscences* (privately printed, n.d.), 7-9, 13, Birr.

[56] James Clerk Maxwell to J.W. Strutt, Glenlair, 8 July 1871, Terling (photocopy of original in Imperial College Archives, Rayleigh Collection). Much of this letter is quoted in Strutt, *Life*, pp. 59.

This evolution in the term's meaning complicates identifying forerunners to the modern laboratories of various specialized types: chemical, physical, engineering, anatomical, morphological, and physiological. In addition to this challenge, there is little documentary evidence identifying private research sites and their nature. Contemporary practitioners had a working knowledge of the sites, but few had reason to catalog them. Exceptions exist for astronomical observatories. John L.E Dreyer, for example, cataloged an extensive list for the ninth edition of the *Encyclopædia Britannica*.[57] Practitioner histories like Cajori's and Welch's also enumerated examples of private chemical laboratories, but they did not intend their accounts as catalogs, and they are therefore grossly incomplete.[58] Certain illustrious cases, like Rosse's Birr Castle, captured the Victorian imagination in the popular press through images that the families themselves helped to produce, but these are again exceptions to the rule.[59]

But, as I suggested in Chapter 1, a preponderance of popular science manuals by the mid-nineteenth century implies a certain ubiquity in the household practice of science at home. With this in view, we might be tempted to simply characterize private research, even within aristocratic households, as instances of a widespread and therefore

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[57] J.L.E. Dreyer, "Observatory," *The Encyclopædia Britannica* 9th ed. (New York: Charles Scribner's Sons, 1884), pp. 708-717; for other compilations, Allan Chapman, *The Victorian Amateur Astronomer: Independent Astronomical Research in Britain, 1820-1920* (New York: John Wiley & Sons, 1998), pp. 312-313.

[58] Cajori, *A History of Physics*; Welch, "The Evolution of Modern Scientific Laboratories"; Lord Rayleigh, "Some Reminiscences of Scientific Workers of the Past Generation and their Surroundings," *The Proceedings of the Physical Society* 48 (1936): 217-246.

[59] Opitz, "So Clever a Photographer."

unquantifiable cultural phenomenon. Janet Browne took this approach in explaining the inspiration for Erasmus and Charles Darwins' chemistry experiments in the scullery shed on their father's estate:

> The development of gas chemistry after John Dalton's explanation of chemical activity in atoms and atomic weights lent itself to repetition in home laboratories. Simple experiments in sheds like the Shrewsbury Lab became enormously popular among the gentry, with a large literature and range of apparatus being rapidly produced to suit.[60]

Neither the apologetic nor the broadside approach seem satisfactory for providing an historical, explanatory framework within which to situate the mid-century country-house scientific practices of interest to me here. We should expect distinguishing features between what was possible on a landed estate from more modest cases like that of the middling James Bisset, noted for the museum he kept at his house in Birmingham.[61]

A particularly rich source of information regarding the social context of aristocratic science is the Victorian life-and-letters genre. A tantalizing wealth of details about particular domestic sites of science are embedded in personal reminiscences, letters, and biographical notes typically published in scientific memoirs. As one example, the well-traveled science expositor Mary Somerville cited over a dozen examples of individuals or marital couples with whom she associated that conducted private research at home; these included Sir David Brewster, William Hyde Wollaston, Thomas Young, Sir James South, Sir John and Lady Herschel, Sir Henry and Lady Bunbury, Admiral

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[60] Janet Browne, *Charles Darwin: Voyaging* (London: Pimlico, 1995), p. 30.

[61] Davidoff and Hall, *Family Fortunes*, pp. 249-250, 283, 416-419.

Smyth, James Veitch, Sir Roderick and Lady Murchison, and others.[62] Similarly, Cornelia, the talented wife of the squire and electrician Andrew Crosse, detailed the hospitality she and her husband enjoyed as guests at various scientific houses, as well as the hospitality they extended in return to visitors to the laboratory at their Somerset country house, Fyne Court.[63] Victoria Carroll's recent study of the social context of Charles Waterton's famous Victorian taxidermic collection at Walton Hall, in West Yorkshire, demonstrates the rich array of visitors, activities, and social conventions involved in a single case of country-house science.[64] Walton Hall reminds us that country-house museums add to the array of observatories, laboratories, photographic rooms, and workshops already identified as types of private research sites.

Enumerating cases of country-house science falls beyond the scope of my present concern, but the few examples indicated here hint at the extensive, private social circles

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[62] Mary Somerville, *Personal Recollections from Early Life to Old Age of Mary Somerville*, ed. Martha C. Somerville (London: John Murray, 1873), pp. 99, 103, 129-135, 154, 212, 218-219; on Somerville, Kathryn A. Neeley, *Mary Somerville: Science, Illumination, and the Female Mind* (Cambridge: Cambridge University Press, 2001). Further on the domestic context to Somerville's own work and for other cases, Sally Gregory Kohlstedt and Donald L. Opitz, "Re-imag(in)ing Women in Science: Projecting Identity and Negotiating Gender in Science," in *The Changing Image of the Sciences*, ed. Ida H. Stamhuis, Tuen Koetsier, Cornelius de Pater, and Albert van Helden (Dordrecht: Kluwer, 2002), pp. 105-139.

[63] [Cornelia A.H. Crosse], *Memorials, Scientific and Literary, of Andrew Crosse, the Electrician* (London: Longman, 1857); Mrs. Andrew Crosse, *Red Letter Days of My Life*, 2 vols. (London: Richard Bentley and Son, 1892); Donald L. Opitz, "Crosse, Andrew (1784-1855)," in *Dictionary of Nineteenth-Century British Scientists*, I: 507-510.

[64] Victoria Carroll, "The Natural History of Visiting: Responses to Charles Waterton and Walton Hall," *Studies in History and Philosophy of Biological and Biomedical Sciences* 35 (2004): 31-64.

through which nineteenth-century British gentlemen and gentlewomen of science moved.[65] It is within the "private" – yet strikingly accessible – spaces of country-house society that the members of the aristocratic elite encountered science and entered among its ranks as amateurs and professionals. The informal associations developed between the families provided a rich social context in which the Balfour, Campbell, Cavendish, Darwin, Gascoyne-Cecil, Parsons, and Strutt families carried on distinct traditions of country-house science in their respective localities. We are left with a question: in which particular ways did individuals of these families become inspired to pursue their avocations in science?

[65] Late-nineteenth century cases in the physical sciences, particularly private laboratories built by the new gentry, are given in Simon Schaffer, "Physics Laboratories and the Victorian Country House," in *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, ed. Crosbie Smith and Jon Agar (Basingstoke: Macmillan, 1998): 149-180. Spiritualism provided yet another context for home study; Alex Owen, *Women Power and Spiritualism in Late Victorian England* (Philadelphia: University of Pennsylvania Press, 1990); Alison Winter, *Mesmerized: Powers of Mind in Victorian Britain* (Chicago: University of Chicago Press, 1998).

Chapter 3

Schooling Young Gentlemen and Ladies: Home Education for Science

> It therefore appears to be very important to success in science, that a man should have an able mother. I believe the reason to be, that a child so circumstanced has the good fortune to be delivered from the ordinary narrowing, partisan influences of home education.[1]

In January 1867 a young Gerald Balfour advertised in his family's holiday newsletter, "The Whittinghame Advertiser," the private natural history collection that he, his four brothers, and his three sisters assembled at their family's country house in Haddingtonshire, Scotland: "A fine stuffed specimen of the Ruff, and one of the Little Owl, have been lately received, and are now being exhibited at the Whittinghame Museum. Admission Free." He added, "Specimens of the Greenshank, the Magpie, & of a species of Merganser may be seen in the Museum on Friday."[2] Balfour's advertisements characterised the museum as publicly accessible, but his mother, Lady Blanche Balfour gave a different impression in a satirical Letter to the Editor: "But when I come to read about birds and their beautiful colors I was dazed to think of them...and so this is to ask Mr Editor, if so be as we poor ignorant creatures that hasn't never seen them birds mightn't have a sight of them and if those birds as is talked about...mightn't never come downstairs to be looked at."[3]

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[1] Francis Galton, *Hereditary Genius: An Inquiry into its Laws and Consequences* [1869] 2nd ed. (London: Macmillan, 1892), p. 196.

[2] "The Whittinghame Advertiser," ser. 2 (2) (1866-67), BP, NAS GD433/2/93/8.

[3] "The Whittinghame Advertiser," ser. 2 (2) (1866-67), BP, NAS GD433/2/93/8.

Private natural history collections, like Whittingehame's, had increasing currency in Victorian Great Britain as popular science texts inundated reading markets at mid-century and various collecting crazes captivated the public.[4] Manuals, catechisms, conversations, and companions emphasised the theological lessons and pleasure obtainable from the study of nature.[5] Aimed primarily for a middle-class readership, these texts also served as suitable primers for the home education of youth of all social classes. While not always their expressed intention, beginner's textbooks inspired some readers to eminent careers in science; Jane Marcet's *Conversations on Chemistry* famously inaugurated Michael Faraday's chemical studies.[6] Largely owing to the popularity of

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[4] *Whittinghame* was the spelling in use until Alice Balfour initiated its change (for pronunciation reasons) in 1894; Lady Frances Balfour, *Ne Obliviscaris: Dinna Forget*, 2 vols. (London: Hodder and Stoughton, 1930), I: 237. A still earlier spelling was *Whittingham.* I will use the modern spelling *Whittingehame* except where earlier spellings appear in titles or quoted material. Anne Larsen, "Equipment for the Field," in *Cultures of Natural History*, ed. N. Jardine, J.A. Secord, and E.C. Spary (1996; Cambridge: Cambridge University Press, 1997), 358-377; David Allen, "Tastes and Crazes," in *Cultures of Natural History*; Bernard Lightman, "'The Voices of Nature': Popularizing Victorian Science," in *Victorian Science in Context*, ed. Bernard Lightman (Chicago: The University of Chicago Press, 1997), pp. 187-211; Harriet Ritvo, "Animal Pleasures: Popular Zoology in 18th- and 19th-century England," *Harvard Library Bulletin* 33 (1985): 239-279.

[5] Greg Myers, "Science for Women and Children: the Dialogue of Popular Science in the Nineteenth Century," in *Nature Transfigured: Science and Literature, 1700-1900*, ed. John Christie and Sally Shuttleworth (Manchester: Manchester University Press, 1989), pp. 171-200; Aileen Fyfe, "Young Readers and the Sciences," in *Books and the sciences in history*, ed. Marina Frasca-Spada and Nick Jardine (Cambridge: Cambridge University Press, 2000), pp. 276-290; Anne Secord, "Botany on a Plate: Pleasure and the Power of Pictures in Promoting Early Nineteenth-Century Scientific Knowledge," *Isis* 93 (2002): 28-57.

[6] Jane Marcet, *Conversations on Chemistry* [1806]. rpt. with intro. by Aileen Fyfe in *Science Writing by Women*, ed. Bernard Lightman, vols. 1-2 of 7 (Bristol: Thoemmes Continuum, 2004), 1: v.

Philip Gosse's books, aquaria, terrariums, and museums increasingly accompanied lay science libraries in Victorian households.[7] The Balfour's museum at Whittingehame thus marked a fairly standard engagement in household science for the 1860s.

As late as the mid-nineteenth century, elementary education remained primarily the province of the home, the influence of which was therefore paramount upon the upbringing of Victorians.[8] In his *Self-Help Series*, biographer Samuel Smiles explained, "Home is the first and most important school of character."[9] Character building in the nineteenth century required individual and private effort, but it also depended upon the social influences of the family. Arthur Balfour reflected, "I was fortunate in being born with the germs of many tastes; I was still more fortunate in the wise way in which they were encouraged by my mother. The home influences were thus unusually propitious."[10] For boys, and especially for girls, who attended boarding schools less often, the home and family determined in large measure the direction of their inclinations.[11]

The Victorian biography – the "life-and-letters" – was an enduring genre that

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[7] Philip F. Rehbock, "The Early Dredgers: 'Naturalizing' in the British Seas, 1830-1850," *Journal of the History of Biology* 12 (1979): 293-368.

[8] Richard D. Altick, *The English Common Reader: A Social History of the Mass Reading Public, 1800-1900* [1957] (Chicago: Phoenix Books, 1963), pp. 166-167.

[9] Samuel Smiles, *Character* [1871], rev. ed., *Self Help Series* (Chicago: Bedford, Clarke and Company, 1881), p. 44.

[10] Arthur James, First Earl of Balfour, *Chapters of Autobiography*, ed. Mrs. Edgar Dugdale (London: Cassell, 1930), p. 10; Stefan Collini, *Public Moralists: Political Thought and Intellectual Life in Britain* (Oxford: Clarendon Press, 1991), pp.108-110.

[11] Jessica Gerard, *Country House Life: Family and Servants, 1815-1914* (Oxford: Blackwell, 1994), pp. 48-55.

presented the private lives of men and women of science to reading publics. More than any other genre, it has detailed the intimate relationships, home life, and private thoughts of noteworthy gentlemen and ladies, endowing intellectual genius with familiar qualities. Because of its emphasis on the private and personal, the life-and-letters genre remains the single most important window into the early home education of Victorian men and women of science.[12] Because Victorian biographies are shaped by their authors' agendas, like the evangelization of a work ethic or the promotion of noble character-building, their portrayals of childhood are also shaped by these same agendas.[13] David Layton has noted how in the absence of "limited assimilation of science into the schools" in the early Victorian period, "there was a not insignificant quantum of scientific knowledge... impossible to account for in terms of formal education." He therefore argued, largely on the basis of biographical sources, that scientific education until the mid-nineteenth century depended upon a strongly autodidactic tradition: "The biographies of nineteenth-century scientists and of working men provide much evidence of self-teaching of science

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[12] Paul White, "Letters and the Scientific Life in the Age of Professionalization," paper presented at the History of Science Society Annual Meeting, Cambridge, MA, 20-23 November 2003. See also Michael Shortland and Richard Yeo, eds., *Telling Lives in Science: Essays on Scientific Biography* (Cambridge: Cambridge University Press, 1996).

[13] Geoffrey N. Cantor, "The Scientist as Hero: Public Images of Michael Faraday," in Shortland and Yeo, *Telling Lives in Science,* pp. 171-193; Christopher Tolley, *Domestic Biography: The Legacy of Evangelicalism in Four Nineteenth-Century Families* (Oxford: Clarendon Press, 1997), pp. 117-161; Anne Secord, "'Be What You Would Seem to Be': Samuel Smiles, Thomas Edward, and the Making of a Working-class Hero," *Science in Context* 16 (2003): 147-173.

and dissemination of scientific knowledge through informal channels."[14] An autodidactic explanation emphasizing "self-teaching," however, places too much emphasis on solitary learning for mastery of rather technical subjects, presenting an image of divinely-endowed genius very much along the lines of the Romantic ideal.[15] While autodidacts certainly thrived during a period in which the social-makeup of British science was dominated by amateurs and "devotees," the "self-taught" concept does not satisfactorily explain the social character of home education that made scientific learning possible.[16]

Layton also argued that "the self-motivated and non-institutionalized pursuit of scientific knowledge was an activity which transcended all class barriers."[17] While it is true that audiences of popular science included members of all classes, the patterns by which working-class and aristocratic youth became exposed to scientific learning nevertheless show marked differences. Aristocratic households, for instance, could afford live-in governesses and tutors, and many of the nation's most significant book collections rested in the private libraries of country gentlemen.[18] Moreover, upper-class children had

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[14] David Layton, *Science for the People: The Origins of the School Science Curriculum in England*, (New York, Science History Publications, 1973), pp. 29-30.

[15] Simon Schaffer, "Genius in Romantic Natural Philosophy," in *Romanticism and the Sciences*, ed. Andrew Cunningham and Nicholas Jardine (Cambridge: Cambridge University Press, 1990), pp. 82-98.

[16] On the devotee, Robert H. Kargon, *Science in Victorian Manchester: Enterprise and Expertise* (Baltimore: The Johns Hopkins University Press, 1977), pp. 34-85.

[17] Layton, *Science for the People*, p. 29.

[18] Thomas Frognall Dibdin, *Reminiscences of a Literary Life* (London: J. Major, 1836).

opportunities to meet legendary names in science right at home, as their fathers' country seats served as popular destinations for intellectuals moving in aristocratic circles. Among the visitors to the young Andrew Crosse's home, Fyne Court (in Somerset), were Benjamin Franklin and Joseph Priestly, two intimate friends of his father Richard Crosse (who was not himself a man of science). The impressions made upon Andrew by these distinguished men of science inspired, in some measure, his later avocation in electricity.[19]

A primary aim of this chapter, therefore, is to challenge the autodidactic thesis explaining the mid-Victorian education of amateurs of science and present an alternative explanation in which the social influences of family members, governesses, tutors, and visitors made possible the scientific education of aristocratic youth during an age in which more formal modes in schools were limited. Moreover, despite the secondary role that some schooling played in children's early education, this chapter will show how households' relationships with schools made possible important, though often private, exposure to scientifically-gifted teachers as well as scientific texts. Lastly, popular science books and periodicals themselves served as critical vehicles by which pupils learned the rudiments of science, but this chapter reveals how such book-learning depended upon social environments that encouraged conversations about reading. In other words, education for science, particularly for children of the landed gentry and

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[19] [Cornelia A.H. Crosse], *Memorials, Scientific and Literary, of Andrew Crosse, the Electrician* (London: Longman, 1857); Donald L. Opitz, "Crosse, Andrew (1784-1855)," in *Dictionary of Nineteenth-Century British Scientists*, ed. Bernard Lightman, 4 vols. (Bristol: Thoemmes, 2004), I: 507-510.

aristocracy, involved a rich combination of formal and informal influences that included the teachings of family members and hired domestic staff, skilled visitors and neighbours, schoolmasters, and texts complemented by conversation in supportive social environments.

Evangelical Motherhood

The mastermind behind the Whittingehame museum project, as well as its advertisements in the family newsletter, was the Balfour children's mother, Lady Blanche. By her instigation, the children assembled "The Whittingehame Advertiser" as an occupation during their quarantine after an outbreak of diphtheria in the county. The museum developed as the children collected geological, zoological, and botanical specimens on a 10,000-acre estate rich in wildlife and exposed rock beds. Scientific tutors, hired by Lady Blanche, further promoted the children's study of nature, as well as a handsome library of scientific books. But behind this variety of educational stimuli lay the prime influence of Lady Blanche's motherhood.[20]

Typically both parents played important roles, but especially within evangelical households the charge of educating the children belonged primarily to mothers. During the Evangelical Revival of the late eighteenth and early nineteenth centuries, evangelicals emphasized the importance of the direct influence of a mother for creating a nurturing home environment for the proper moral upbringing of youth.[21] The Gascoyne-Cecil

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[20] Rev. James Robertson, *Lady Blanche Balfour: A Reminiscence* (Edinburgh: Oliphant and Ferrier, 1897), pp. 31-43.

[21] Paul Sangster, *Pity My Simplicity: the Evangelical Revival and the Religious Education of Children, 1738-1800* (London: The Epworth Press, 1963), pp. 81-82; John

family, according to Lady Gwendolyn, owed more to their mother, Georgina Gascoyne-Cecil, Marchioness of Salisbury, than their father, Robert: "It was fortunate, perhaps, that the part which he took in the direction of his young children's lives was only sporadic and subordinate."[22] Lady Salisbury, who made deliberate choices in historical and theological readings for her children, disowned having adopted any particular "system" of education: "She complained once to friends who would worry her by wanting to know upon what 'system' she trained her children. 'If I were to tell them the truth they wouldn't understand.' She had got no system, she said."[23]

But home education in the country house, while private and varied, was nevertheless, indeed, a *system.* It involved mothers' carefully-prescribed daily schedules that included standard meal times; specified subjects forming the basis of a curriculum; lessons in a designated schoolroom with governesses and tutors; planned outdoor activities; and sessions with the parents that often included prayer and Bible-readings. Randal Parsons characterized his early home education as a "Spartan" schoolroom system designed by his mother and carried out by a governess, Miss Payne: "We began lessons at 7.30 a.m., breakfast at 8.0 a.m., lessons from 9.0 a.m. to 12.0, then out of doors for two hours, luncheon at 2.0 p.m., lessons from 5.0 to 6.30 p.m. I well remember the pangs of

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Tosh, *A Man's Place: Masculinity and the Middle-Class Home in Victorian England* (New Haven: Yale University Press, 1999), pp. 110-119.

[22] Lady Gwendolyn Cecil, *Life of Robert Marquis of Salisbury*, 4 vols. (London: Hodder and Stoughton, 1921-1932), III: 13.

[23] Cecil, *Life of Robert Marquis of Salisbury*, III: 14.

hunger between 8.0 a.m. and 2.0 p.m."[24] To Eleanor Sidgwick, her mother's influence was felt more through the choice of curriculum than through the schedule: "My mother always kept a general supervision over the scheme of our lessons – what we learnt, and how many hours a day (very few) were to be devoted to it. She was very particular about our reading and practically till grown up I only read books approved by her."[25]

A letter from Clara, Lady Rayleigh, to her children's governess, Miss Gibson, illustrates the maternal involvement and authority that defined the evangelical mother's moral duty to the children's education. Rayleigh stipulated, "Now the first object of any one who has the charge of children, is to lead them as far as human teaching can do, to Love & fear God, the next unquestionably is to lead them to love & fear their *Parents*." Respecting lessons, she advised, "I would not make *slowness* at lessons, or idleness at them, so great a fault as, *moral* ones – such as deceit or disobedience."[26] Religion played a central role. A frequent guest was Lady Rayleigh's brother, Captain Hedley Vicars, a well-known evangelical Christian who died during his service in the Crimean War.[27] Like Vicars and Lady Rayleigh, John James, second Baron Rayleigh, was also avowedly

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[24] Randal Parsons, *Reminiscences*, (privately printed, n.d.), p. 3, Birr.

[25] Eleanor Sigwick, "Some Things I Remember about my Mother," corrected typewritten draft, October, 1922, p. 22, BP, NAS GD433/2/145/1. More generally on the country-house schoolroom system, see Gerard, *Country House Life*, pp. 38-64.

[26] Clara, Lady Rayleigh to Miss Gibson, Terling Place, n.d. [1847?], Terling.

[27] Catherine Marsh, *Memorials of Captain Hedley Vicars, Ninety-Seventh Regiment* (London: J. Nisbet, 1856); Robert John Strutt, Fourth Baron Rayleigh, *Life of John William Strutt, Third Baron Rayleigh*, aug. ed. with an intro. by John N. Howard (Madison: The University of Wisconsin Press, 1968), p. 8.

evangelical. He led the family's nightly prayers: "It was his custom at family prayers to expound passages from the Bible that he had read, sometimes at a length that was displeasing to the younger members of the family."[28]

Evangelical motherhood, however, required more direct involvement than simply supervising governesses and tutors. Eleanor Sidgwick recalled her mother's own lessons: "I remember liking doing lessons with her. Those I remember were arithmetic, geography, and history.... In arithmetic she made me understand from the beginning the principles underlying the simple rules, why you carry one and so forth – the decimal system in fact – and I have been interested in mathematics ever since."[29] Similarly, Lady Rayleigh intervened in lessons otherwise carried out by the governess. Observing on one occasion that "Little John" was upset when attempting "his sums," she stepped in: "I then go sit beside him & say 'now dear do the sums once with me & then I shall find out what your difficulty is' & he goes thro' it *himself* with me & having stopped crying when he came to what before had puzzled him, it occurred to his mind & he said merrily 'Oh now I have found it out Mamma'."[30] In addition to individual tutoring, religious lessons involved all of the children. Lady Balfour often read from the Bible to her eight children, even as the elder siblings approached their comings of age (Figure 3.1).

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[28] Strutt, *Life*, p. 6.

[29] Eleanor Sigwick, "Some Things I remember about my Mother," corrected typewritten draft, October, 1922, p. 10, BP, NAS GD433/2/145/1.

[30] Clara, Lady Rayleigh to Miss Gibson, Terling Place, n.d. [1847?], Terling.

Figure 3.1. The Balfour family assembled for a Bible reading in front of Whittingehame House, c. 1865. Standing, from left to right, are Cecil, Eleanor, Gerald, and Eustace. Seated, from left to right, are Francis, Arthur, Lady Blanche, Alice, and Evelyn. Reproduced from James Robertson, *Lady Blanche Balfour: A Reminiscence*, rev. ed. (1926). By courtesy of the University of Georgia Libraries.

Mothers taking active parts in lessons could impress upon their children the importance of self-discipline and intellectual development – both viewed as necessary to building sound character for personal atonement and accomplishing one's duty in society. In a reminiscence originally written for the evangelical magazine, *Good Words*, the parish minister of Whittingehame, Rev. James Robertson, explained Lady Balfour's educational plan:

> I am sure that in the education of her children Lady Blanche thought rather of the duty of cultivating mental gifts than of any successes to which this might lead. She seemed to me to have the strongest conviction of any one I had known of the moral benefit of intellectual discipline. Mental and moral good were associated together in her mind with a wholly unusual closeness.[31]

The ends of aristocratic home schooling lay more in teaching family honor, *noblesse oblige*, and a sense of duty in life rather than pursuit of professions as among the middle classes.[32] Nora Sidgwick recognized this emphasis in her mother's approach: "Her educational schemes were not I think aimed at what would now be called vocational training. A good general education with a wide outlook and a real taste for something was what she would have liked to give us." She added, "Life, position, wealth, opportunities were given us to use to the best of our ability for the benefit of others – of the world in general. The principle applied in little things as well as big." Religion always framed the lessons: "Religion was in her teaching closely connected with conduct."[33]

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[31] Robertson, *Lady Blanche Balfour,* pp. 32-33.

[32] Gerard, *Country House Life,* pp. 69-70.

[33] Eleanor Sigwick, "Some Things I Remember about my Mother," corrected typewritten draft, October, 1922, pp. 26, 32 and 24, BP, NAS GD433/2/145/1.

Governesses and Tutors

The country-house schoolroom system generally involved passages from nursery to schoolroom and ultimately to boarding school, for boys, and "finishing" lessons for girls. While both sexes spent their early childhood under the supervision of nurses and governesses, during adolescence boys had tutors at home and schoolmasters away from home while girls more often than not continued with a less rigorous home education provided by finishing governesses.[34]

According to Robert Strutt, fourth Baron Rayleigh, writing about his father in the mid-nineteenth century, "A boy's opportunities of getting any glimpse of science in the country in those days were very limited."[35] More generally, Kathryn Hughes noted that among Victorian home schoolrooms everywhere, "arithmetic remained a weak subject with governesses and their pupils until the end of the century," and "science of any type was also unknown."[36] But these observations only beg the question of how upper-class youth who became accomplished men of science first learned anything in their fields or aspired to research.

Despite Hughes's assessment of deficiencies, hired governesses and tutors nevertheless played important roles. Governesses' variable skills extended across general

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[34] F.M.L. Thompson, *English Landed Society in the Nineteenth Century*, rpt. ed. (London: Routledge and Kegan Paul, 1963; 1980), pp. 82-85; Gerard, *Country House Life*, pp. 38-64.

[35] Strutt, *Life*, p. 12.

[36] Kathryn Hughes, *The Victorian Governess* (London: Hambledon and London, 2001), pp. 71-73.

subjects and languages. Randal Parsons thought highly of his governess, Miss Payne: "She was well informed, clever and painstaking, and much liked, and I owe much to her. She grounded me carefully in the elements of Latin and English literature and also religious knowledge."[37] Lady Rayleigh condescendingly acknowledged the skill of her children's governess, Miss Gibson, "I know that your birth and education make you above the situation of Nursery governess." In a letter she opined, "I think you are very clever in teaching & have both a talent and fondness for it."[38] Gibson included arithmetic among the subjects she taught the Strutt children, who regarded her knowledge highly enough for little John to approach her with a "mechanical" question about train engines, although her response dissatisfied him.[39]

Until preparatory schools became the norm in the 1870s, upper-class parents hired tutors to provide their sons lessons in more specialized subjects prior to their enrollment in public secondary schools and universities. Girls continued with lessons by governesses that focussed on cultivating lady-like manners in preparation for "coming-out" and attracting suitors.[40] Boys required deeper knowledge in traditional university subjects, like the classics, history or mathematics, as they prepared for their final passage to the status of learned gentleman. The second Earl of Rosse took pride in the manner by which

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[37] Parsons, *Reminiscences*, p. 12.

[38] Clara, Lady Rayleigh to Miss Gibson, Terling Place, n.d. [1847?], Terling.

[39] Strutt, *Life*, p. 12.

[40] Jessica Gerard, *Country House Life*, pp. 48-49. Middle-class boys followed similar patterns, although their formal schooling usually ended in adolescence; Tosh, *A Man's Place,* pp. 104-105.

he home-schooled his sons John Clere and William Parsons. "I educated [them] with private tutors at home; a mode of bringing up which I had no reason to regret, for no young men of their time surpassed them in maturity of parts, and proficiency in litterature." His sons learned French "by conversing with a Frenchman who...was constantly with them in their walks and hours of amusement."[41] Rosse believed in the value of the tutorial system to such an extent that even after his boys enrolled at Trinity College, Dublin, they remained in residence at home to prepare for their examinations with tutors: "[They] used only to go there for three or four days to attend the quarterly examinations – pursuing their studies always in the country with me, having a gentleman from the College to read with them and instruct them."[42] The scheme had good results; both boys ranked first in their final mathematics examinations. One friend wrote to Rosse to congratulate him on his sons' successes: "It is most creditable indeed to them so to have done, more especially as they have availed themselves of their Rank as Peer's Sons to take their degree one year sooner than ordinary Men."[43]

William followed his father's home tutorial system for educating the next generation of Parsons boys, even during a period when public schooling became more standard. Having achieved some fame for building the world's largest reflecting telescope on his estate, he attracted astronomical research assistants who also doubled as his sons'

[41] Lawrence Parsons, Second Earl of Rosse, "Reflections of Lawrence 2nd Earl of Rosse on his son John Clere," pp. 1 and 5, E/23, Birr.

[42] Lawrence Parsons, Second Earl of Rosse, "Reflections of Lawrence 2nd Earl of Rosse on his son John Clere," p. 6, E/23, Birr.

[43] J. Russell to Rosse, Charterhouse School, 24 Dec. 1822, E/16/9, Birr.

tutors. The tutors included men who later achieved note in science: Thomas T. Gray, R.F. Mitchell, John F. Purser, Binden and Johnstone Stoney, and Sir Robert Ball.[44] Charles Parsons explained the importance of both the tutors and his father in his scientific education:

> My father had, rightly or wrongly, a rooted objection to public-school education, and consequently, with my brothers, I was taught by tutors at our home in Ireland. Concurrently I had the advantage of working in well-equipped workshops where my father had constructed his telescope, and from him I learnt the first principles of mechanical construction and engineering, for he was a skilled engineer as well as a scientist and an astronomer.[45]

In the Balfour family, the hiring and supervision of tutors fell to Lady Blanche, whose husband died from tuberculosis in Madeira in 1856. The eldest son, Arthur, was only eight years of age. According to Evelyn, Lady Rayleigh's recollection, "The boys' first tutor after we came back from Madeira – Mr Probert – was encouraged to show us chemical experiments in a room set apart for the purpose and to help us collect and dry wild flowers. Mr Kitto later on was desired to study and read geology with Frank, when the latter showed interest in a fossil."[46] James Kitto (afterwards parish minister at Whitnash, Warwickshire) encouraged both practical and book study. Probably referring to

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[44] W. Vallentine Ball, *Reminiscences and Letters of Sir Robert Ball* (London: Cassell, 1915); Rollo Appleyard, *Charles A. Parsons: His Life and Work* (London: Constable, 1933), pp. 8-9; Patrick Moore, *The Astronomy of Birr Castle* (London: Mitchell Beazley, 1971), pp. 45-46 and Appendix 1.

[45] Charles Algernon Parsons, "Address on the Occasion of the Presentation of the Freedom of the City of Newcastle-Upon-Tyne to C.A. Parsons," *Proceedings of the Newcastle Council* (1914), quoted in Appleyard, *Charles A. Parsons*, p. 18.

[46] E. Rayleigh, "Some Recollections of my Mother," September 1922, BP, NAS GD433/2/145/2.

the standard Mollusca series by Samuel Peckworth Woodward, Kitto wrote to Frank in 1864: "I am glad you are studying Woodward. You can do very little at geology without a good knowledge of shells. This you have already proved in some measure haven't you?"[47] Evelyn's recollections hint at how, despite the tutors' hire for the boys' benefit, the girls also engaged in the lessons. The Balfour sisters showed an avid interest in a full range of scientific subjects covered in the lessons. In March 1864, Eleanor reported in "The Whittinghame Advertiser": "A Botany class, in which the deepest scientific research is carried on, takes place every evening. Mr. Eustace Balfour has lately purchased an excellent magnifying glass, which it is hoped will be of great assistance in these researches."[48] While the instructor of the class is not identified, a later issue of the newsletter discloses the leadership role that Eleanor assumed in the research: "E.M.B. has kindly undertaken the Botany, & has, we believe, overcome some of its earliest difficulties, in this she has been constantly assisted by E.J.A.B" – "E.M.B." signifiying Eleanor Mildred Balfour and "E.J.A.B." Eustace James Anthony Balfour.[49] Natural history notes and illustrations by all three sisters are well represented among the pages of "The Whittinghame Advertiser."

Relatives and Friends

In addition to parents, governesses, and tutors, children of country houses also

[47] J. Kitto to F.M. Balfour, Cambridge 14 March 1864, BP, NAS GD433/2/103A/112.

[48] "The Whittinghame Advertiser," ser. 1 (5) (1864), BP, NAS GD433/2/93/13.

[49] "The Whittinghame Advertiser," ser. 3 (1) (1867), BP, NAS GD433/2/93/1.

enjoyed the influences of relatives and friends. A frequent guest at Birr Castle was Mary King, a first cousin of William Parsons, third Earl of Rosse. As Owen Harry has shown, Mary, and her sisters Harriet and Jane, also engaged in country-house science, making "regular excursions over the extensive peat bogs near Ballylin to collect plants and animals." Their collections transformed their Ballylin mansion into a country museum: "The interior walls of the house were hung with cases of insects, feathers, shells, and pressed flowers."[50] A telescope provided by her father enabled Mary, when only eight years old, to announce her sighting of Halley's Comet to a dinner party at the house. Her developing knowledge of science and her skill at illustration prepared her for a noted popular-science writing career. When visiting at Rosse's Birr Castle, Mary would sometimes give lessons in drawing and microscopy to the youngest boys, Clere and Charles.[51]

Similar exposure to neighbors and friends enriched the Balfour children's practical skills in natural history. Alice Balfour credited William Nisbet, a small-holder at the neighbouring village of Lint Mill (and "delightful friend to us children") as the earliest source of her practical knowledge: "From him I first learnt anything about

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[50] Owen G. Harry, "Mary Ward at Castle Ward: The Making of a Naturalist,"*Apollo: The International Magazine of the Arts* 141, 398 (1995): 37-41, quotes on 38.

[51] Owen G. Harry, "Mary Ward at Castle Ward"; Harry, "The Hon. Mrs. Ward (1827-1869): Artist, Naturalist, Astronomer and Ireland's First Lady of the Microscope," *The Irish Naturalists's Journal* 21, 5 (1984): 193-200; Susan McKenna-Lawlor, "The Hon. Mrs. Henry Ward (1827-1869): Astronomer, Microscopist, Artist and Entrepreneur," in *Whatever Shines Should be Observed* (Blackrock, County Dublin: Samton, 1998), pp. 29-55.

collecting and setting insects, but he himself was practically self-taught, and had no books or any means of getting much information or apparatus." She gradually learned of other Lepidoptera collections in the district, including Thomas Majoribank's, Archibald Hepburn's, and Dr. Nelson's at Pitcox.[52] In search of rare birds, several of the Balfour brothers joined shooting parties consisting of neighbors and friends. In January 1868, "The Whittinghame Advertiser" recorded a successful shooting expedition: "There has been great excitement in the ornithological department this week. Rare birds have lately been foolish enough to avoid the guns of our naturalists, imaging perhaps in their silly minds that it was pleasant to be flying about wild, than to be skinned for a collection or possibly even stuffed." The party of "naturalists" included Cecil, Frank, and Arthur Balfour; the Earl of Haddington (from Tyninghame); Alexander Kinloch (from Gilmerton House); T. Mitchell Innes; the Hon. Col. Nisbet Hamilton (from Winton House); and Henry Hope.[53] Alice helped Frank with preparing and labelling the skins for display in the Whittingehame museum.[54]

To support her son's enthusiasm for marine zoology, Lady Balfour engaged a fisherman and his yacht for Frank to dredge in the North Sea along the coast at Dunbar –

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[52] Alice Blanche Balfour, "Butterflies and Moths found in East Lothian," *Transactions of the East Lothian Antiquarian and Field Naturalists' Society* 1 (5) (1930): 169-184, quote on 170.

[53] "The Whittinghame Advertiser," ser. 3 (4) (1868), BP, NAS GD433/2/93/2; Paul Harris, *Life in a Scottish Country House: The Story of A J Balfour and Whittingehame House* (Whittingehame: Whittingehame House Publishing, 1989), p. 48.

[54] "The Whittinghame Advertiser," ser. 2 (1) (1866-67), BP, NAS GD433/2/93/7; Francis Maitland Balfour, *The Works of Francis Maitland Balfour*, ed. M. Foster and A. Sedgwick, 4 vols. (London: Macmillan, 1885), I: 2.

following a practice of other noted Edinburgh naturalists, including Robert Jameson and Edward Forbes.[55] During a period when the British Association for the Advancement of Science's dredging expeditions attracted much public interest, Haddingtonshire's county newspaper found the pursuit of a local young gentleman particularly newsworthy. Its account records the assistance he received from John Burgon, "an excellent person for the work":

> For some time past the harbour has been graced by a smart little yacht belonging to Mr Francis Balfour, of Whittingham. The yacht is a trim, trig, little craft, a splendid sailor, and altogether a very pretty specimen in its class. The owner, whose scientific tastes lead him to the study of conchology and kindred subjects, as well as marine fauna and flora, has been pretty successful in his researches....It is likely that the community may be favoured at some future time with the result of the investigations, and there is little doubt that a large addition will be made to our knowledge of the treasures of the deep in our own locality.[56]

Among Frank's dredges were numerous shells that his sister Evelyn helped arrange and identify by scientific name, consulting Sowerby's *A Conchologist's Manual*.[57]

Books and Equipment

Book-learning was central to the scientific-education of upper-class youth, whose parents made handsome collections of scientific books and periodicals available to them in the private libraries of their country seats. A pervasive popular interest in natural

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[55] Robertson, *Lady Blanche Balfour*, p. 32; Rehbock, "The Early Dredgers."

[56] [Anon.], "Yachting," *The Haddingtonshire Courier*, Haddington, 9 Feb. 1872.

[57] F.M. Balfour to E. Balfour, Harrow, 25 November, 1866, Terling; George Brettingham Sowerby, Jr., *A Conchologist's Manual*, 4th enl. ed. (London: H.G. Bohn, 1852); Balfour, *The Works of Francis Maitland Balfour*, I: 5.

theology made scientific learning fashionable for religious reasons, as the study of nature came to be seen as a means for divine revelation. Evangelical expositors of natural theology – and its variants – invited readers to experience the awe and wonder of creation. Published sermons as well as popular science books contributed to this gospel. The culture of reading generated by these concerns, as well as the early-nineteenth-century revolution in "steam printing," promoted the art of polite conversation around books, especially sensations like the *Vestiges of the Natural History of Creation.*[58]

The second Earl of Rosse engaged sufficiently with the leading scientific works to base his *An Argument to Prove the Truth of the Christian Revelation* (1834) upon authorities like Laplace, Cuvier, Humboldt, Buckland and Lyell. Showing a remarkable understanding of their key geological and cosmological theories, Rosse synthesized their ideas in support of the argument from design: "Thus, whether the labours of science descend into the recesses of the earth or rise into the regions of planetary orbits, facts

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[58] On evangelicalism in popular science, see especially Aileen Fyfe, *Science and Salvation: Evangelical Popular Science Publishing in Victorian Britain* (Chicago: University of Chicago Press, 2004); David W. Bebbington, "Science and Evangelical Theology in Britain from Wesley to Orr," in David N. Livingstone, D.G. Hart, and Mark A. Noll, eds., *Evangelicals and Science in Historical Perspective* (New York: Oxford University Press, 1999), pp. 120-141; Jonathan R. Topham, "Science, Natural Theology, and Evangelicalism in Early Ninteteenth-Century Scotland: Thomas Chalmers and the *Evidence* Controversy," in *ibid.*, pp. 142-174; and Topham, "Science and Popular Education in the 1830s: the Role of the *Bridgewater Treatises*," *British Journal for the History of Science* 25 (1992): 397-430. On the natural-theological genre in popular science, see Barbara Gates, "Re-telling the Story of Science," *Victorian Literature and Culture* 21 (1993): 289-306. On the culture of reading and polite conversation, see James A. Secord, *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of* Vestiges of the Natural History of Creation (Chicago: The University of Chicago Press, 2000), especially pp. 155-190 and 410-419, and for antebellum America, Sally Gregory Kohlstedt, "Parlors, Primers, and Public Schooling: Education for Science in Nineteenth-Century America," *Isis* 81 (1990): 425-445.

unlooked-for, and unthought of are discovered, which witness the truth of those stupendous communications which the Deity has made of his will to man, and which prove incontestibly that there has been a divine revelation." He engaged in his study for this book after the premature death of his younger son, John Clere, in 1828 and "during the long period of deep affliction for so great a loss."[59]

Yet Rosse's religious perspective and admiration for science long preceded this opus. He desired a scientific education for his sons and sought the advice of the faculty at Trinity College, Dublin, to guide his choice of books. William Stokes, apparently a tutor to the boys (and later a noted physician), consulted with the chemist Francis Barker on Lord Rosse's behalf:

> I deferred replying to your Lordship's letter in order to consult Dr. Barker our Professor of Chemistry whom I failed of meeting two or three times. He recommends the following: Henry's Epitome of Chemistry, Late edition; Aikin's Dictionary of Chemistry & Supplement; Thenard's Traité de Chimie; Murray's System of Chemistry; Thomson's System of Chemistry. As the Science is rapidly advancing some periodical work w$^{d.}$ be highly usefull of which Thomson's Annals of Philosophy are probably the best.[60]

Following a similar procedure, the second Baron Rayleigh conferred with scholars at Trinity College, Cambridge, for advice on mathematical study for his son. Joseph Barber Lightfoot recommended Frederick Thompson, who came to Terling Place to coach the

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[59] Earl of Rosse, *An Argument to Prove the Truth of the Christian Revelation* (London: John Murray, 1834), p. 113 and dedicatory page.

[60] W. Stokes to L. Rosse, Dublin, 2 January 1817, E/16/4, Birr. William Stokes belonged to an earlier generation of the eminent Stokes family that also included, in a younger generation, the physicist, George Gabriel Stokes; Mrs. Laurence Humphry, "Notes and Recollections," in *Memoir and Scientific Correspondence of the Late Sir George Gabriel Stokes*, ed. Joseph Larmor, 2 vols. (Cambridge: Cambridge University Press, 1907), I: 1-2.

adolescent John Strutt in preparation for enrollment at Trinity. No doubt Thompson brought along appropriate texts for the lessons.[61]

Parental provisions for children's readings sometimes included scientific selections for the girls, particularly if they displayed inclinations toward science. At Ballylin, Mary King enjoyed a handsome library that included astronomical almanacs and star maps. Her copy of Buffon's *Natural History* was inscribed with the dedication, "Miss Mary King, Ballylin, April 21, 1834. A Natural History given to her by her Papa for a present." Willoughby's *Birds and Fishes* and Henry Baker's *The Microscope Made Easy* also claimed shelf space in the Ballylin library.[62] Evelyn Balfour showed a keen engagement with popular science texts, enabling her to correct an error made by her brother Cecil in his description of the argonaut:

> The argonaut does not move about on the surface of the water by using its arms as oars & sails but propells itself backwards by ejecting water from its breathing funnel.... In the supplement to the second number of the Whittinghame Advertiser there was an article signed C.C.B. F.S.A. stating the former idea, but the information must have been drawn from an antiquated authority as that is quite an exploded theory & the paper nautilus is now well known to use the latter mode of progression."[63]

Also with a naturalist's bent, Alice Balfour gleaned natural history information in texts belonging to non-scientific genres. She based her notes on the Ndzoodzoo of Madagascar, "a horse-like creature," for "The Whittinghame Advertiser" on the published descriptions of the well-known missionary, Joseph John Freeman. Freeman presented his travels in

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[61] Strutt, *Life*, p. 24.

[62] McKenna-Lawlor, "The Hon. Mrs. Henry Ward (1827-1869)," pp. 30-32.

[63] "The Whittinghame Advertiser," ser. 1 (4) (1864), BP, NAS GD433/2/93/12.

Africa to a children's audience in *The Juvenile Missionary Magazine* (1844-1887), Alice's most likely source on the subject.[64]

John Strutt also had early exposure to science through general periodical literature. His sister Clara recalled how their Aunt Emily Strutt "took in the *Family Friend* for John's benefit and there he found an account of an experiment with gun-powder"(Figure 3.2). The reading inspired him to send for ingredients to reproduce the experiment. "This is the first instance I can remember in which his bent was clearly shewn."[65] The magazine promised, "A flow of religious feeling, and a high moral tone, will be found to pervade our work," consistent with the evangelical mission of "companionate" children's literature like the similarly-named *The Children's Friend.*[66] Sometime after this, he colonised the book-room, the family's usual site for prayer, with "strange bottles," "magnets," and an "electric machine." After his sister came out and her governess departed, he moved his home laboratory into the schoolroom, "where he could

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[64] "The Whittinghame Advertiser," ser. 1 (2) (1864), BP, NAS GD433/2/93/10. Freeman also wrote of his travels in his monograph, Joseph John Freeman, *A Tour in South Africa, with Notices of Natal, Mauritius, Madagascar, Ceylon, Egypt, and Palestine* (London: J. Snow, 1851), but the Ndzoodzoo is not described there.

[65] Notes by Clara Strutt, dated 1909, quoted in Strutt, *Life*, pp. 11-12.

[66] Anonymous, "Preface," *The Family Friend* 1 (1849): iv. *The Family Friend* ran in several series beginning in 1848 and circulating as late as 1905. An illustrated monthly, it contained advice for child-rearing as well as articles for children's reading. Strutt likely read the short note on "Wooden Gunpowder" in the first issue; *The Family Friend* 1 (1849): 24. See Patricia Demers, *Heaven upon Earth: The Form of Moral and Religious Children's Literature, to 1850* (Knoxville: The University of Tennessee Press, 1993), pp. 40-48. On science in general periodical literature, see Louise Henson, Geoffrey Cantor, Gowan Dawson, Richard Noakes, Sally Shuttleworth, and Jonathan R. Topham, eds., *Culture and Science in the Nineteenth-Century Media* (Aldershot: Ashgate, 2004).

Figure 3.2 Title page of *The Family Friend*, volume 1 (1849), depicting families in educational settings at home. By courtesy of University of Minnesota Libraries.

keep things more undisturbed."[67] Strutt's laboratory thus illustrated the fairly popular engagement in experimental science by Victorian children who read popular science accounts instructing them in the art.[68]

Chemicals, magnets, glassware, microscopes, telescopes, cameras, dredges, cabinets, aquaria, and mechanical devices numbered among country-house children's tools for home education in science. On a visit to Birr Castle in 1845 to attend the inauguration of Rosse's "Leviathan" telescope, the astronomer Sir James South saw Mary King's drawings of tiny objects that she observed through a magnifying lens. In view of her talent, he suggested that her parents provide her with a good microscope. They sent for a "state of the art" Andrew Ross microscope from London, which King then turned to good use.[69] An inventory of instruments at Birr Castle indicates that the Parsons boys also owned several microscopes in the 1850s.[70] The "excellent magnifying glass" purchased by Eustace Balfour in 1864 complemented a microscope at Whittingehame House, cited by his brother Cecil when at public school in Hertfordshire: "Two boys have got very

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[67] Notes by Clara Strutt, dated 1909, quoted in Strutt, *Life*, pp. 15, 21-22.

[68] Brian Gee, "Amusement Chests and Portable Laboratories: Practical Alternatives to the Regular Laboratory," in *The Development of the Laboratory: Essays on the Place of Experiment in Industrial Civilization*, ed. Frank A.J.L. James (New York: American Institute of Physics, 1989), pp. 37-60.

[69] McKenna-Lawlor, "The Hon. Mrs. Henry Ward (1827-1869)," p. 32; Graeme Gooday, "'Nature' in the Laboratory: Domestication and Discipline with the Microscope in Victorian Life Science," *British Journal for the History of Science* 24 (1991): 307-341.

[70] Charles Mollan, *Irish National Inventory of Historic Scientific Instruments Interim Report* (Dublin: Royal Dublin Society, 1990), pp. 45-46.

jolly microscopes, indeed one of them is a large one of the one in the Library at home."[71] Frank Balfour's growing fossil collection prompted him to request a large box, with trays and divisions, as his birthday present one year. His dredges at Dunbar helped stock an aquarium, also kept at the house.[72]

By the mid-1850s, photography captivated popular attention, although patents on processing methods slowed its diffusion for some years. Processing prints by a variety of methods required careful application of chemicals and adherence to recipes in photographic manuals.[73] At Birr Castle, the third Earl of Rosse wrote to William Henry Fox Talbot for advice about using photography in his astronomical work, but when Rosse's efforts failed, he abandoned the technique in favor of traditional sketching. Mary, Countess of Rosse turned her husband's photographic equipment to her own use, and by the late-1850s won national acclaim for her skilled negatives and photographs using the wax-paper process.[74] Laurence Parsons, fourth Earl of Rosse, also shared her

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[71] "The Whittinghame Advertiser," ser. 1 (5) (1864), BP, NAS GD433/2/93/13; C.C. Balfour to E. Balfour, Mr. Chittenden's School (Hertfordshire), n.d. [1864?], Terling.

[72] M[ichael] F[oster], "Francis Maitland Balfour," *Proceedings of the Royal Society of London* 35 (1882): xx-xxvii; F. Balfour to E. Balfour, Whittingehame, n.d. [1869?], Terling; Eleanor Sigwick, "Some Things I Remember about my Mother," corrected typewritten draft, October, 1922, p. 26, BP, NAS GD433/2/145/1.

[73] Larry Schaaf, *Out of the Shadows: Herschel, Talbot and the Invention of Photography* (New Haven: Yale University Press, 1993).

[74] David H. Davison, *Impressions of an Irish Countess* (Birr: Scientific Heritage, 1989); McKenna-Lawlor, "Mary, Countess of Rosse (1813-1885)," pp. 15-28.

interest and likely learned photographic techniques from her.[75] Similarly, at Terling Place Clara, Lady Rayleigh encouraged her son's interest in photography. John Strutt presented his first wet-collodion print of a fern leaf, developed with silver nitrate and common salt, to her in December, 1857. He later mastered various dry-collodion processes. According to his sister, "My mother used to then help him. The photographs were taken in the conservatory."[76]

Public-schooling

Upon reaching adolescence, aristocratic sons generally attended one of the public schools; Harrow and Eton were among the best regarded, though critics called for their reform. With numerous new schools opening by the 1840s, enrollment was progressively more standard, but as in the Parsons' case, not all boys took advantage of the opportunities.[77] For those who did enroll, length of attendance varied; in John Strutt's case, he spent only short periods at Eton, George Murray's School at Wimbledon

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[75] W. Garrett Scaife, *From Galaxies to Turbines: Science, Technology and the Parsons Family* (Bristol: Institute of Physics, 2000), pp. 109-113.

[76] John Strutt presented his first public lecture on the science of photography in 1865; Hon. John William Strutt, *Photography: its History, Position, and Prospects. A Lecture Delivered at Bury St. Edmunds* (Witham: R.S. Cheek, 1865); Strutt, *Life*, pp. 21-23 and 37.

[77] According to Martin J. Wiener, less than one in twenty Englishmen ever passed through them; Wiener, *English Culture and the Decline of the Industrial Spirit, 1850-1980* [1984], 2nd ed. (Cambridge: Cambridge University Press, 2004), p. 21. On English public schools, J.R. de S. Honey, *Tom Brown's Universe: The Development of the English Public School in the Nineteenth Century* (New York: Quadrangle, 1977), and John Chandos, *Boys Together: English Public Schools, 1800-1864* (New Haven: Yale University Press, 1984). On Ireland, see Donald H. Akenson, *The Irish Education Experiment* (London: Routledge and K. Paul, 1970), and John Coolahan, *Irish Education: Its History and Structure* (Dublin: Institute of Public Administration, 1981).

Common, and Harrow School before finally attending the Rev. George Townsend Warner's School at Highstead, Torquay for a total of four years. His enrollment coincided with a family visit to Birr to see the Leviathan telescope, causing some disappointment. His father wrote, "I am sorry if John loses [out on seeing] Lord Rosse's telescope, and if he could have gone then."[78] The missed opportunity touched upon a more general problem in public school education – opportunities to learn science generally lay outside the classroom.

The level of science education at the schools varied. Generally classical subjects received the most emphasis. As grounds for cultivating chivalry becoming of gentlemen, sports and manners were also stressed.[79] Strutt studied mathematics at Highstead under a tutor, Lewis Hensley, who according to another of the pupils, "did not pretend to be a great mathematician himself." Strutt regarded himself "an average boy," although a mathematical classmate judged, "About his ability there was no doubt whatever." He competed unsuccessfully for a Trinity College scholarship in 1860 and entered the following year as a fellow-commoner – a distinction customary of peers' firstborn sons

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[78] J.J. Rayleigh to C. Rayleigh, 25 August 1857, quoted in Strutt, *Life*, p. 404; see also pp. 13-17.

[79] Mark Girouard, *The Return to Camelot: Chivalry and the English Gentleman* (New Haven: Yale University Press, 1981), esp. Chapter 11, "The Public Schools," pp. 163-176; on scientific and technical instruction in public-school reform, G.W. Roderick and M.D. Stephens, "Scientific Studies in the Public Schools and the Endowed Grammar Schools in the 19th Century: The Evidence of the Royal Commissions," *The Vocational Aspects of Secondary and Further Education* 23 (1971): 97-205; A.J. Meadows and W.H Brock, "Topics fit for Gentlemen: The Problem of Science in the Public School Curriculum," in *The Victorian Public School: Studies in the Development of an Educational Institution*, ed. Brian Simon and Ian C. Bradley (Dublin: Gill and Macmillan, 1975), pp. 95-114.

that entitled them to wear special academic dress and dine with the dons at the high table.[80]

Contrasting with Strutt's limited science opportunities at Highstead, Frank Balfour's studies at Harrow fortunately coincided with the introduction of a more modern curriculum that included the natural sciences. Beginning in 1867 he took lessons in "practical work" in biology with the newly-hired George Griffith, dissecting a full range of zoological specimens. Balfour carried this work on for three years, using as a guide George Rolleston's *Forms of Animal Life* when it became available.[81] He participated in debates of the new School Scientific Society, founded in 1868; in one contest he argued against the validity of Darwin's theory of natural selection.[82] He brought many of the specimens of the Whittingehame collection to school in order to name them, reporting to Lady Balfour in the summer of 1868 the results of his identification work: "Fossils 77. Birds 163. Shells 119. But I am afraid that I shall have to take away a few of the species of the shells, as some shells which we found dead on the shore are West India species and of course cannot have lived near us but must have been brought in a ship."[83] His analysis

[80] Strutt, *Life*, pp. 19-21.

[81] G[eorge] Griffith, "Francis Maitland Balfour," *Nature* 26 (1882): 365; George Rolleston, *Forms of Animal Life: Being Outlines of Zoological Classification Based upon Anatomical Investigation and Illustrated by Descriptions of Specimens and of Figures* (Oxford, Clarendon Press, 1870). The case of Harrow's science curriculum detracts from Wiener's general argument about the lack of support for science education in public schools; Wiener, *English Culture*, pp. 16-22.

[82] Balfour, *The Works of Francis Maitland Balfour*, I: 4.

[83] F.M. Balfour to Lady B. Balfour, Harrow, 4 June 1868, Terling.

of the specimens, and particularly of the fossils and their role in Haddingtonshire's geology, tied for first prize in a competition adjudicated by Thomas Henry Huxley. The paper helped qualify Frank for a natural science scholarship at Trinity College, Cambridge, where he enrolled as an undergraduate in 1870. There, with his brother Gerald, he elaborated the account into a short article that challenged the theory of Edinburgh geologist James Geikie on the formation of the East Lothian Coast.[84]

Scientific Learning through Conversations

In the Balfour family, the boys' scientific learning at school often circulated back home, where the sisters read of their brothers' experiences in letters and joined them in scientific conversations during the holidays. Reports on lectures, lessons, or books translated new information while improving the messenger's understanding of the details. Frank wrote to Evelyn from Harrow about a lecture by John Tyndall, Professor of Physics of the Royal Institution:

> I did not write you an account of Professor Tyndall's lecture because I have just written a rosy account of it to Mamma. But if you like since I am suffering under the same lack of news, I will give you a short account of it. He first demonstrated the short action of waves of sound before the car, showing that a musical note was simply the equal beats of sound doing experiments upon it with tuning forks for most of which I think you saw at the Royal Institution. He went on to show that colour is simply the effect of light, making one of the fellows face green by a prism, which you can imagine created much laughter. He then showed the crystalization [sic] of lead through a microscope throwing it upon a white sheet. The effect was magnificent. On the one side beautiful ferns grew and on the other

[84] G.W. Balfour and F.M. Balfour, "On Some Points in the Geology of the East Lothian Coast," *Geological Magazine* 9 (1872): 161-164; Griffith, "Francis Maitland Balfour," 365.

> numbers of small balls. This was by far the most amusing as well as most effective experiment of the evening.[85]

In another letter to Evelyn toward the end of his Harrow days (and after his conversion to Darwinism), Frank wrote about his reading of Francis Morris's attack on Darwin's theory of natural selection:

> I believe I told you in the holidays that Mr. Morris (the bird man) had written a pamphlet against Darwinism...and if you want, one of the most scurrilous and abusive pamphlets of the many scurrilous and abusive pamphlets which have been written against Darwinism I should advise you to read it. He seems to imagine that if he can load Huxley with sufficient abuse he will have clearly made out the case against Darwin, and Darwinism. The paper consists of a series of questions, most of which show in my opinion that he has missed the whole point of Darwin's argument.[86]

The brilliance of Donati's comet in the skies during the autumn of 1858 captivated John Strutt's interest at Highstead. He wrote his father about his ideas on the comet's periodicity: "What gives it especial interest I think is that *we* shall never see it again if anybody ever will, as it does not come back probably for several hundred years. It is now moving at an enormous rate as it is near the sun, but when far away altogether outside the planets it moves so slow as only to get over perhaps a few inches a day. Adams the great astronomer who discovered Neptune...thinks it will never come back at all."[87]

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[85] F.M. Balfour to E. Balfour, Harrow, 25 November 1866, Terling.

[86] F.M. Balfour to E. Balfour, Harrow, 7 February 1870, Terling; Francis Orpen Morris, *Difficulties of Darwinism: Read before the British Association at Norwich and Exeter in 1868 and 1869, with a Preface and a Correspondence with Professor Huxley* (London: Longmans, Green and Company, 1869).

[87] Quoted in Strutt, *Life*, pp.17-18.

Family conversations about science also occurred in more formal settings. Randal Parsons retained fond memories of his father's Royal Society soirees at their London house, 13 Connaught Place: "The guests used to bring models of their inventions, and any interesting objects for exhibition and discussion. We boys used to be allowed to see these; there were model engines, boats, etc."[88] Among polite society, soirees provided gentlemen and ladies civil opportunities for scientific learning; as James Secord has noted, "At soirees in Mayfair and Belgravia, new books were laid out on tables to serve as conversation pieces."[89] Randal, Charles, Laurence and Richard Parsons all had the good fortune of access to these social venues, which their father hosted for several years as President of the Royal Society.

Letters and conversations thus provided a typical means by which aristocratic youth engaged with scientific ideas. Their discussions about science fell within a more general education in manners that cultivated skills for debate and polite conversation – prerequisites to their membership in civil society. Within the family circle, the art of conversation provided an enduring means for intellectual intercourse. This aspect to the home educational environment epitomized the informal but effective patterns of scientific education among the aristocracy prior to formal schooling.

[88] Parsons, *Reminiscences*, pp. 17-18.

[89] Secord, *Victorian Sensation*, p. 159; also Samuel Alberti, "Conversaziones and the Experience of Science in Victorian England," *Journal of Victorian Culture* 8 (2003): 208-230.

Chapter 4

The Aristocracy in the Academy: Science and Reform at Cambridge, 1866-1873

> Whereas in 1858 our institutions were still mediaeval, in 1883 the lines of a new Cambridge and a new Trinity had been laid down.[1]

The aristocratic network consisting of the Balfours, Campbells, Gascoyne-Cecils, and Strutts, despite important intellectual and political differences, tended to articulate a similar vision for science infusing their private research as well as professional politics. This claim rests on a fundamental assumption of a close-knit social circuit of individuals moving between particular sites and sharing a system of values.[2] The focus of this chapter, then, is the establishment of a friendship circle that included Arthur Balfour and his brothers and sisters, Robert Gascoyne-Cecil (Lord Salisbury), John Strutt (afterwards Lord Rayleigh), and various scholars from Cambridge, including the Darwins. Subsequent chapters will follow the extension of their circle through a variety of key,

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[1] Henry Jackson, *Commemoration Sermon, 9 December 1913* (Cambridge: Cambridge University Press, 1913), p. 9.

[2] In addition to social historians' definitions of aristocratic society discussed further in this chapter, also useful is the concept of a "scientific community" commonly used in the institutional history of science, for example David Cahan's definition: "Scientific institutions and communities may be characterized as consisting of populations of individuals who share similar cognitive interests and values that serve to provide them with a collective social identity and to advance individual scientific careers and group needs. Such populations are naturally composed of individual scientists and their variegated associates, yet they only become institutions and communities when those individuals – perhaps only few in number – act in concert over an extended period of time and perceive themselves as bound together in some particular professional manner.... In principle a scientific institution or community may be an academic or nonacademic unit within a state or private structure." Cahan, "Institutions and Communities," in *From Natural Philosophy to the Sciences: Writing the History of Nineteenth-Century Science*, ed. David Cahan (Chicago and London: University of Chicago Press, 2003), pp. 291-328, on 293.

supporting institutions – family, country seats, London Society, and metropolitan and provincial learned associations.

The Aristocratic Elite

The official *Return of the Owners of Land* (1876) (also known as the New Domesday Survey) showed that although over a million individuals owned some measure of land in the British Isles, four-fifths of the nation's total land acreage belonged to fewer than 7,000 owners, most of whom had 1,000 or more acres apiece. For a nation of some twenty-two million inhabitants, this meant that only a fraction of a percent of the British population owned a large majority of the nation's territory.[3] The landowners drew from both the nobility and gentry, whose all-important influence in political, religious, and militaristic realms lent much to F.M.L. Thompson's view that "England remained, down to 1914, or more precisely until 1922, not merely an aristocratic country, but a country of a landed aristocracy."[4] In nineteenth-century science, based on the assumption of aristocratic hegemony, Morris Berman argued that "the evolution of the English scientific community becomes understandable only when seen within the framework of the cultural imprint of the ruling class."[5]

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[3] F.M.L. Thompson, *English Landed Society in the Nineteenth Century* [1963], rpt. ed. (London: Routledge and Kegan Paul, 1980), pp. 27-28; David Thomson, *England in the Nineteenth Century* [1950] *The Pelican History of England*, ed. J.E. Morpurgo (Harmondsworth: Penguin Books, 1986), p. 137. More conservative estimates are given in David Cannadine, *The Decline and Fall of the British Aristocracy*, rpt. of rev. ed. [1992] (New York: Vintage Books, 1999), p. 9.

[4] Thompson, *English Landed Society*, p. 1.

[5] Morris Berman, "'Hegemony' and the Amateur Tradition in British Science," *Journal of Social History* 8 (1974-1975): 30-50, on 34.

For my purpose here, more important than the aristocracy's widespread cultural influence was its size; even when bracketed with the landed gentry, which was a distinct group, aristocrats comprised a relatively small elite. David Cannadine's analysis of *Burke's Peerage and Baronetage* and *Burke's Landed Gentry*, shows that only about 5,500 of all landowning families in 1883 could claim membership in the patrician class, marked by wealth and gentlemanly social status. Britain's titled nobles of 1880 formed an even smaller elite of 580 peers and 856 baronets.[6] By comparison, titled aristocracies on the Continent boasted numbers many times Britain's figures: in Prussia, 20,000 titled families in 1800; in Russia, 600,000 in 1858; in Italy, 12,000 in 1906; and in Austria-Hungary, 250,000 in 1914. Whether or not these international statistics are directly comparable, we cannot escape Cannadine's conclusion that Britain's aristocracy formed "a very small and very exclusive caste indeed."[7]

Important gradations and variations existed within what outwardly and comparatively qualified as a distinct elite, however. These included disparities in estate and family sizes, farming business types, geographical location, religious and political beliefs, philanthropic work, avocations, and, intellectual predilections. The same can be said of the smaller family units. Brothers and sisters may have sided differently in the major questions of the day, such as Irish Home Rule or the truth of evolution by natural selection. In tracing the formation and growth of a particular network of aristocratic families, therefore, I do not suppose that its members always shared the same orientations

[6] Cannadine, *The Decline and Fall of the British Aristocracy*, pp. 16-17.

[7] Cannadine, *The Decline and Fall of the British Aristocracy*, pp. 10-11 and 20.

in politics or religion or that they sided consistently in public controversies. But, while exceptions existed, the commonalities are even more notable, as they are what gave this country-house network a particular orientation in matters of science that, despite "strong individuality," defined a circle that stood "shoulder to shoulder."[8]

The privilege of sitting in the House of Lords conferred by United Kingdom titles (above the rank of baronet) made Parliament and its attendant London Season two key institutional means by which the grandees of the landed establishment forged relationships along party, collegial, and friendship lines. The Season, coinciding with the height of the annual Parliamentary sessions between May and July, created a further social venue for families to associate at gentlemen's clubs, learned societies, soirees, balls, garden parties, and opera and theater performances.[9] Aristocratic sons formed alliances even prior to their engagement in London Society at public schools and universities (particularly Cambridge and Oxford). Further opportunities existed within the context of family life.

My analysis in the next two chapters will demonstrate how the Balfours, Gascoyne-Cecils, Strutts and Campbells formed alliances not simply to preserve prestige and power. Among their circle, friendship and marriage embraced the new intellectual and companionate ideals of the mid-Victorian period also popular among the middle and professional classes – though as aristocrats they set themselves apart from "vulgar"

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[8] Lady Frances Balfour, *Ne Obliviscaris: Dinna Forget*, 2 vols. (London: Hodder and Stoughton, 1930), I: 79-80.

[9] Leonore Davidoff, *The Best Circles: Society, Etiquette, and the Season* (London: Croom Helm, 1973).

society.[10] To begin, I will examine the formation of this aristocratic circle at Cambridge, where, in the background, educational reform shaped its members' activities and attitudes in science, philosophy, and educational policies.

Arthur James Balfour

Arthur Balfour entered Trinity College as a Fellow-Commoner in 1866, an enrolment status reflecting the wishes of his late grandfather and father, and the advice of his uncle Salisbury. Balfour later recollected, without regret, the undemocratic nature of the Fellow-Commoner system, which conferred special undergraduate privileges upon sons of landed gentlemen who could afford the higher fees.[11] Balfour's ability to sit at the High Table in the college's dining hall allowed him to form enduring friendships with Trinity fellows and dons, two of whom, John Strutt and Henry Sidgwick, ended up becoming his brothers-in-law: "I was the youngest of the three, and when I first knew them, the eldest [Sidgwick] was only twenty-eight. Considering how different we were in

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[10] In his classic essay, Noel Annan traced the genealogical connections forming a new "intellectual aristocracy" of the nineteenth century defined by evangelicalism, academic reform, and philanthropic interests. His analysis encompassed families, related by marriage, of an academic and primarily middle-class network centered on the evangelical Clapham Sect, including important marital links to aristocratic families like the Balfours and Strutts. Traditionally, marriage among the aristocracy was concerned with the preservation and continuity of the country seat and, by association, its family, above moral and intellectual agendas. N.G. Annan, "The Intellectual Aristocracy," in *Studies in Social History: A Tribute to G.M. Trevelyan*, ed. J.H. Plumb (London: Longmans, Green and Company, 1955), pp. 243-287. On aristocratic marriage strategies, Lawrence Stone and Jeanne C. Fawtier Stone, *An Open Elite? England, 1540-1880* (Oxford: Clarendon Press, 1984), esp. pp. 69-147. On aristocratic "Society" dissociated from the "vulgar" public, Balfour, *Ne Obliviscaris*, I: 50, 55.

[11] Arthur James, First Earl of Balfour, *Chapters of Autobiography*, ed. Mrs. Edgar Dugdale (London: Cassell, 1930), pp. 25-28.

temperament, in aptitudes, in our main occupations, in many tastes, and in some opinions, even the family intimacies due to inter-marriage hardly explain the close sympathy between us which nothing but death could terminate."[12]

For Balfour, his friendship with Sidgwick was the most important influence in the development of his thought. Sidgwick participated in reform at Cambridge including, in 1867, the remodeling of the Moral Sciences Tripos (originally established in 1851), which raised its credibility as a viable alternative to the Classical and Mathematical Triposes in the Honors system. He served officially as Balfour's tutor for the remodeled Moral Sciences Tripos examination, but according to Balfour, "The relation of tutor and pupil rapidly ripened into a warm friendship; and I find it quite impossible to disentangle the impressions he left on me, and to assign some to official teaching, others to private conversation."[13] His examination tested him in moral philosophy and political economy, but Sidgwick's method of instruction departed from the traditional "coaching" system of other examinations. At the time Balfour and another student joined a special class on the "metaphysical side" of the moral sciences that met in Sidgwick's private college rooms. "The teaching was largely in the nature of conversational discussion," Balfour later recollected. "We were allowed to forget that we were preparing for an examination, an oblivion which may or may not be desirable in other branches of study, but is almost

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[12] Balfour, *Chapters of Autobiography*, p. 28.

[13] Arthur J. Balfour to Eleanor Sidgwick, 23 Sep. 1904, Add. Ms. b. 7153, SP, Wren; A. S[idgwick] and E.M. S[idgwick], *Henry Sidgwick: A Memoir* (London: Macmillan, 1909), pp. 310-311.

essential if the pleasures of speculation are to be enjoyed without alloy."[14] As a result of his readings and debates with Sidgwick in preparation for the Tripos examination, Balfour's philosophical position crystallized; he later recalled, "I had my own views as to the philosophic work which lay immediately before me."[15] His views, to be explored more fully in Chapter 7, shared Sidgwick's rejection of John Stuart Mill's positivism but focused on a fundamentally distinct set of philosophical problems. Whereas Sidgwick was primarily concerned with ethics, Balfour became more interested in the foundations of human beliefs about the external world. His line of inquiry brought him into the heart of debates concerning religion and science during the post-Darwinian controversies.[16]

Through Sidgwick and at the Trinity High Table, Balfour joined the circle of reform-minded fellows and dons that also included Henry Jackson, Richard Claverhouse Jebb, William Edmund Currey, and Frederic William Henry Myers. Most members of this circle associated in elite Cambridge societies like the Grote Club and the Apostles

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[14]Arthur J. Balfour to Eleanor Sidgwick, 23 Sep. 1904, Add. Ms. b. 7153, SP, Wren; quoted in A.S. and E.M.S., *Henry Sidgwick*, p. 310. On the reform of the Moral Sciences Tripos, see A.S. and E.M.S., *Henry Sidgwick*, pp. 155-159; Peter Slee, *Learning and a Liberal Education: The Study of Modern History in the Universities of Oxford, Cambridge and Manchester, 1800-1914* (Manchester: Manchester University Press, 1986), pp. 25-35; and Bart Schultz, *Henry Sidgwick: Eye of the Universe: An Intellectual Autobiography* (Cambridge: Cambridge University Press, 2004), pp. 291-293.

[15] Balfour, *Chapters of Autobiography*, p. 60.

[16] Frank Miller Turner, *Between Science and Religion: The Reaction to Scientific Naturalism in Late Victorian England* (New Haven: Yale University Press, 1974), pp. 60-67; James R. Moore, *The Post-Darwinian Controversies: A Study of the Protestant Struggle to Come to Terms with Darwinism in Britain and America, 1870-1900* (Cambridge: Cambridge University Press, 1979), pp. 67, 98-99; Peter J. Bowler, *Reconciling Science and Religion: The Debate in Early-Twentieth-Century Britain* (Chicago: University of Chicago Press, 2001), pp. 369-372.

(the Cambridge Conversazione Society) and rebelled against the Trinity establishment: compulsory Greek and Latin as prerequisites to degrees, the coaching system for examinations, and the affirmation of the Apostles' Creed and celibacy required of Fellows. This elite advocated for reforms that gradually modernized and professionalized Cambridge, including the opening of lecture schemes and colleges for women students.[17] In response to his wavering Anglican faith that contradicted "the dogmatic obligation of the Apostles' Creed" required of Trinity fellows, Sidgwick famously resigned his own Fellowship in 1869.[18] His religious nonconformity led him to spiritualism studies and, with Myers, the establishment of the Society for Psychical Research in 1882. Balfour, although rejecting his teacher's skepticism of religion, was an enthusiastic participant in the SPR movement.[19]

Balfour also attracted a distinguished circle of friends among his undergraduate peers at Trinity who shared his tastes for philosophical discussion, "real" (court) tennis, and music. A member of this scholarly circle, Sir Walter Durnford, recalled, "We used to meet in Balfour's rooms (at the corner of the New Court adjoining the Library) almost every Sunday evening and discuss in moderation his excellent claret, with much talk of

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[17] Sheldon Rothblatt, *The Revolution of the Dons: Cambridge and Society in Victorian England* (Cambridge: Cambridge University Press, 1968), *passim*; A.S. and E.M.S., *Henry Sidgwick*, passim; Schultz, *Henry Sidgwick*, pp. 21-36; Christopher Stray, "Curriculum and Style in the Collegiate University: Classics in Nineteenth-Century Oxbridge," *History of the Universities* 16 (2001): 183-218.

[18] A.S. and E.M.S., *Henry Sidgwick*, p. 198.

[19] Turner, *Between Science and Religion*, pp. 50-60, and 104-122; Richard Noakes, "Cranks and Visionaries: Science, Spiritualism, and Transgression in Victorian Britain," Ph.D. thesis, University of Cambridge, 1998.

men and books."[20] According to another friend, Hugh Frederick Hislop Elliot, a son of the third Earl of Minto, "Balfour was not reputed to be a great reader, but to have a wonderful facility for picking the brains of other people."[21] On the tennis court, Balfour met George Howard Darwin, son of the celebrated author of *On the Origin of Species*. Balfour and John Strutt, who also frequented the courts, made Charles Darwin's acquaintance through George, who invited his tennis friends to Down House around 1870.[22] Balfour's musical friend, George William Spencer Lyttelton (called by friends "Spencer"), introduced Balfour and Strutt to the aristocratic Lyttelton family and their cousins, the Gladstones. Balfour's association with the Lytteltons – highlighted by an unrequited affection for Spencer's sister, Mary ("May") – continued for many years in both domestic and political settings.[23]

John William Strutt

John Strutt moved in the same friendship circles at Cambridge as Balfour and

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[20] Blanche E.C. Dugdale, *Arthur James Balfour, First Earl of Balfour*, 2 vols. (London: Hutchinson, 1936), I: 28.

[21] Dugdale, *Arthur James Balfour*, I: 29.

[22] Balfour, *Chapters of Autobiography*, p. 37; Robert John Strutt, Fourth Baron Rayleigh, *Life of John William Strutt, Third Baron Rayleigh* [1924], aug. ed. with an intro. by John N. Howard (Madison: The University of Wisconsin Press, 1968), p. 45.

[23] Kenneth Young, *Arthur James Balfour: The Happy Life of the Politician, Prime Minister, Statesman and Philosopher, 1848-1930* (London: G. Bell and Sons, 1963), pp. 31-36. Historians dispute whether Balfour and Lyttelton became engaged, but any possibility for marriage ended when May died from typhoid in March 1875; Jane Ridley and Clayre Percy (eds.), *The Letters of Arthur Balfour and Lady Elcho, 1885-1917* (London: Hamish Hamilton, 1992), pp. 4-6.

therefore claimed many of the same intimates.[24] Strutt obtained his undergraduate degree in 1865 after placing as Senior Wrangler (the highest position) in the Mathematical Tripos examination and first in the Smith Prizes competition. Such a distinction for an aristocrat's first-born son was extremely unusual. One of the few predecessors was William Cavendish, afterwards Seventh Duke of Devonshire, who placed as Second Wrangler and First Smith's Prizeman in 1829 – a feat requiring examiners to make two independent adjudications to ensure that the scoring reflected no favoritism toward the aristocracy.[25] Strutt's own success fueled a flurry of press images, including a paragraph in the *The Times* that insinuated such favoritism. Henry Sidgwick defended Strutt's merit in a letter to the Editor of *The Times*: "I believe no one who has examined him has any doubt about his singular ability."[26] London's popular humor weekly, *Punch*, predictably ridiculed the accomplishment by carrying it to a logical conclusion: "As the old moons are cut up into little stars, these larger luminaries of the University are cut up into lesser lights, as College Dons and Heads, University Professors, rectors of fat College livings."[27]

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[24] "Notes by Evelyn Lady Rayleigh," Terling; Strutt, *Life*, p. 30.

[25] J.G. Crowther, *Statesmen of Science* (London: Cresset Press, 1965), p. 215. Salisbury's father-in-law, Baron Alderson, genteel in character (though not of the aristocracy), was Senior Wrangler, first Smith's Prizeman, and Senior Medallist – a triple honor achieved only once before and never afterwards; Lady Gwendolen Cecil, *Life of Robert Marquis of Salisbury*, 4 vols. (London: Hodder and Stoughton, 1921-1932), I: 52.

[26] [Anon.], "Honours at Cambridge," *The Times*, London, 30 January 1865; [Henry Sidgwick], "To the Editor of *The Times*," *The Times*, London, 1 February 1865; Strutt, *Life*, p. 35.

[27] [Anon.], "Where the Senior Wranglers Go," *Punch, or the London Charivari* 48 (1865): 56.

Family members constituted another source of mixed reactions to Strutt's academic successes. When Trinity elected him a fellow in 1866, his father, Lord Rayleigh, questioned the appropriateness: "I think [a fellowship] should not be hastily accepted. The Duke of Devonshire and Lord Lyttelton were not fellows, and however much thought of at Cambridge, would not be thought much of for one in your position in life."[28] Rayleigh chose his points of comparison carefully – two scholarly gentlemen already known to his son. (Devonshire was then Chancellor of Cambridge and Lyttelton the father of Strutt's college friend.) Similarly, a relative (the Rev. Leonard Burrows) criticized what appeared to be a shirking of the country squire's normal public "duty," though Strutt himself regarded science as "the duty."[29] In the face of such criticism, his acceptance and pursuit of the Trinity fellowship launched a recurring pattern in his scientific vocation that required him to reconcile an outwardly professional pursuit with the expectations and grace of aristocratic duty.[30]

As a fellow, Strutt sought laboratory experience, but the options at Cambridge were severely limited. He gleaned what he could from demonstrations given by George Gabriel Stokes, Lucasian professor of mathematics, and George Downing Liveing, professor of chemistry – Cambridge's two noted practitioners of experimental science.

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[28] Quoted in Strutt, *Life*, p. 39.

[29] Strutt, *Life*, p. 36.

[30] This need for reconciliation highlighted a growing perception of science as a profession versus amateur avocation, a development analyzed in Robert Kargon, *Science in Victorian Manchester: Enterprise and Expertise* (Baltimore: The Johns Hopkins University Press, 1977).

But, they conducted their research in private laboratories generally closed to students. Strutt therefore spent his fellowship years reading published research while attempting to repeat experiments in vacant college rooms, using apparatus he bought with funds from home. He read James Clerk Maxwell's seminal paper, "A Dynamical Theory of the Electromagnetic Field," recommended to him by the reform-minded fellow, James Stuart, later an organizer of an intercollegiate lecture scheme in physical astronomy and theories of heat, electricity, and magnetism.[31] This paper inspired Strutt to repeat some of Clerk Maxwell's experiments and to enter into regular correspondence with him. Both men presented in a session on color perception at the 1870 British Association for the Advancement of Science meeting in Liverpool, for which Clerk Maxwell was president of Section A (Mathematics and Physics). Strutt later recalled of this period, "I had the sense to cultivate Maxwell as much as I could."[32] As a result, Strutt remained wedded to Maxwellian electrodynamics throughout his long career, possibly to an extent that later prevented him from accepting the new ideas of quantum theory.[33]

In addition to the academic influences, Strutt's informal friendships also

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[31] J. Clerk Maxwell, "A Dynamical Theory of the Electromagnetic Field," *Philosophical Transactions of the Royal Society of London* 155 (1865): 459-512; Andrew Warwick, *Masters of Theory: Cambridge and the Rise of Mathematical Physics* (Chicago: University of Chicago Press, 2003), pp. 266-267.

[32] Strutt, *Life*, pp. 38, 44-54 (Strutt's quote on p. 44); Bruce J. Hunt, *The Maxwellians* (Ithaca: Cornell University Press, 1991).

[33] Among standard accounts of the shift from "classical" to "quantum" physics, Rayleigh is symbolic of the rear-guard, classical view; Max Jammer, *The Conceptual Foundations of Quantum Mechanics* (New York: McGraw-Hill, 1966); Thomas S. Kuhn, *Black-body Theory and the Quantum Discontinuity, 1894-1912* (New York: Oxford University Press, 1978).

supported his scientific learning. After Balfour left Cambridge in 1869 to assume proprietorship over his late father's estates, he maintained friendships within the private houses of his family circle. Balfour's Whittingehame House became a popular gathering place during the summer vacations. Within the various get-togethers, which also often included Balfour's sisters, Strutt developed a romantic interest in the musically-talented Evelyn Balfour. He wrote to his mother, Lady Rayleigh, from Whittingehame in 1869, indicating the large size of the party as well as his affection for Evelyn: "All the Balfours are here (4 brothers & 3 sisters), Mrs. Herbert of Muckross, their Aunt & 2 daughters, Mr. & Mrs. Campbell, L^y^ Mary Cecil & her younger sister, [George] Darwin, so that we are rather a large party. Arthur Elliott came today. I am enjoying myself & of course rapidly falling in love with Miss Evelyn."[34] John found in Evelyn a learned companion who enjoyed discussing scientific ideas – adding a very personal character to his informal exposure to science.

The friends attended science lectures and held conversations at relatives' homes. Strutt accompanied the Balfours in London outings which included John Tyndall's lectures on sound at the Royal Institution. In another gathering, at Salisbury's Hatfield House in the autumn of 1870, Strutt learned of his host's amateur research in electricity and magnetism. Strutt wrote to his mother: "[Salisbury] took me into his laboratory which also serves as a dressing room and showed me some magnetic experiments which I am supposed to explain! He is too awkward to succeed well as an experimenter I think."

[34] J.W. Strutt to C. Rayleigh, Whittingehame, n.d. [1869], Terling.

Afterwards, Strutt sent Salisbury the requested explanations.[35] Such exposure to popular and amateur science enhanced Strutt's academic studies.

Science Reform at Cambridge

In the background to Strutt's scientific learning in college rooms, lecture halls and country houses, a broader dissatisfaction with deficient laboratory resources fueled a reform movement at Cambridge.[36] Clerk Maxwell, who was an examiner in the Mathematical Tripos in 1866, 1867, 1869, and 1870, personally helped propel the reform by introducing new practical questions dealing with heat and electricity. As Andrew Warwick has pointed out, Strutt's readings in Clerk Maxwell's new theory of electromagnetism illustrated an increasing interest at Trinity in technical and physical science topics believed to be important preparation for professional careers in industry.[37] Practical questions in heat and electricity, however, required a teaching physical laboratory, which did not yet exist at Cambridge.

Contemporaneously, a growing national concern over the low status of scientific

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[35] J.W. Strutt to C. Rayleigh, Cambridge, 1 November 1870, quoted in Strutt, *Life*, p. 56.

[36] Roy MacLeod and Russell Moseley, "The 'Naturals' and Victorian Cambridge: Reflections on the Anatomy of an Elite, 1851-1914," *Oxford Review of Education* 6 (1982): 177-196; MacLeod and Moseley, "Breaking the Circle of Science: The Natural Sciences Tripos and the 'Examination Revolution'," in *Days of Judgment: Science, Examinations, and the Organization of Knowledge in Late Victorian Britain*, ed. R.M. MacLeod (Driffield: Studies in Education, 1982), pp. 189-212; David B. Wilson, "Experimentalists among the Mathematicians: Physics in the Cambridge Natural Sciences Tripos, 1851-1900," *Historical Studies in the Physical Sciences* 12 (1982): 325-371.

[37] Lewis Campbell and William Garnett, *The Life of James Clerk Maxwell*, ed. Robert H. Kargon, The Sources of Science, no. 85 (New York: Johnson Reprint, 1969), p. 325, 357-358; Warwick, *Masters of Theory*, pp. 286-356.

teaching and research in Britain also contributed to the impulse to reform Cambridge. An address by the astronomer and instrument-maker Alexander Strange at the 1868 British Association for the Advancement of Science meeting at Norwich convinced the BAAS to appoint a committee to investigate the need for state intervention in science. In 1870 the BAAS delivered its report to Prime Minister Gladstone's ministry, which in turn reacted by appointing a Royal Commission to investigate the national status of "Scientific Instruction and the Advancement of Science." Gladstone appointed the Duke of Devonshire, a faithful Liberal supporter of his ministry, as the Commission's chair. Over the next six years, the Commission, consisting of an admixture of professional scientists, gentlemen amateurs, and statesmen, conducted its broad inquiry and issued its testimony in a series of eight reports. The third report, issued in August 1873, dealt squarely with Oxford and Cambridge and indicated the deficiencies in laboratory resources alongside the great promise the universities held for advancing in scientific teaching and research.[38]

As these developments unfolded, a Cambridge syndicate recommended the establishment of a physics laboratory in 1869, but lacking funds thwarted immediate action. The Chancellor, Devonshire, recognized the importance of the laboratory both in terms of its significance to technical education for industry and his new Royal

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[38] *Royal Commission on Scientific Instruction and Advancement of Science*, Reports 1-8, 3 vols. (London: Her Majesty's Stationery Office, 1872-1875); Roy MacLeod, "The Support of Victorian Science: The Endowment of Research Movement in Great Britain, 1868-1900," *Minerva* 2 (1971): 197-230; reprinted in MacLeod, *Public Science and Public Policy in Victorian England* (Aldershot: Variorum, 1996); A.J. Meadows, *Science and Controversy: A Biography of Sir Norman Lockyer* (Cambridge, MA: MIT Press, 1972), pp. 75-112; and Crowther, *Statesmen of Science*, pp. 224-233.

Commission charge.[39] To move things forward, in 1870 he offered to meet the initial estimate of £6300 for the physical laboratory's building and apparatus, afterwards raised to an actual cost of £8450. To hire a Professor of Experimental Physics to direct the laboratory, a syndicate invited William Thomson at Glasgow and Hermann Helmholtz at Berlin – both first-rate men of science who appreciated the importance of physical science to industry – to stand as candidates, but neither could be drawn from their home institutions. Next, the committee looked to Clerk Maxwell, who previously held the chair of Natural Philosophy at King's College, London, and, after his resignation in 1865, conducted private research at his country seat, Glenlair. Strutt, following the Cambridge developments, wrote to Clerk Maxwell in February 1871 to encourage that he stand for the candidacy:

> When I came here last Friday I found every one talking about the new professorship, and hoping that you would come. Thomson, it seems, has definitely declined.... There is no one here in the least fit for the post. What is wanted by most who know anything about it is not so much a lecturer as a mathematician who has actual experience in experimenting, and who might direct the energies of the younger Fellows and bachelors into a proper channel.... I hope you may be induced to come; if not, I don't know who it is to be."[40]

Swayed by the arguments of Strutt and other friends, Clerk Maxwell entered as a

[39] Gerald L. Geison, *Michael Foster and the Cambridge School of Physiology: The Scientific Enterprise in Late-Victorian Society* (Princeton: Princeton University Press, 1978), pp. 113-114, challenges the overriding historical consensus that Devonshire's motives were related to his industrial interests. Geison placed greater emphasis on Devonshire's benevolence as an aristocratic philanthropist desiring to support his own institution than his industrial interests, but I do not see these two factors as mutually exclusive – in fact, I believe both importantly conditioned his decision.

[40] J.W. Strutt to J. Clerk Maxwell, Cambridge, 14 February 1871, quoted in Campbell and Garnett, *The Life of James Clerk Maxwell*, p. 349.

candidate and, unopposed, received official appointment on 8 March 1871. Planning, building, and outfitting of the laboratory continued until its opening in 1874. The name, initially "Devonshire" but permanently "Cavendish," associated the laboratory not only with the generous Chancellor but also with his famous late relative, the chemist Henry Cavendish, whose papers Clerk Maxwell collected and edited for publication.[41]

Independent Experiments and Theorizing

Against this background of developments, Strutt's individual efforts in vacant college rooms led him to later conclude that "3 precious years of experimental work were lost for want of knowing how to set to work."[42] Nevertheless, in this manner he began important investigations that later defined, in large measure, his career's major works: elaboration and illustration of Clerk Maxwell's theory of electrodynamics, problems in optics, and a mathematical treatment of acoustics. (Strutt's celebrated work on electrical standards and gases – particularly his discovery of argon – are inquiries initiated in later

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[41] Henry Cavendish, *The Electrical Researches of the Honourable Henry Cavendish, F.R.S., written between 1781 and 1781*, ed. J. Clerk Maxwell (Cambridge: Cambridge University Press, 1879). The history of the Cavendish laboratory is very well documented; standard accounts include *A History of the Cavendish Laboratory, 1871-1910* (New York: Longmans, Green, and Co., 1910); J.G. Crowther, *The Cavendish Laboratory, 1874-1974* (New York: Macmillan, 1974); Romualdas Sviedrys, "The Rise of Physical Science at Victorian Cambridge," *Historical Studies in the Physical Sciences* 2 (1970): 127-151; Graeme Gooday, "Precision Measurement and the Genesis of Physics Teaching Laboratories," *British Journal for the History of Science* 23 (1990): 25-51; Andrew Warwick, "The Worlds of Cambridge Physics," in Richard Staley, ed., *The Physics of Empire: Public Lectures* (Cambridge: Whipple Museum of the History of Science, 1994), pp. 57-86.

[42] Evelyn Rayleigh, Diary, quoted in Strutt, *Life*, p. 407.

periods.)[43] In 1868 he purchased an outfit of apparatus consisting of a Rhumkorf coil, Grove cells, a Ladd galvanometer, and a large electro-magnet. His experiments on the deflection of the galvanometer needle resulted in a paper read to the BAAS at Norwich in 1868.[44] His first published refereed paper in 1869 summarized the results of his experiments on mechanical analogies to electrical phenomena governed under Clerk Maxwell's laws of electrodynamics. Following this paper, Strutt made three suggestions that Clerk Maxwell adopted in his *The Theory of Heat*, published in 1871.[45]

Strutt also repeated a series of Clerk Maxwell's experiments on color perception. In the late 1850s, Clerk Maxwell studied the production of compound colors from primary colors using a color top. An observer viewing a spinning disc, sectioned into primary colors, typically sees a single hue formed by the mixture of the colors, for example yellow from a spinning disc sectioned into green and red. Clerk Maxwell showed that from a set of six colors – red, blue, green, yellow, white and black – with any one color removed the remaining five can be distributed into two discs that, when spun, will produce matching composite colors. He calculated the proportions of colors required for the matches, and found that the experimental results agreed reasonably well with his

[43] The best overview of Strutt's scientific work remains Arthur Schuster, "John William Strutt, Third Baron Rayleigh, 1842-1919," *Proceedings of the Royal Society of London*, series A, 93 (1921): i-l.

[44] Strutt, *Life*, pp. 45-46.

[45] James Clerk Maxwell, *Theory of Heat* (London: Longmans, 1871); Strutt, *Life*, p. 48.

predictions based on theory.[46]

Between 1869 and 1870, Strutt repeated the experiments, as he explained, more "for my own satisfaction than with the hope of adding anything new to a subject already so fully and ably treated." His observed results agreed more closely with theory than Clerk Maxwell's observations, which Strutt attributed to "an excellent perception of minute differences of colour (to which I have always found my eyes very sensitive) than to greater care in conducting the experiments."[47] While Strutt's study indeed added nothing new to theory, it did raise two questions that led to new lines of inquiry. One issue lay in the difficulty for humans to resolve compound yellow into its constituents, red and green, making it "doubtful whether our vision is trichromic or tetrachromic."[48] On this point, Strutt argued in favor of trichromatic vision, a stance that prompted a debate with Charles John Monro, another Trinity fellow. Strutt's continued interest in this problem led to a series of experiments in which he tested human subjects' abilities to distinguish compound yellow in solution from pure spectral yellow. In this project, he recruited subjects among his family and friends.[49]

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[46] Campbell and Garnett, *The Life of James Clerk Maxwell*, pp. 466-483. An excellent contemporary exposition of Clerk Maxwell's color theory is in Ogden N. Rood, *Modern Chromatics: with Applications to Art and Industry*, Volume 27 of *International Scientific Series* (London: C.K. Paul, 1879).

[47] John William Strutt, Baron Rayleigh, "Some Experiments on Colour," in *Scientific Papers*, 6 vols. (Cambridge: Cambridge University Press, 1899-1920), I: 79-86, on 80-81.

[48] Rayleigh, "Some Experiments on Colour," p. 85.

[49] The debate occurred in *Nature* 3 (January, 1871). Strutt's side of the debate is reprinted in Rayleigh, "Some Experiments on Colour."

The second question that Strutt raised followed from his observation that the clearness or cloudiness of the sky influenced the proportions of primary colors required to make the color matches. He concluded, "There is no doubt that the colour equations are dependent on the character of the light, as may easily be proved by taking an observation looking all the time through a layer of coloured liquid." In this connection, he mused on the nature of sky color: "I am not aware whether the difference of sky and cloud light has ever been made the subject of direct investigation, but it would seem a fair inference that it must consist mainly in a relative deficiency of the red rays."[50]

Strutt immediately considered this question in an extended study of the physical atmospheric properties responsible for producing the blue color of the sky. His conclusions overthrew previous theories by Rudolf Clausius and John Tyndall, who each assumed the action of light on airborne water particles and the applicability of Newton's theory of thin plates. Strutt's explanation, which argued for the scattering of light by molecules smaller in dimension than the wavelength of light, resulted in his well-known statement of the scattering law: "*When light is scattered by particles which are very small compared with any of the wave-lengths, the ratio of the amplitudes of the vibrations of the scattered and incident light varies inversely as the square of the wave-length, and the intensity of the lights themselves as the inverse fourth power.*"[51] By this law, the intensity of scattered light is greatest from incident light whose wavelength is nearer the violet end

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[50] Strutt, "Some Experiments on Colour," in *Scientific Papers*, I: 79-86, on 82-83.

[51] Strutt, "On the Light from the Sky, its Polarization and Colour," in *Scientific Papers*, I: 87-109, on 91 (italics in original).

of the visible spectrum than the red. While all colors in the spectrum scatter, the greater contributions from the violet end of the spectrum produce scattered light composed predominantly of blue. He confirmed the validity of his scattering law through experiments conducted in rooms at Trinity. Tyndall, Clerk Maxwell, and even Monro received Strutt's explanation favorably.[52]

The third of Strutt's major lines of research during his fellowship lay in acoustics. At the suggestion of another Trinity fellow, Coutts Trotter, Strutt took up reading Hermann Helmholtz's *Lehre von den Tonempfindungen* (*On the Sensations of Tone*), in part to learn German.[53] Characteristically, Strutt followed his reading with experiments. He focused, in particular, on the resonance of organ pipes, bottles, and flasks. Finding Helmholtz's theory for the resonance produced by a cavity with holes impractical and too complicated mathematically, Strutt framed the problem anew by considering "the case where the communication with the external air is no longer by a mere hole in the side, but by a neck of greater or less length...because resonators with necks are frequently used in

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[52] Strutt followed up this initial study with a mathematical derivation that "attacked the problem more generally"; Strutt, "On the Scattering of Light by Small Particles," in *Scientific Papers*, I: 104-110, on 104. The significance of Strutt's scattering work to physics has been analyzed by several scholars: Victor Twersky, "Rayleigh Scattering," *Applied Optics* 3 (1964): 1150-1162; Nelson A. Logan, "Survey of Some Early Studies of the Scattering of Plane Waves by a Sphere," *Proceedings of the IEEE* 53 (1965): 773-785; J.D. Hey, "From Leonard to the Graser: Light Scattering in Historical Perspective," *South African Journal of Science* 79 (1983); 11-27, 310-324; and Andrew T. Young, "Rayleigh Scattering," *Physics Today* 34, 1 (1982): 42-48.

[53] Hermann Helmholtz, *Die lehre von den tonempfindungen als physiologische gundlage für die theorie der musik* [*On the Sensations of Tone as a Physiological Basis for the Theory of Music*] (Braunschweig: F. Vieweg und sohn, 1863); Strutt, *Life*, p. 50.

practice."[54] He offered a relatively simple mathematical derivation that gave a more general rule governing the relationship between the pitch of a resonating cavity with the cavity's volume and its neck's length.

To verify his experiments experimentally, he returned to Terling Place where he could make use of his sister's piano in the book-room. To determine pitches, he used a simple technique: "I have...found it possible to determine with considerable precision the pitch of small flasks with long necks by simply holding them rather close to the wires of the piano while the chromatic scale is sounded. The resonant note announces itself by a quivering of the body of the flask, easily perceptible by the fingers."[55] In addition to this method, he also fixed pitches by feeding one end of flexible tubing made of india-rubber into a given flask through its neck, and inserting the other end into the ear: "A good ear would find no difficulty in identifying the note produced when the body of the globe is struck with the soft part of the hand." Strutt found his results to agree "very satisfactorily," the maximum error less than half a semitone.[56]

His studies of resonance launched a major project in mathematical acoustics that occupied his attention for much of the next decade.[57] The availability of a piano and organ

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[54] Strutt, "On the Theory of Resonance," in *Scientific Papers*, I: 33-75, on 34. His paper won the Hopkins Prize; F.M. Balfour, [Announcement], *Proceedings of the Cambridge Philosophical Society* 4 (1882): 236.

[55] Strutt, "On the Theory of Resonance," p. 70.

[56] Strutt, "On the Theory of Resonance," pp. 71-72; Strutt, *Life*, p. 51.

[57] John William Strutt, Baron Rayleigh, *On the Theory of Sound*, 2 vols. (London: Macmillan, 1878-1879); Robert Bruce Lindsay, "Historical Introduction," in John William Strutt, Third Baron Rayleigh, *The Theory of Sound* (New York: Dover, 1945),

at Terling encouraged him to conduct experiments there, but another reason for working at home also intervened. In May 1871 he became engaged to Evelyn Balfour, and in July the couple married. Trinity statutes (afterwards repealed in 1882) required Strutt to resign his fellowship upon his marriage.[58] Despite the experimental deficiencies, he found Cambridge's intellectual environment, the return of Clerk Maxwell, and the imminent opening of the new physical laboratory a source of mixed feelings over his decision to marry and thus sever his formal ties to Cambridge. He wrote to his friend Henry Sidgwick, "You have heard doubtless of my engagement to Miss Balfour.... I want to know whether I ought to make a formal announcement to the Master, & whether there is any other etiquette to be observed....To me the breaking of my connection with Cambridge is the dark side of the approaching change."[59]

Francis Maitland Balfour

In October 1870 Frank Balfour took up residence at Trinity College as a Pensioner, departing from the Fellow-Commoner route taken by his brother Arthur. With Strutt's departure looming, and Arthur already back at Whittingehame, Frank's participation in the his older brother's circle occurred primarily outside of Cambridge. He joined the outings and parties in London and at relatives' country seats. When left at

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pp. 5-32, and Lindsay, ed., *Acoustics: Historical and Philosophical Development* (Stroudsburg, PA: Dowden, Hutchinson & Ross, 1973).

[58] Rothblatt, *The Revolution of the Dons*, p. 242.

[59] J.W. Strutt to H. Sidgwick, 4 July 1871, Terling.

Cambridge, he sent news home through letters written especially to his sisters.[60] As an undergraduate, he established strong roots for a scientific career that would be based in Cambridge for the next twelve years. He became a central figure in a developing Cambridge school of embryology, as well as an active participant in an informal aristocratic network coalescing in Cambridge in the late 1870s. His undergraduate years form the important background to these later developments.

Balfour's first college tutor was Joseph Prior, who later supervised the studies of King Edward VII's elder son, the Duke of Clarence. But the private tutelage of Marlborough Robert Pryor, Trinity's first fellow in the natural sciences, proved more important to Balfour's initial scholastic development at Trinity. Under Pryor's supervision in 1870 and 1871, Balfour successfully passed the Previous Examination and won election to a Trinity natural science scholarship. Pryor and Balfour became fast friends; they later toured Brazil during a trip at once recreational, scientific and business in its purpose. Balfour admired Pryor, defending him against critics as a man unparalleled in "promising scientific abilities" and "genuine love of science."[61] Apparently Pryor left Cambridge within a few years. He afterwards succeeded to his family's estate, Weston Park, near Hitchin in Hertsfordshire, and became chairman of an insurance company.[62]

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[60] F.M. Balfour to H. Sidgwick, [1871 or 1872?], Add. Ms. c. 93^{20}, SP, Wren.

[61] Francis M. Balfour, "Scientific Endowments and Bequests," *Nature* 8 (1873): 25; Theodore Edmund Alexander, "Francis Maitland Balfour's Contributions to Embryology," University of California – Los Angeles: Ph.D. thesis, 1969, p. 43-45; M[ichael] F[oster], "Francis Maitland Balfour," *Proceedings of the Royal Society of London* 35 (1883): xx-xxvii.

[62] *Alum. Camb.* Pryor married in 1875, thus ending his fellowship.

No Cambridge scholar furthered Balfour's intellectual development in biology more than Michael Foster, Thomas Huxley's former demonstrator in biology at University College, London, and the recently-elected Praelector of Physiology at Trinity. Balfour attended Foster's lectures during the 1871 Lent term, but he did not attract Foster's notice until his examination for the Trinity scholarship just before Easter. According to Foster, "I did not distinctly make [Balfour's] acquaintance until March, 1871, when I took part in an examination at Trinity College, which resulted in Balfour being elected Natural Science Scholar. From that time forward we became more and more intimate, and I took an increasing share in the direction of his studies." Foster's "share" included what some perceived as "rash" advice: "I counselled him to neglect the ordinary routine preparation for his degree, and to apply himself at once to original work."[63]

This encouragement of Balfour's research furthered Foster's own interests as well; his vision for a biological school of research at Cambridge depended upon the contributions of his students. Foster's election as Praelector in 1870, supported by Coutts Trotter and other advocates for reform of science at Trinity, included space for practical instruction and experimental research – amounting to a small room in the Philosophical Library. According to one of his pupils, Walter Holbrook Gaskell, "He carefully studied the bent of his various students, and picked out Balfour to study the new science of embryology and [Sydney H.] Vines to work at the new botany. In his own department of

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[63] M. Foster, "Francis Maitland Balfour," *Nature* 26 (1882): 313-314, on 313. George Murray Humphry, professor of anatomy and physiology, may also have encouraged Balfour; J. Stanley Gardiner, *The Zoological Department, Cambridge* (Cambridge: W. Heffer and Sons, 1934), p. 2, BNL.

physiology he had besides H[enry] N[ewell] Martin as workers and helpers [John Newport] Langley, [Arthur Sheridan] Lea, Gaskell, and [Albert George] Dew Smith. By this means he gradually built up a school of biology of a new type."[64] About Foster's instigation of Balfour's pursuit, Gaskell recalled, "It was a memorable day in the history of biology when Foster, talking in the little room of the philosophical library about his future career with Balfour, who wanted to devote himself to science, but was uncertain what line of research to follow, took up an egg, cracked it, showed him the embryo inside, and said 'What do you think of working at that?'"[65]

A highlight of Foster's lectures in embryology was the development of the chick embryo; he presented Balfour with the challenge of clarifying obscure points.[66] Using a technique devised by Russian physiologists and recently adopted by the younger generation of English morphologists led by Edwin Ray Lankester, Jr., Balfour opened freshly-laid eggs, removed and hardened the blastoderm in a solution of chromic acid and, afterwards, gold chloride. He then cut cross sections of the blastoderm for

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[64] W[alter] H[olbrook] G[askell], "Sir Michael Foster, 1836-1907," *Proceedings of the Royal Society* 80 (1908): lxxi-lxxxi, on lxxiv.

[65] G[askell], "Sir Michael Foster, 1836-1907,"p. lxxix; compare Geison, *Michael Foster and the Cambridge School of Physiology*, p. 125.

[66] Balfour's student notes, unfortunately, cannot be traced. Insights into the range of subjects covered in Foster's classes are available from two contemporary sources: A.G. Dew-Smith (Balfour's classmate in Foster's lectures), [untitled notebook], Trinity College, 26 April 1871, PL; E. Klein, J. Burdon-Sanderson, Michael Foster, and T. Lauder Brunton, *Handbook for the Physiological Laboratory*, 2 vols. (London: J. & A. Churchill, 1873), PL.

microscopic study.[67] He recorded the changes which took place in the cells of the blastoderm during the first thirty to forty hours of incubation, confirming earlier studies, but he also challenged received views on the formation of the mesodermal layer by proposing contributions from the primitive streak of the chick embryo and the lower layer of the blastoderm.[68]

His investigations followed a method then in vogue among the younger generation of evolutionary morphologists, namely to discover homologous structures of lower animal forms in the embryonic development of higher forms, an approach derived from German morphologists.[69] His careful observations of the chick embryos led him to recognize in the structure of the primitive streak the "homologue" (vestige) of the invertebrates' blastopore, the hollow sphere formed by the initial subdivision of the egg cell. The morphologist Henry Nottidge Moseley later judged, "This brilliant discovery, which was absolutely new, was fully established by him subsequently, and is of the greatest importance as proving the identity of the early processes in the formation of the

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[67] Leon Stephen Jacyna, "Scientific Naturalism in Victorian Britain: An Essay in the Social History of Ideas," Ph.D. thesis, University of Edinburgh, 1980, pp. 252-253; Alexander, "Francis Maitland Balfour's Contributions to Embryology," pp. 52-53; Peter J. Bowler, *Life's Splendid Drama: Evolutionary Biology and the Reconstruction of Life's Ancestry, 1860-1940* (Chicago: University of Chicago Press, 1998), pp. 79-82.

[68] Alexander, "Francis Maitland Balfour's Contributions to Embryology," pp. 54-55.

[69] A.H. Sykes, "Foster and Sharpey's Tour of Europe," *Notes and Records of the Royal Society of London* 54 (1) (2000): 47-52; Lynn K. Nyhart, *Biology Takes Form: Animal Morphology and the German Universities, 1800-1900* (Chicago: University of Chicago Press, 1995); Jacyna, "Scientific Naturalism," pp. 246-248.

[cell] layers in the lower and higher [animal] forms."[70]

Balfour published his chick studies in a series of papers that appeared in the *Quarterly Journal of Microscopical Science*, edited by Lankester, and reprinted in Foster's new *Studies from the Physiological Laboratory in the University of Cambridge.*[71] With Balfour's papers leading the Cambridge publication, Foster presented his new journal to Trinity as proof of the merits of research over examination study:

> When I ask you to accept these pages, it is because I sincerely trust their publication may help towards the establishment of a habit of research among our students of physiology at Cambridge.... Among us, if anywhere, research ought to be possible; and I believe much valuable work would soon be done, if our multitudinous regulations could be exchanged for definite organisation and the energies of our students were less cramped by formal examinations.[72]

While the journal's title explicitly identified a "Physiological Laboratory," the designation applied in reality to the small room assigned to Foster; an official laboratory

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[70] H.N. Moseley, "Francis Maitland Balfour," *Fortnightly Review* 32 (1882): 568-580, on 577. On Balfour's approach within contemporary homology, Jacyna, "Scientific Naturalism," pp. 246-266, and Alexander, "Francis Maitland Balfour's Contributions to Embryology," *passim.*

[71] Francis Maitland Balfour, "The Development and Growth of the Layers of the Blastoderm," *Quarterly Journal of Microscopical Science* 13 (1873): 266-276; reprinted in *Studies from the Physiological Laboratory in the University of Cambridge* 1 (1873): 1-10; "On the Disappearance of the Primitive Groove in the Embryo Chick," *Quarterly Journal of Microscopical Science* 13 (1873): 276-280; reprinted in *Studies from the Physiological Laboratory in the University of Cambridge* 1 (1873): 10-14; "The Development of the Bloodvessels of the Chick," *Quarterly Journal of Microscopical Science* 13 (1873): 280-290; reprinted in *Studies from the Physiological Laboratory in the University of Cambridge* 1 (1873): 15-24; Balfour, *The Works of Francis Maitland Balfour*, mem. ed. by M. Foster and A. Sedgwick, 4 vols. (London: Macmillan, 1885).

[72] Michael Foster to George Murray Humphry, 5 November 1873, printed as a preface to *Studies from the Physiological Laboratory in the University of Cambridge* 1 (1873).

by this name was not established at Cambridge until 1878. Other papers published in this first number of the journal included ones by Foster, Dew-Smith, and Newell Martin.

Balfour's series of chick studies also made possible another goal of Foster, to publish an elementary embryology textbook for use in college teaching. The resulting handbook, coauthored by Foster and Balfour, came out in 1874 and received favorable reviews. It went to a second edition and was translated into several languages. As late as 1887 Edward Bagnall Poulton identified it as the text with which "an ideal course of embryology will begin."[73] Although Balfour was listed as secondary author, Alexander argued that "the work was really a product of Balfour's efforts."[74] Foster implied as much in the preface: "The work took its origin in the course of lectures delivered by myself, but many causes prevented my taking the task seriously in hand, until I was joined by my friend and former pupil Mr. F.M. Balfour, whose share in the matter has, to say the least, been no less than my own.[75] Balfour worked on *The Elements of Embryology* at Cambridge and at home, where he recruited his sister Alice to draw many of the books' figures. In the publication, her contributions appear unsigned, but the authors duly acknowledged her assistance in the preface: "The figures, whose source is not acknowledged in the text, were drawn by Miss A.B. Balfour, except a few by

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[73] Jacyna, "Scientific Naturalism," p. 260; M. Foster and Francis M. Balfour, *The Elements of Embryology*, 2 vols. (London: Macmillan, 1874).

[74] Alexander, "Francis Maitland Balfour's Contributions to Embryology," p. 60.

[75] M. Foster and Francis M. Balfour, *The Elements of Embryology*, 2 vols. (London: Macmillan, 1874), I: ix.

ourselves."[76]

Frank Balfour kept busy with laboratory studies at Cambridge, but, as a colleague recollected, "[He] was as keen in his recreations as at his work."[77] For exercise he enjoyed bicycle-riding on the Fens and, like Arthur Balfour and John Strutt, played tennis. Away from Cambridge, he spent his holidays with family at Whittingehame much as during the days of "The Whittingehame Advertiser."[78] His love of natural history never diminished during concentrated study of embryos beneath the microscope. He wrote to his sister Evelyn about some of his holiday jaunts with Nora: "We go out in the afternoons geologising and botanising, & have been fairly successful in our endeavours. We went to Dunbar on Saturday to stock aquarium w^h^ we have done."[79] In 1873 he journeyed through Lapland with his friend and former Harrow schoolmate, Arthur Evans, who desired to study remnants of the ancient habits and superstitions of the Lapps.[80]

Balfour devoted the last few months of his undergraduate years preparing for the Natural Sciences Tripos, in which he placed second, behind Newell Martin, in December 1873. Geison speculated that Balfour's "deep and early involvement in research may have

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[76] Foster and Balfour, *The Elements of Embryology*, I: ix; Donald L. Opitz, "'Behind folding shutters in Whittingehame House': Alice Blanche Balfour (1850-1936) and Amateur Natural History," *Archives of Natural History* 31 (2004): 330-348.

[77] H.N. Moseley, "Francis Maitland Balfour," 573.

[78] See Chapter 3.

[79] F.M. Balfour to E.G.M. Balfour, Whittingehame [1872?], Terling.

[80] Moseley, "Francis Maitland Balfour," pp. 570-571.

prevented [him] from doing as well as expected in his degree work."[81] Balfour left Cambridge upon taking his degree, but only for a short time; he returned after being elected a Trinity fellow in October 1874. His return launched a new period at Cambridge marked by his role in aristocratic politicking, to which I will return in Chapter 6.

Balfour's Cambridge friends remembered him as a private man: "He rather shunned publicity; he was not much or often before the eyes of the world; he was always modest, studious, retiring."[82] According to Moseley, "[He] never threw off a certain trace of shyness and reserve as long as he lived."[83] But he attracted around him at Cambridge an intimate circle of friends that shared his love of science and devotion to research. Lea found in Balfour not only a colleague but a confidante: "Many who were engaged in lines of life entirely divergent from his, both those who were older as well as those who were younger than himself, were led to seek his advice in affairs not only of everyday life, but in matters which were of the most private nature."[84] In privacy Balfour best exerted his influence among friends. His personal charm also made him a favorite among his family circle.[85]

Conclusion

While Arthur Balfour, Frank Balfour and John Strutt each participated in distinct

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[81] Geison, *Michael Foster and the Cambridge School of Physiology*, p. 126.

[82] *Balfour Memorial: Undergraduate Meeting at the Union, Cambridge, 30th October, 1882* (Cambridge: Fabb & Tyler, 1882), p. 4, BNL.

[83] Moseley, "Francis Maitland Balfour," 560.

[84] *Balfour Memorial*, pp. 9-10.

[85] Balfour, *Ne Obliviscaris*, I: 311.

academic circles defined by their individual fields of study, they also formed an intimate circle of friends and family that crossed disciplinary boundaries. Their private circle was marked by its aristocratic membership, intellectualism, and relations sustained between country seats, city townhouses, and Cambridge college rooms. By being at Trinity during the late 1860s and early 1870s, the Balfour brothers and Strutt became immersed in currents of scientific reform led by Sidgwick, Foster and Clerk Maxwell – three of the most influential advocates of reform at Cambridge and illustrious scholars of their respective fields. Cambridge inspired the three aristocrats to pursue lines of inquiry in science philosophy, biology and physics to a degree that drew them away from conventional lives as gentlemen concerned with affairs of estate and politics – at least for the time being. While each achieved note early in his career and showed promise as a great scholar, most critically these men became associated in a social circle that would enable them to accomplish much more in science than they might have as solitary gentlemen amateurs.

Chapter 5

Science in the Evangelical Home: The Rayleighs at Terling Place

> In the country more especially, the young gentlemen of the house may find themselves very much at a loss sometimes for an informal place in which "to do as they like." In one corner there may be a work-bench and tool-chest; over the mantelpiece there may be foils and dumb-bells; the fireside may be dedicated to the cigar, very properly forbidden elsewhere; there may be a lathe in another corner; in a closet, out of harm's way, there may be an electrical machine and half a dozen things of the sort; while in a plain cabinet at the end of the room there may be deposited collections, prepared and unprepared, botanical, entomological, mineralogical, &c. &c. &c. There seems no reason why, in a large house, there should not be one room more on this account.[1]

Upon his father's death in 1873, John Strutt inherited the title Baron Rayleigh and his father's Essex farming estate, Terling Place. Here he built the laboratory that popular narratives and certain historiographies have made emblematic of a romantic era of British individualistic science.[2] But Terling as an emblem and Terling as an historically-situated site are two different things. In one interpretation of Terling science as an example of late-Victorian "country house science," Simon Schaffer has emphasized the laboratory's pastoral (bucolic) setting and gentlemanly protocols, particularly Rayleigh's style of hierarchical laboratory leadership consistent with the position of an estate lord.[3] However,

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[1] Robert Kerr, *The Gentleman's House: Or, How to Plan English Residences, from the Parsonage to the Palace*, 2nd rev. ed. (London: John Murray, 1865), p. 130: "Gentlemen's Odd Room."

[2] I cite several examples further in this chapter. A particularly good example of the popularization is in Sir Evelyn Wrench, "The British Way: Great Britain's Major Gifts to Freedom, Democratic Government, Science, and Society," *The National Geographic Magazine* 95, 4 (April, 1949): 421-542; also Peter Tooley, "The Terling Laboratory," *Chemistry in Britain* 15 (1979): 284-285.

[3] Simon Schaffer, "Physics Laboratories and the Victorian Country House," in *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, ed. Crosbie

Schaffer's analysis overlooks two crucial elements that, when considered, evoke a different understanding. First, there is another sense to "pastoral" we should also consider: namely, the role of religion. Second, for a research site based within a domestic setting, we should also wonder in what ways Rayleigh's science interfaced with family life. Born into a family that embraced the tenets of the evangelical revival, including the cultivation of the intellect, as I discussed in Chapters 2 and 3 Rayleigh's early education in science owed much to the influence of his evangelical elders. His marriage to Evelyn Balfour – also from a strongly evangelical family – sustained the religious and intellectual tone of his home, which became the physical and moral center of his scientific work. But evangelical values also shaped Evelyn's role as a companionate wife, who applied her scientific talents in support of her husband's work. These aspects suggest that the layers of meaning to Terling's "country house science" fundamentally relied upon its particular evangelical, familial infrastructure, a critical concept to any definition of country house science within this particular aristocratic network.[4]

To flesh out these themes, this chapter will thus reconsider the status of Terling science by situating it within its familial and religious context. It begins with a

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Smith and Jon Agar (Basingstoke: Macmillan, 1998), pp. 149-180, esp. pp. 162-167.

[4] By familial infrastructure, I mean a social and material support system based upon the family unit. A similar concept is given in M. Jeanne Peterson, *Family, Love, and Work in the Lives of Victorian Gentlewomen* (Bloomington, IN: Indiana University Press, 1989) pp. 166 and 188, as a "family economy of the upper-middle class," analogous to the productive household economies of the working-classes; also Louise A. Tilly and Joan W. Scott, *Women, Work, and Family* (New York: Holt, Rinehart and Winston, 1978), and Pat Hudson and W.R. Lee, eds., *Women's Work and the Family Economy in Historical Perspective* (Manchester: University Press, 1990).

deconstruction of popular narratives portraying Rayleigh's private research as the embodiment of stereotypes of gentlemanly, amateur, individualistic, and modest research endeavors. Next, to counter this imagery, I proceed to a close examination of the family dynamics surrounding Rayleigh's research at Terling Place. A major focus here is the role of the estate's chatelaine, Lady Rayleigh, in the domestic arrangements, experimental assistance, and companionate support of her husband's work. Moving beyond the assumptions of popular stereotypes and stock characterizations fueling the literary and historical representations of Rayleigh's private science, I propose to enter his household and examine the place of its scientific activities amid a religious family's domestic life.

Images of Private Science

Leisurely Avocation

Within Rayleigh's lifetime, popular accounts of his contributions to science marveled that a peer should engage in serious scientific work. A local Essex journalist wrote, "In former days scions of noble houses – like Robert Boyle and Henry Cavendish – were among our foremost discoverers. Lord Rayleigh holds a place of his own as a scientific man.... In spite of popular ideas to the contrary, the peerage has contributed not insignificantly to scientific advancement by personal research."[5] "Popular attitudes to the contrary" implied the stereotypes of an idle aristocracy, explained by George Lillie Craik as the outcome of wealth: "A rich man, who can live without exertion of any kind, is apt to lose the power even of that degree of exertion which is necessary for the acquisition of

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[5] [Anon.], " 'Echo' Portrait Gallery: Lord Rayleigh, F.R.S.," *The Essex County Chronicle*, Chelmsford, 15 September 1891, Terling.

knowledge."[6] As late as 1919, when taking stock of Rayleigh's life, a Social-Democratic journalist wrote,

> [Lord Rayleigh's] career as a man of science was not only creditable to himself, but a reproach to his own class. How very rarely do the titled personages of this country contribute anything to the common stock of human knowledge. With every possible advantage, they consider they have fulfilled their duties towards the nation when they have done us the honour to be born. Lord Rayleigh had high abilities, great industry, and, in regard to science, a perfectly open mind.[7]

Writers from the patrician class, however, worked to correct such popular stereotypes of idleness. The simultaneous discovery of argon by William Ramsay and Rayleigh, announced in a joint publication, instigated a flurry of press accounts and controversy over whom deserved more credit in the work.[8] Alice Balfour noted the agitation that the bad press stirred among the family's scientific friends: "G[eorge] Darwin, who was with us on Thursday, says that Ld. Kelvin thinks Ramsay's behaviour was bad. G Darwin was very cross with some newspaper (the DT [*Daily Times*] I think) which evidently thought that from a born Lord [could] come no good thing, & had (if I

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[6] [George Lillie Craik], *Pursuit of Knowledge under Difficulties; Its Pleasures and Rewards*, Harper's Family Library, 2 vols. (New York: Harper & Brothers, 1939), II: 8; for descriptions of the daily pursuits of Victorian gentlemen, F.M.L. Thompson, *English Landed Society in the Nineteenth Century* (London: Routledge & Kegan Paul, 1969), pp. 17 and 76-108; for professions, especially during the period of aristocratic decline, David Cannadine, *The Decline and Fall of the British Aristocracy* [1992], rpt. of rev. ed. (New York: Vintage Books, 1999), pp. 236-296 and 391-444.

[7] [Anon.], *Cooperative News*, 5 July 1919, untitled news clipping, Terling.

[8] Robert John Strutt, Fourth Baron Rayleigh, *Life of John William Strutt, Third Baron Rayleigh* [1924], aug. ed. by John N. Howard (Madison: University of Wisconsin Press, 1968), pp. 187-225.

remember right) phrased their notice of argon with 'assisted by Ld. R,' coming last."[9] In her memoirs, Lady Frances Balfour counteracted similar caricatures, calling the "leisure class" label "as great a misnomer as it is to call the present opposition party the Labour party, the best of them have never done a day of manual work."[10] In private, she turned the stereotypes to her own clever purposes, however; in a letter she addressed Rayleigh "My Dear Lord Argon" when congratulating him on his discovery of the inert gas named after the Greek term meaning *idle*.[11]

In the popular accounts, Rayleigh's industry emerges as an exception to idleness in the leisure class. The intensity and regularity of his daily regime were emphasized in his biography, written by his son:

> The day at Terling was begun with family prayers.... After breakfast, he went to the book-room and began by answering letters.... Rayleigh then usually spent the rest of the morning in reading and writing work.... He would then sit at his writing table, and work for the greater part of the morning at the numerical reductions of experiments, or mathematical analysis, or in writing out an investigation for publication. He was able to do work of this kind for long hours without getting tired or stale.... After luncheon a preliminary study of the newspaper was made in the Library.... On coming in [after his afternoon walk] he often worked for an hour or so in the laboratory, and then had tea.... At six o'clock, when Gordon [the laboratory technician] returned from tea, Rayleigh returned to the laboratory, and worked on till about a quarter to eight.... After dinner, he returned to the study of the *Times*, and various other weeklies.... He sometimes worked in the laboratory or at his writing table for an hour before going to bed.... The domestic regime at Terling was punctual, though not pedantically so.[12]

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9 A.B. Balfour to E.G.M. Rayleigh, Whittingehame, 26 January 1896, Terling.

10 Lady Frances Balfour, *Ne Obliviscaris: Dinna Forget*, 2 vols. (London: Hodder and Stoughton, 1930), I: 203.

11 F. Balfour to J.W.S. Rayleigh, Glasgow, 29 January 1895, Terling.

12 Strutt, *Life*, pp. 254-258.

Sir Arthur Schuster noted the high productivity that Rayleigh achieved even alongside administrative duties by outlining the number of his publications for successive five-year intervals. Schuster showed that Rayleigh published between 32 and 60 papers within any given five-year period after 1871, for a total of 446 papers.[13] (Within Derek de Solla Price's analysis of scientists' productivity, this output places Rayleigh among the top three percent of scientists who were "highly prolific, major contributors."[14]) While there is no question that Rayleigh followed a rigorous work schedule and published at a high rate, it is important to place his work habits in their proper context. The scientific biographies present his industry as an illustration of his character; Schuster emphasized "his magnanimity, his single-mindedness, the high ideals that have borne fruit in his generation."[15] However, a reconsideration of his domestic context reveals more important factors that enabled his exceptional scientific productivity.

"Homely," Solitary Science

But first I wish to consider another facet to the contemporary and historical imagery. The popular narratives also uniformly emphasized the economical character of Rayleigh's science, to the extent of romanticizing it as the epitome of a halcyon era of small-scale, amateur research. Domestic appliances, like "sealing-wax and string," served

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[13] Arthur Schuster, "John William Strutt, Baron Rayleigh, 1842-1919," *Proceedings of the Royal Society of London* 48 (1920-21): i-l, on xxviii-xxix. Rayleigh's papers were reprinted in John William Strutt, Baron Rayleigh, *Scientific Papers*, 6 vols. (Cambridge: Cambridge University Press, 1899-1920).

[14] Derek J. de Solla Price, *Little Science, Big Science* (New York: Columbia University Press, 1963), p. 49.

[15] Schuster, "John William Strutt," p. l.

as powerful symbols within a teleological historiography that gained particular force in the post-World War II decades.[16] A 1949 article in *National Geographic* propagandized "Great Britain's Major Gifts to Freedom, Democratic Government, Science, and Society," including the Nobel-prize-winning discovery of argon, made in 1894 by Rayleigh "in a somewhat crude and homemade workroom which no doubt would seem pitifully inadequate to the research workers of today."[17] In a biographical account concerned chiefly with Terling's leadership in English milk production and farming, Sir William Gavin wrote about Rayleigh's experimenting, "Whenever possible apparatus was home-made and strange articles, even biscuit tins, were pressed into service."[18] John Howard, a retired physicist and former archivist for an important collection of Rayleigh's notebooks, dubbed him "the last of the great 'sealing-wax and string' individual researchers."[19] The powerful imagery lent by these postwar portrayals romanticized the modest, private efforts of individuals in an age prior to "Big Science," a term associated with large research teams and laboratories spanning acres, like the cyclotrons.[20]

Wrapped up within the imagery of Terling's "little science" is the idealization of

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[16] Price, *Big Science, Little Science*, pp. 1-4.

[17] Wrench, "The British Way," p. 524.

[18] Sir William Gavin, *Ninety Years of Family Farming: The Story of Lord Rayleigh's and Strutt & Parker Farms* (London: Hutchinson, 1967), p. 30.

[19] John N. Howard, "John William Strutt, Third Baron Rayleigh," *Applied Optics* 3 (1964): 1091-1101, on 1100.

[20] Peter Galison and Bruce Hevly (eds.), *Big Science: The Growth of Large-Scale Research* (Stanford: Stanford University Press, 1992).

the nineteenth-century English gentleman working "independently in his own laboratory."[21] The image is in one sense a variation of the picture criticized by Derek de Solla Price of "the Little Scientist as the lone, long-haired genius, moldering in an attic or basement workshop, despised by society as a nonconformist, existing in a state of near poverty, motivated by the flame burning within him."[22] But aside from the distortions, I question the validity of an interpretation of private research isolated from other areas of home life. When biographers and historians have made this separation, they rigorously applied a Victorian ideology of "separate-spheres," assigning distinct spheres of work and public engagement to men of science, and child-rearing and domestic management to companionate wives. By heeding this and portraying a "specialized male domain" into which gentlemen of science could withdraw, biographers sustained an ideal of genius as a solitary, enlightened experience.[23] The sharp distinction between work and home life reflected contemporary ideology, but as noted by gender studies scholars, its normalizing

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[21] Sir William Gavin, *Ninety Years of Family Farming: The Story of Lord Rayleigh's and Strutt & Parker Farms* (London: Hutchinson, 1967), p. 70.

[22] Price, *Big Science, Little Science*, p. 3.

[23] Simon Schaffer, "Physics Laboratories and the Victorian Country House," in *Making Space for Science: Territorial Themes in the Shaping of Knowledge* (New York: St. Martin's Press, 1988), pp. 149-180, quote on 169; on solitude, Steven Shapin, "'The Mind is its Own Place': Science and Solitude in Seventeenth-Century England," *Science in Context* 4 (1990): 191-218; on genius, Simon Schaffer, "Genius in Romantic Natural Philosophy," in *Romanticism and the Sciences*, ed. Andrew Cunningham and Nicholas Jardine (Cambridge: Cambridge University Press, 1990), pp. 82-98. Generally Schaffer and Shapin have argued for the importance of gentlemanly values in shaping the nature of early experimental life and its literary representation; also Shapin and Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*, corrected ed. (Princeton: Princeton University Press, 1989); Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994).

effect undermines its utility in historical analysis.[24] Given the emblematic status Terling science has achieved, it is crucial that we move beyond the social conventions defining genius and separation of spheres to reconstruct the historical reality of Terling science as experienced by the actors involved.[25]

The Evangelical Context

Many of the historical images of Rayleigh as a model gentleman-scientist were part and parcel of an evangelical ethos emphasizing the importance of work for atonement, devotion to home and family, and chasteness. These mores guided many Victorian biographers in their construction of role models for young readers.[26] Home as a moral center relied upon an involved paterfamilias, but it also served to replenish his energies for devoted work. After spending hours in retreat, by reemerging and engaging in family affairs, the man of science refreshed himself while fulfilling his moral duties as

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[24] A good introduction into the debates and the voluminous literature on separate spheres is Amanda Vickery, *The Gentleman's Daughter: Women's Lives in Georgian England* (New Haven: Yale University Press, 1998), pp. 3-11. For men's studies, John Tosh, *A Man's Place: Masculinity and the Middle-Class Home in Victorian England* (New Haven: Yale University Press, 1999), pp. 77-78.

[25] Feminist historians have guided the historiographical discussions on this point; Kathleen Canning, "Feminist History after the Linguistic Turn: Historicizing Discourse and Experience," *Signs* 19 (1994): 368-404.

[26] Christopher Tolley, *Domestic Biography: The Legacy of Evangelicalism in Four Nineteenth-Century Families* (Oxford: Clarendon Press, 1997); Geoffrey Cantor, "The Scientist as Hero: Public Images of Michael Faraday," in *Telling Lives in Science: Essays on Scientific Biography,* ed. Michael Shortland and Richard Yeo (Cambridge: Cambridge University Press, 1996), pp. 171-193; Anne Secord, "'Be what you would seem to be': Samuel Smiles, Thomas Edward, and the Making of a Working-Class Scientific Hero," *Science in Context* 16 (2003): 147-173.

father and husband.[27] Amusements might include laboratory demonstrations, as depicted in an illustration of George Stephenson in a mid-nineteenth century biographical anthology (Figure 5.1). But amusements could result from unplanned mishaps as well, as recounted by Salisbury's daughter: "The household was roused by a loud explosion, and its master issued from the laboratory, covered with blood and severely cut about the face and hands, to explain to his terrified family – with evident satisfaction at the accurate workings of chemical laws – that he had been experimenting with sodium in an insufficiently dried retort."[28] Rayleigh's son consistently punctuated his description of his father's work routine with highlights of his engagement with the rest of the family at meals and during breaks: "In his prime, [after lunch] he usually went for a walk by himself, but occasionally, if the weather was pleasant, a drive with Lady Rayleigh in the pony-carriage was arranged." Similarly, "After tea, more particularly in the winter, he would devote himself to amusing his children or grandchildren."[29] In these various ways, the devotee of science fulfilled his paterfamilias duties.

The laboratory's locus within the home dictated a need to follow principles of home economics, which in evangelical households meant middle-class economy and

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[27] Paul White, "Letters and the Scientific Life in the Age of Professionalization," paper presented at the History of Science Society Annual Meeting, Cambridge, MA, 20-23 November 2003.

[28] Lady Gwendolyn Cecil, *Life of Robert Marquis of Salisbury*, 4 vols. (London: Hodder and Stoughton, 1921-1932), I: 175-176.

[29] Strutt, *Life*, pp. 256-257.

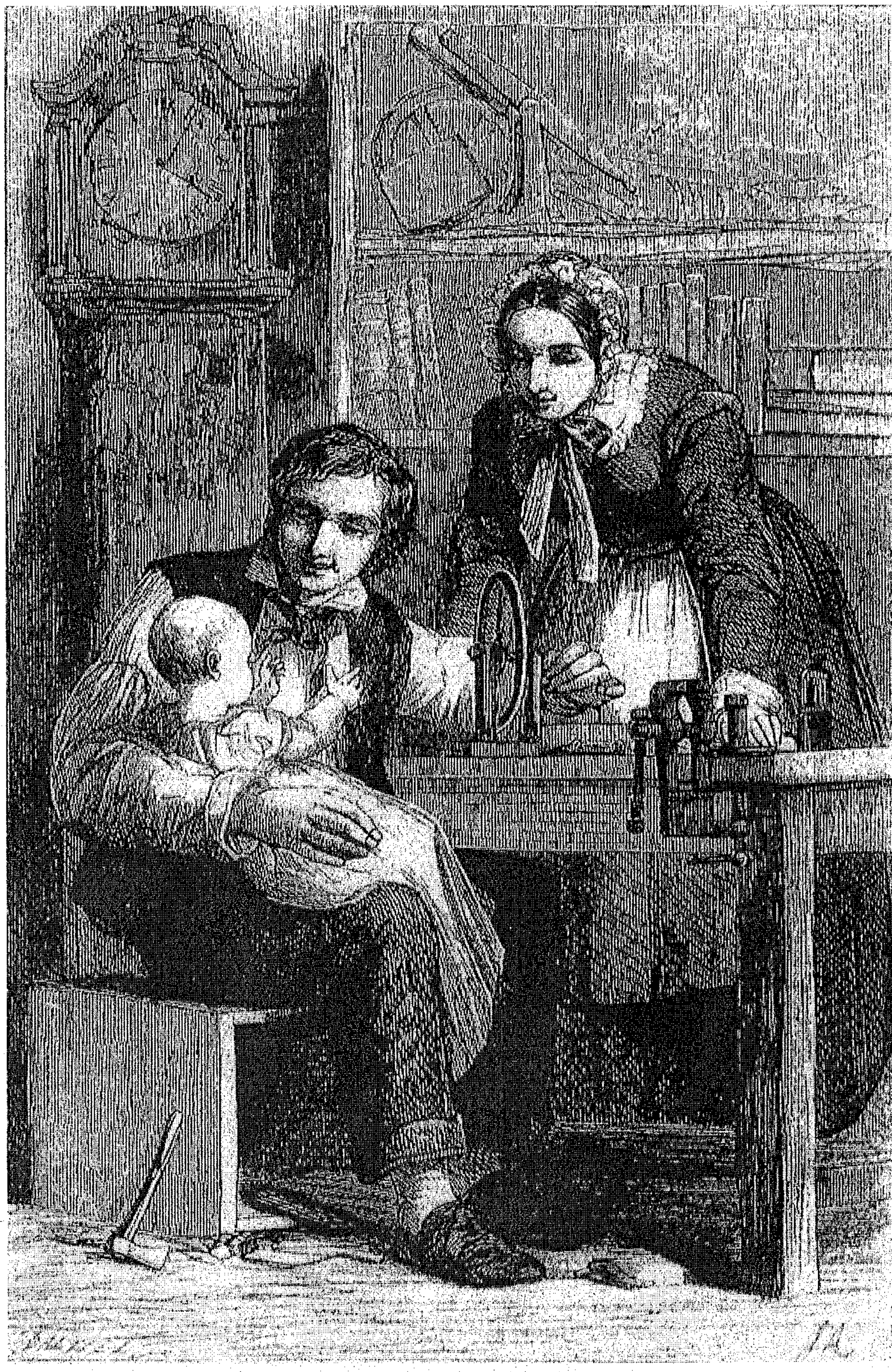

Figure 5.1 George Stephenson, drawn by John Absolon, appearing as the frontispiece to C.L. Brightwell, *Heroes of the Laboratory and the Workshop* (1859). By courtesy of The Baldwin Library, Department of Special Collections, University of Florida.

utilitarianism rather than traditional aristocratic ostentatiousness.[30] Domestic biographies highlighted the Strutt family's pride in evangelical chasteness. This included farm management. According to his son, Rayleigh resisted replacing "tumble-down" farm buildings on the estate: "A costly structure that was not economically justified was to him the worst kind of eyesore."[31] A similar conservatism delayed the introduction of modern household technologies. According to his niece, Blanche Dugdale, "Uncle John resisted electric light and bathrooms long after these were considered by others necessities of life."[32] Lady Rayleigh explained how her husband had "an uneasy dislike of extravagant luxury of the rich," identifying the influence of his evangelical religious upbringing.[33] The practice of economy was nowhere more evident than in the laboratory (Figure 5.2). Rayleigh's son pointed out how visitors (especially foreigners), noted its simplicity:

> Generally speaking, the impression produced on them was one of surprise at the homely appliances with which his experimental work was carried out. Sealing wax, string, rough unplaned woodwork, and glass tubes joined together by bulbous and unsightly joints, met the eye in every direction. The Terling laboratory was far from being a temple of the 'brazen image which the Instrument Maker has set up.'[34]

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[30] Leonore Davidoff and Catherine Hall, *Family Fortunes: Men and Women of the English Middle Class, 1780-1850* (Chicago: University of Chicago Press, 1991), p. 21.

[31] Strutt, *Life*, p. 76.

[32] E.C. Dugdale, *Family Homespun* (London: John Murray, 1940), p. 163.

[33] Evelyn Rayleigh, "Notes," Terling.

[34] Strutt, *Life*, pp. 275-276. See Chapter 2 for further discussion of the families' evangelical backgrounds. Authors of advice manuals also emphasized "modesty" as a gentlemanly attribute; Earl of Chesterfield, *The Accomplished Gentleman: or, the Principles of Politeness; extracted from the Letters of the Late Earl of Chesterfield, to his son Philip Dorner Stanhope, Esq.* (Philadelphia: William Spotswood, 1789), pp. 1-3.

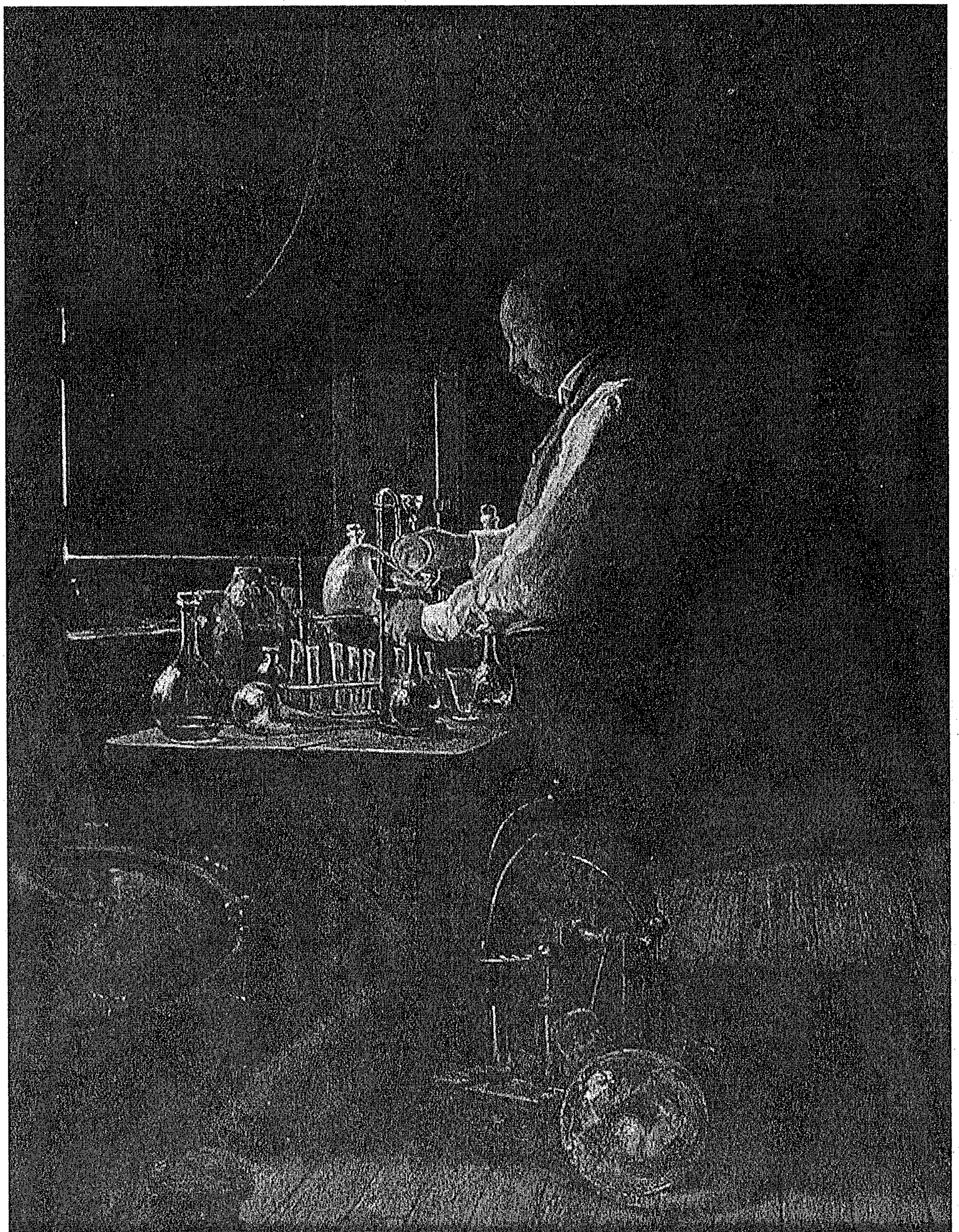

Figure 5.2 Lord Rayleigh in his laboratory at Terling Place, oil painting by Philip Burne-Jones, 1888. By Permission of the Master and Fellows of Trinity College, Cambridge.

Family members thus spoke of Rayleigh's science in terms consistent with evangelical ideals, and later biographers adapted these descriptions to romanticized narratives about individualistic, private science. But, the nature of Terling science relied upon a religious home setting distinct from the literary representations.

"Not Merely Wifely Devotion": Lady Rayleigh's Role in Domestic Scientific Culture

Historians have long noted the importance of the domestic setting as an important locus for the participation of women in science, particularly prior to and concurrently with the establishment of research institutions from which women were patently excluded.[35] More recently, Deborah Harkness and Debra Lindsay have shown through a variety of cases how scientific wives participated in a domestic culture of science in a diversity of ways beyond direct assistance in experiments.[36] In Rayleigh's case, scholars have analyzed the assistance of his sister-in-law, Nora Sidgwick, in important research projects, particularly his work in reestablishing standard electrical units of measure.[37]

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[35] The pioneering work is Pnina G. Abir-Am and Dorinda Outram (eds.), *Uneasy Careers and Intimate Wives: Women in Science, 1789-1979* (New Brunswick: Rutgers University Press, 1989). Other important contributions include Ann B. Shteir, *Cultivating Women, Cultivating Science: Flora's Daughters and Botany in England, 1760-1860* (Baltimore: Johns Hopkins University Press, 1996), and Helena M. Pycior, Nancy G. Slack, and Pnina Abir-Am (eds.), *Creative Couples in the Sciences* (New Brunswick: Rutgers University Press, 1996).

[36] Deborah E. Harkness, "Managing an Experimental Household: The Dees of Mortlake and the Practice of Natural Philosophy," *Isis* 88 (1997): 247-262; Debra Lindsay, "Intimate Inmates: Wives, Households, and Science in Nineteenth-Century America," *Isis* 89 (1998): 631-652.

[37] John N. Howard, "Eleanor Mildred Sidgwick and the Rayleighs," *Applied Optics* 3 (10) (1964): 1120-1122, and Raymond W. Schmitt, "The Salt Fingers of Jevons (1857) and Rayleigh (1880)," *Journal of Physical Oceanography* 25 (1995): 8-17.

Sidgwick's skill received the notice of the preeminent physicists of the period; by one contemporary estimate (her Cambridge mathematics coach), she would have placed as a high Wrangler in the Cambridge Mathematical Tripos had she sat for the examination.[38]

Ironically, however, the historical literature gives no attention to Rayleigh's closest confidante, his wife.[39] Contemporary accounts and biographers mention her role at Terling with divergent judgments of her scientific skill. A ladies' magazine implied that she learned what she knew of science by exposure through her husband: "She knows more about science than do many women who have made scientific enquiry one of their objects in life," explaining, "when in town she frequently attends lectures at the Royal Society, to which institution her husband was secretary for nine years."[40] Generous estimates of her importance to science at Terling are made by her sister-in-law and niece in their domestic biographies, but even these refrain from indicating her independent study of science. Lady Balfour wrote,

> [John Rayleigh] has been described in his Biography written by the present Lord Rayleigh [Robert], a book of much accurate description, except that it almost entirely eliminates the scientific work of his mother in the Social order. John liked Society, but he liked all trouble taken off his hands, he emerged from his laboratory and his speculations and calculations to find himself in a very human *milieu*....[41]

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[38] Margaret Rossiter, *Women Scientists in America: Struggles and Strategies to 1940* (Baltimore: Johns Hopkins University Press, 1982); 324 (note 34); Ethel Sidgwick, *Mrs. Henry Sidgwick: A Memoir* (London: Sidgwick and Jackson, 1938), pp. 66-67.

[39] Howard, "Eleanor Mildred Sidgwick and the Rayleighs," mentions only her secondary assistance at the Cavendish Laboratory.

[40] [Anon.], *The Ladies' Field*, London, 18 June 1898, clipping, Terling.

[41] Balfour, *Ne Obliviscaris*, I: 401.

Dudgale judged, "She had the Balfour inclination towards science, so that her pride in his achievements was not mere wifely devotion."[42] Having consulted these biographical sources, Gavin concluded, "She had no practical skills in science."[43]

Given the neglect – and, in my view, misjudgments – of Lady Rayleigh's role in science at Terling, I wish to examine it more closely here. My aim is not simply to compensate for another "vanishing wife" in the sciences; rather, I will interpret Evelyn Rayleigh's contributions to the domestic culture of science at Terling as among the most important factors shaping the nature of this instance of country-house science.[44]

As I demonstrated in Chapter 3, Evelyn Balfour developed a deep interest in the sciences, which she studied at Whittingehame, her family's country seat, prior to her marriage. She benefitted from a home education system that included scientific readings from her family's library, lessons with tutors, natural history projects, and conversations on science with brothers attending public schools. Like her brothers and sisters, she applied her sharp intellect in contributions to "The Whittinghame Advertiser," her family's holiday newsletter of the late-1860s. After her coming of age, she attended lectures of the Royal Institution with her brother and his college friends (see Chapter 4).

Her particular interest in music provided an entre into her future husband's field

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[42] Dugdale, *Family Homespun*, p. 164.

[43] Gavin, *Ninety Years of Family Farming*, p. 38.

[44] Joy Harvey, "The Mystery of the Nobel Laureate and the Vanishing Wife," paper presented at the History of Science Society Annual Meeting, Pittsburgh, 4-7 November 1999.

of study, acoustics. Prior to their marriage, in late 1869 or early 1870, she borrowed John Strutt's copy of Hermann Helmholtz's *Lehre von den Tonempfindungen*.[45] Her brother Frank, experiencing difficulties with mathematics at Harrow School, chided: "I think that your sarcasms of my mathematical powers need some rejoinders. And I would ask as a mild 'tu quoque' whether you have yet worked out all the formulas in Helmholtz."[46] A letter from Strutt later in the year suggests his further conversations on acoustics with her: "I have lately come across the account of the French experiments on the numerical intervals, which I think may interest you & so I take the liberty of sending it....It would be very interesting to know what Helmholtz would say."[47]

In addition to the breadth of science she studied during the course of her home education, Evelyn Balfour felt a duty to learn about John Strutt's lines of research. But, he also expected this, and he looked to her as a moral guide. An exchange of letters during their engagement reveals their understanding of these points. During a busy period of scientific work – in which unsolved problems were "apt to leave the mind irritable" – John Strutt wrote, "The thing I have most to ask of you is not to damp my scientific ardour, but on the contrary to encourage it when it is flagging."[48] To this, Evelyn Balfour

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[45] Hermann Helmholtz, *Die lehre von den tonempfindungen als physiologische gundlage für die theorie der musik* [*On the Sensations of Tone as a Physiological Basis for the Theory of Music*] (Braunschweig: F. Vieweg und sohn, 1863). Strutt, *Life*, p. 55; Nora Balfour recorded the loan in her diary (no longer extant); Sidgwick, *Mrs. Henry Sidgwick*, p. 23.

[46] F.M. Balfour to E.G.M. Balfour, Harrow, 7 February 1870, Terling.

[47] J.W. Strutt to E.G.M. Balfour, Terling Place, 19 October 1870, Terling.

[48] J.W. Strutt to E.G.M. Balfour, Terling Place, n.d. [June or July 1871], Terling.

replied, "As for science, of course you must go on with it – in fact you must work double, for you have to teach me, as well as to go on yourself."[49] Strutt responded with calculations for her to do. Within a month, she reported, "I have finished another thin plate calculation which continues the curve smoothly – but shows no signs of crossing the earlier part of the curve. I will try another still further on. Did you say you wanted me to do one with $1/\lambda^2$ or $1/\lambda^4$?"[50]

These exchanges evidence a prenuptial negotiation that was not particularly unusual during the late-Victorian period, when social expectations emphasized the role of wife as helpmate and moral guide to her husband.[51] As Paul White has shown, Thomas Huxley and Henrietta Heathorn engaged in a similar, but longer, negotiation process through letters written prior to marriage, while Huxley sailed aboard the H.M.S. *Rattlesnake* as surgeon-naturalist on a survey expedition of the Australian seas.[52] Similarly, the letters between the betrothed George Gabriel Stokes and Mary Robinson in the late 1850s reveal a process of coming to terms on their view of marriage as a companionate arrangement supporting Stokes's work. He wrote,

> And I felt too that the presence of one I honoured as well as loved would forbid me to indulge in those investigations to the undue postponement of my appointed work... But I do indeed hope and trust that I shall (nay, I must not say *shall*, but *should*, if you permitted it) have that higher love which would sweeten

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[49] E.G.M. Balfour to J.W. Strutt, London, 3 July 1871, Terling.

[50] E.G.M. Strutt to J.W. Strutt, Terling Place, 2 August [1871], Terling.

[51] Peterson, *Family, Love, and Work*, pp. 162-166.

[52] Paul White, "Science at Home: The Space between Henrietta Heathorn and Thomas Huxley," *History of Science* 34 (1996): 33-56.

uninteresting work by the thought that it is for you.[53]

The effect of these prenuptial negotiations was the reinforcement of gender roles in marriage defined along evangelical principles. The Biblical basis of the wife's "help-meet" function would have been well-known to Evelyn Balfour and John Strutt; both grew up in evangelical homes where their parents regularly read from Scriptures.[54]

A popular advice literature prescribing proper marital roles also promoted these principles in the intellectual marketplace. Samuel Smiles wrote, "The true wife is a staff to lean upon in times of trial and difficulty; and she is never wanting in sympathy and solace when distress occurs or fortune frowns. In the time of youth, she is a comfort and an ornament of a man's life; and she remains a faithful helpmate in maturer years."[55] Smiles offered several model companionate marriages in the sciences: the Galvanis, Bucklands, Hubers, Hamiltons, and Faradays.[56] Whether or not John Strutt or Evelyn Balfour read the advice literature, the infusion of these marriage standards within Victorian culture could not have escaped them.

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[53] G.G. Stokes to M. Robinson, London, 18 June 1857, quoted in Mrs. Laurence Humphry, "Notes and Recollections," in *Memoir and Scientific Correspondence of the Late Sir George Gabriel Stokes*, ed. Joseph Larmor, 2 vols. (Cambridge: Cambridge University Press, 1907), I: 70-71.

[54] Rev. James Robertson, *Lady Blanche Balfour: A Reminiscence* (Edinburgh: Oliphant and Ferrier, 1897), pp. 33-34; Strutt, *Life*, pp. 9-10.

[55] Samuel Smiles, *Character* [1871], rev. ed., Self Help Series (Chicago: Bedford, Clarke and Company, 1881), p. 336; for other examples, Jessica Gerard, *Country House Life: Family and Servants, 1815-1914* (Oxford: Blackwell, 1994), pp. 101-102.

[56] Smiles, *Character*, pp. 356-362.

Negotiating Domestic Space for Science

In the weeks leading up to their wedding day, July 19, 1871, the engaged pair made plans for their marriage cottage at Tofts, Little Baddow, near the Terling seat. As noted in Chapter 4, because Strutt's engagement signaled a breach in the celibacy requirement of his Trinity College fellowship, he relinquished his college post and his access to Cambridge's experimental resources. Strutt's first attempts to continue his experiments at his parent's manor house, Terling Place, proved frustrating at best, as he wrote to his fiancee: "You may imagine that my attempts at thinking are not very successful, while the combined malignity of Instrument makers & the house maids (who have tidied everything away) makes experiment impossible."[57] For advice, he turned to his teacher James Clerk Maxwell, who could only provide an outline: "It is difficult to imagine…your condition. I have put down what happened to be in my head."[58]

Evelyn Balfour, who learned household management from her mother, attempted to impress upon Strutt the importance of having definite plans in setting up the house:

> I do agree with you that it would be best to get into Tofts as soon as possible.… My mother…thinks we should have an inventory of the things at Tofts, so as to know exactly what we want. If you agree, could you arrange about it's being done? I think it will be difficult for us to settle what we want without it, as to decide about the laboratory without a plan.[59]

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[57] J.W. Strutt to E.G.M. Balfour, Terling Place, 2 July [1871], Terling.

[58] J.C. Maxwell to J.W. Strutt, Glenlair, 8 July 1871, Terling (photocopy of original in Imperial College Archives, Rayleigh Collection). Much of this letter is quoted in Strutt, *Life*, pp. 59-60.

[59] E.G.M. Balfour to J.W. Strutt, 23 Arlington St., London, 10 July [1871], Terling.

Her note attempted to broaden Strutt's considerations beyond strictly laboratory matters. He replied within a few days with reassuring news about plans for the space: "My dearest, We worked hard this afternoon & have come to something more definite. Saunders considers Paley's plan for the laboratory feasible, & is to send me a design with details." Included in this plan was the expansion of the current study with the removal of a wall. "We shall thus have a room large enough to hold both of us," Strutt ensured.[60] Work on Tofts ensued over the next several months, and in the meantime, as newlyweds, they lived with his parents. Evelyn detailed in a letter to her mother the less than ideal workspace there that she shared with her new husband:

> The room where he does his work & where I sit – is only to be reached through the conservatory – & is used for miscellaneous purposes prayers, &c – & is known as the book room....& the furniture consists of some very uncomfortable chairs & benches...a worn out piano & dresser for John's experiments & two large tables covered with his books....The writing instruments have hitherto been a nasty little inkstand, some bad pens – & a loose sheet of blotting paper. If you wanted to write you had to fetch some paper – & clear yourself a place among the books at one of the tables. Today however I have imported some of my wedding presents to make writing more possible....[61]

Their sharing of study and sitting space became an established pattern in their marriage, breaking down the usual prescriptions of separate spheres that assigned spaces as either male or female domains.[62]

Evelyn's complaints to her mother may well have exaggerated the

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[60] J.W. Strutt to E.G.M. Balfour, Terling Place, 15 July 1871, Terling.

[61] E.G.M. Strutt to B. Balfour, Terling Place, n.d. [1871], Terling; also quoted in Strutt, *Life*, pp. 408-409.

[62] Strutt, *Life*, p. 156; Schaffer, "Physics Laboratories," p. 169; Peterson, *Family, Love, and Work*, p. 182.

impoverishment of her situation, but the room's apparent substandard furnishings hinted at a simplicity consistent with the values of an evangelical household. Her mention of prayers conducted within the room suggested the religious character of the space: "The books with which it's walls are lined are chiefly theological works such as it would delight Miss F[aithfull]'s heart to see at Whittingehame."[63] The couple continued their parents' daily habits of prayer and weekly attendance at Sunday services. Rayleigh regularly read lessons at the Sunday morning service at Terling Church.[64] The churchyard adjoined the estate, separated by a gate only (Figure 5.3). The "book-room" served as a temporary sitting room for the newlyweds, but it became a permanent one once Rayleigh inherited the house in 1873. The room continued to function as a study after he expanded the laboratory into other adjacent rooms in this west wing of the house and above the attached stable lofts. Lady Rayleigh kept a roll-top desk in the room, often working alongside her husband.[65]

Historians have described in detail Rayleigh's expanded layout of the laboratory.[66] It is important to note its grand scale, gasworks, and full range of scientific instruments – strong evidence for a workshop that superceded "homemade appliances." His work

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[63] E.G.M. Strutt to Lady B. Balfour, Terling Place, n.d. [1871], Terling. Emily Faithfull was daughter of the Rector at Hatfield and long-time friend to the Balfour family; Robertson, *Lady Blanche Balfour*, pp. 8-9, 20.

[64] Strutt, *Life*, pp. 6, 218, 258, 360; Dugdale, *Family Homespun*, p. 163.

[65] Strutt, *Life*, p. 156.

[66] Strutt, *Life*, pp. 64, 149-165; Schaffer, "Physics Laboratories," pp. 162-167; A.T. Humphrey, "Lord Rayleigh – The Last of the Great Victorian Polymaths," *GEC Review* 7 (3) (1992): 167-188.

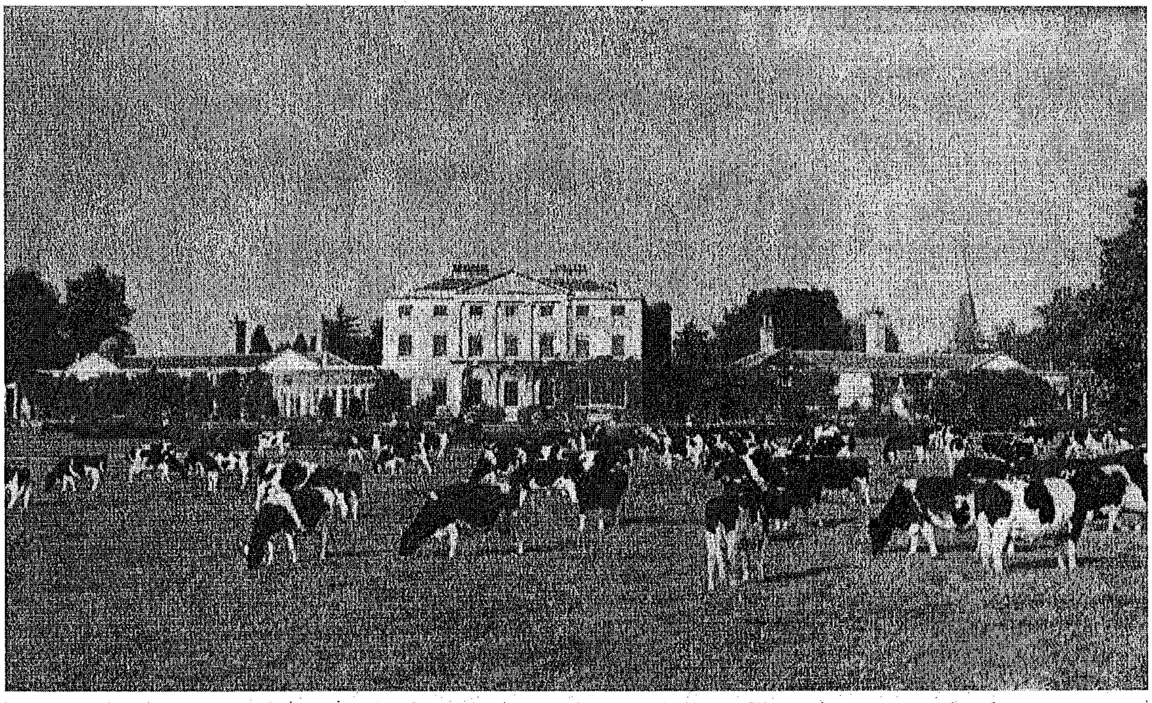

Figure 5.3 Terling Place, c. 1967. The steeple to Terling Church appears in the background to the right. The laboratory is in the wing to the left. Reproduced from Sir William Gavin, *Ninety Years of Family Farming: The Story of Lord Rayleigh's and Strutt & Parker Farms*. By permission of Lord Rayleigh.

spaces included several rooms spanning two levels devoted to specialized activities, including a darkroom for photography and separate rooms for spectroscopy and mixing chemicals. His accumulation of instruments included standard chemicals and glassware, camera and photographic developing equipment, blowpipe torch, Bunsen burner, foot lathe, collection of glass prisms, diffraction gratings, Michelson interferometer, Töpler mercury pump, manometer, balance, electrostat, and hydraulic "hut." Moreover, he hired technicians, some noteworthy men of science in their own right, to help with setting up experiments and crafting apparatus: Beauchamp Tower (1875-1876), Arnulph Mallock (1876), George Gordon (1880-1904), and J.K. Enoch (1905-1908). Unfortunately, no financial records are extant confirming the costs associated with running the laboratory; they likely perished in the fire that destroyed much of the wing in 1930.[67] His colonization of the house for science did not stop at the laboratory's walls. He commandeered other rooms for experiments, transgressing borders meant to separate domestic and work cultures. Examples include his use of the basement tunnel and front lawn for certain acoustics experiments.

Rayleigh's laboratory requirements clearly dominated in the marriage plans, but as the couple's prenuptial letters reveal, Evelyn played an active role, as opposed to bystander, in negotiating their domestic space for science. But her involvement went beyond the typical role of domestic manager; her education in science proved her to be a valuable assistant in Rayleigh's research.

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[67] [Anon.], "The Fire at Terling," *Nature* 125 (1930): 420. Apparently, Rayleigh kept these records separate from the farming and household expense records, which are extant.

Marital Collaboration

Evelyn continued her lessons with her husband throughout the 1870s, progressing from mathematics to elementary physics. In 1872, during a yachting trip on the Nile with Evelyn and Nora Balfour, John wrote to his mother: "After breakfast we generally take a short walk to warm ourselves & then settle down to work till Lunch at 1. I work at my acoustics, Nora at her integral calculus, & Evelyn at mathematics and sketching."[68] When they moved into the manor house in 1873, Evelyn admitted that in the midst of her preoccupations with setting up house, "Have not even pretended to do any mathematics."[69] But evidence of her continued study, even independently of her husband's help, appear as late as 1879. When, during a summer stay with friends in Schwalbach, Switzerland, she tackled both her brother's recent philosophical monograph and some physics lessons.[70] She sent progress reports to her husband, who stayed back at Terling to work at experiments: "I have begun Arthur's book & get on well with it especially when I come to such well known points as the share of the fixed stars in causation....I attacked Parkinson yesterday."[71] A week later: "I have read about half his

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[68] J.W. Strutt to C. Rayleigh, Minich (near Cairo), 25 December 1872, Terling; Strutt, *Life*, pp. 60-63. Strutt completed much of volume I of his treatise on this trip.

[69] E.G.M. Strutt to J.W. Strutt , Terling Place, n.d. [1873], Terling.

[70] Arthur Balfour, *A Defence of Philosophical Doubt, Being an Essay on the Foundations of Belief* (London: Macmillan, 1879).

[71] E.G.M. Strutt to J.W. Strutt , Schwalbach, 12 July 1879, Terling; she probably read Stephen Parkinson, *An Elementary Treatise on Mechanics, For the Use of the Junior Classes at the University and the Higher Classes in Schools* (Cambridge: Macmillan, 1855).

[Arthur's] book & the first chapter of Parkinson's."[72] But she admitted to her husband difficulties in understanding the physics text, but he warned that these owed more to its age than her own abilities: "The marks in Parkinson are of old Cambridge date, & were therefore not made for your benefit."[73] As late as 1884, she wrote about her attempts to cope with the cold weather: "I try to forget it in calculations of thin plates."[74]

Evelyn Rayleigh achieved sufficient mathematical skill to assist her husband in some calculations and experiments by the late 1870s and early 1880s. During their separation in the summer of 1879, Lord Rayleigh noted a missed opportunity for her assistance. "If you were here," he complained in a letter, "you would have to help me with some arithmetic! It is connected with the calculation of the performance of lenses affected with aberration. I do not remember ever having been reduced to calculate the integrals by brute summation ('quadratures') before, but here there seems no help for it."[75] Her assistance was forthcoming on other occasions. One instance that she included in her autobiographical notes illustrates the character of their teamwork. During their stay with her brother Gerald Balfour in Florence during the 1882 Christmas holiday, she remembered devoting much of her time to calculations:

> We occupied the quiet time before lunch over some long calculations with logarithms. I forget for what purpose. R[ayleigh] would go through them first – then I would look for mistakes in his work which as arithmetic was not his strong

[72] E.G.M. Strutt to J.W. Strutt , Schwalbach, 20 July 1879, Terling.

[73] J.W. Strutt to E.G.M. Strutt , Terling Place, 1 August 1879, Terling.

[74] E.G.M. Strutt to J.W. Strutt , Terling Place, 25 November 1884, Terling.

[75] J.W. Strutt to E.G.M. Strutt, Terling Place, 8 August 1879, Terling.

point I practically always found. Then he would look over my correction & as arithmetic was still less my strong point he usually found mistakes but finally we came to agreement.[76]

In addition to calculations, she applied her musical skill to experiments. She cultivated her singing and piano-playing with her brother-in-law, Dick Strutt. She reported her mother not long after her marriage, "Dick & I have established playing duets after dinner regularly...." Later, she played the Terling organ for her family's amusement on Sundays, and in the 1880s she sang in chorus concerts with the Handel Society.[77] Her husband recruited her talent for acoustics experiments. In his notebooks, he entered hints of her assistance; on 15 September 1879, he recorded, "Evelyn," in a marginal note, "by bookroom g′, a′, b′, c′, d′," "& Dick," adding, "by drawing room," "independently fixed pitch of church bells." As late as April 16, 1889, he entered a similar note: "Terling Bells by the Saloon piano Evelyn ... f$^{\#}$, g$^{\#}$, a$^{\#}$, b, c$^{\#}$ without regard to octave."[78]

Their practice of country-house science did not remain confined to Terling Place. They visited Evelyn's aunt, Lady Mildred Beresford Hope, at Bedgebury Park, Kent, in 1872. Their stay ended up being an extended one, as John fell ill with rheumatic fever.[79]

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[76] E.G.M. Strutt, "Notes" (manuscript), Terling; compare Strutt, *Life*, p. 134.

[77] E.G.M. Strutt to Lady B. Balfour, Terling Place, n.d. [1871], Terling ["Dick" refers to Rayleigh's younger brother, Richard Strutt (1848-1927)]; Strutt, *Life*, p. 258; E.G.M. Strutt, "Diary of Evelyn Lady Rayleigh," typescript ed. E.M. Sidgwick, 2 vols., Terling, I: 55; II: 387. Another illustration of her musical interest is the book she edited and had published for her late son: William Maitland Strutt [1886-1912], *The Reminiscences of a Musical Amateur*, ed. Evelyn Rayleigh (London: Macmillan, 1915).

[78] J.W. Strutt, "Experimental Notebook, 1878-89, Part 11," Terling (photocopy of original in Air Force Research Library, Rayleigh Collection).

[79] Strutt, *Life*, pp. 58-59.

During his recovery, he made observations of echoes reflected from the trees of the nearby wood (later popularly known as "Fright Woods," now a part of the Bedgebury National Pinetum and Forest Gardens). He observed that "the sound of a woman's voice was returned from a plantation of firs, situated across a valley, with the pitch *raised an octave*."[80] The "woman's voice" was probably Evelyn's. He explained this phenomenon in terms analogous to that of light waves being diverted by an obstacle small in its dimensions relative to the wavelength – the very situation that he studied in connection with the blue of the sky (see Chapter 4). In both cases he argued that the diverting power of the obstacle varies inversely as the fourth power of the wavelength. With a composite note of sound, as that issued by the human throat, the first harmonic, or octave, would reflect sixteen times more powerfully than the fundamental tone, resulting in an echo that would sound an octave higher than the incident tone.

The Rayleighs produced further studies of human perception of sound between 1876 and 1906. At Terling, the final set of experiments, conducted in 1906, required isolation of the observer from the sound sources. To accommodate the separation, Rayleigh used the only room adjacent to the laboratory – the master bedroom. Tubes fed through the walls carried sound produced by tuning forks in two adjacent laboratory rooms to an observer seated in the bedroom. With Lady Rayleigh serving as an observer, in this case science was not only a family affair but a bedroom experiment as well.[81]

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[80] Strutt, "Harmonic Echoes," *Scientific Papers*, I: 189.

[81] Strutt, *Life*, pp. 152-153, 302-306; Strutt, "On our Perception of Sound Direction," *Scientific Papers*, V: 347-363. J.K. Enock also assisted.

Conversations on Science

Throughout their marriage, the couple typically detailed their activities in letters only during periods of physical separation, and these were rare indeed. The more common mode for their exchanges was simply conversation. Through it, Lady Rayleigh remained informed of experiments underway even when she was not directly assisting. Her niece wrote, for example, "She was one of the few who knew what was going on in the laboratory during the anxious months which preceded the discovery of argon."[82] Historically, these moments are difficult to document. Their son recorded his father's habit of discussing scientific work with visitors, but he is silent about the more intimate conversations Rayleigh doubtlessly enjoyed with members of his immediate family. As I already noted, the son's account of his father's daily routine portrays a Spartan-like schedule dominated by scientific work and nearly devoid of any interaction with Lady Rayleigh. The only hint of their companionship is a mention of their luncheon when "the afternoon's plans would be settled" and an occasional afternoon drive together in the pony-drawn carriage.[83] Nora Sidgwick, a frequent guest and assistant at the country house laboratory, provided a somewhat different perspective: "He often used to tell me at length about things he was working at when *e.g.* we walked together or drove in the pony carriage, and I think in doing so he interested himself as much as me."[84] Lady Rayleigh

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[82] Dugdale, *Family Homespun*, p. 164.

[83] Strutt, *Life*, p. 256.

[84] E.M. Sidgwick, "Notes," manuscript dated January 1920, Terling; compare Strutt, *Life*, p. 257. Rayleigh's indiscriminate habit of discussing science included the women of the family: "My mother [Lady Frances Balfour] used to aver that if she stated

recorded another hint in her diary, where she recounted listening to her brother Arthur Balfour complain about his lack of scientific ability. She countered, "John [Rayleigh] does not agree with that, he says a conversation on Science with you sometimes strains his powers."[85]

Instances of the couple's scientific discussions may be elusive, but Lady Rayleigh's conversations with other men of science are less so. Her skill as a conversationalist kept her informed of the latest debates in science while hosting salon-like parties at Terling. Lady Frances Balfour described her social ability in glowing terms:

> If the Balfours as a whole were unsocial, Evelyn was the great exception that proved the rule. Her whole interests were social, and she loved to make new friends, and to welcome old ones. Most clever she was in weaving into pattern John's scientific friends, with the best of London Society, and the famous visitors' book in Terling Place is witness to this. Her week end parties everybody enjoyed....[86]

During the couple's American tour after the 1884 Montreal meeting of the British Association for the Advancement of Science, over which Rayleigh presided, the Dowager Lady Rayleigh (John Rayleigh's mother) observed, "John and E[velyn]...seem to be enjoying themselves and are gay, seeing lots of scientific folk at Baltimore and *here* at

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to this great scientist that the earth went around the sun, he would answer with his favorite phrase, 'That depends'"; Dugdale, *Family Homespun*, p. 91.

[85] Rayleigh, "Diary," II, entry for 10 September 1888, at Whittingehame, p. 26, Terling; Lord Rayleigh, *Lord Balfour in Relation to His Science* (Cambridge: Cambridge University Press, 1930), pp. 15-16.

[86] Balfour, *Ne Obliviscaris*, I: 400. "Aunt Evelyn was the best talker of the three [Balfour] sisters"; Dugdale, *Family Homespun*, p. 89.

Cambridge."[87] A decade later at the BAAS meeting in Oxford, Evelyn listened to her uncle Salisbury's presidential address, further discussed in Chapter 7. She noted how its anti-Darwinian tone had visibly incensed Thomas Huxley. She afterwards talked about the controversy with other men of science, and the following day she recorded in her diary:

> Adam Sedgwick, Prof. of Animal Morphology at Cambridge, tells me most of the younger biologists now would be in sympathy with Lord S. as to the inadequacy of that [Darwinian] theory to explain evolution. The address was very brilliant, of course, and most of the leading men of Science I spoke to last night were pleased.[88]

Evelyn's pattern of engaging in intellectual conversation continued into her widowhood and old age. She maintained her wit in conversations with visitors to her London home, a scene characterized by Nora Sidgwick as "quite a little 'salon'."[89]

Lady Rayleigh thus participated centrally in the scientific affairs of Terling Place in a variety of capacities. Her effort is all but erased from the public record of her illustrious husband's career, even though it was perhaps the most important factor that sustained his productivity at home. It would be an overstatement to attribute independent accomplishment in science to her, but it would be a worse understatement to conclude as

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[87] Clara Lady Rayleigh, *The British Association's Visit to Montreal, 1884: Letters by Clara Lady Rayleigh* (London: Privately printed, 1885), p. 86, Terling.

[88] Rayleigh, "Diary," II, entry for 9 August 1894, at Merton College, Oxford, p. 91, Terling. On 10 June 1899, at Terling Place, she recorded, "We have a scientific party here, including M. Cornu, the French Physicist. I had some talk with him last night…." *Ibid.*, II, p. 168.

[89] Sidgwick, *Mrs. Henry Sidgwick*, p. 288; compare Dugdale, *Family Homespun*, p. 164.

did Gavin, that "she had no practical skills in science."[90] Her assistance and devotion to the work of her husband continued through the posthumous publication of his final paper, which he dictated to her from his sickbed.[91]

Conclusion

Lord Rayleigh's daily work routine with frequent periods of solitude has resulted in a romanticized image of him as a gentlemanly "investigator working independently in his own laboratory."[92] Yet, a broadened perspective that takes into account the immediate religious and social context of Terling suggests a somewhat different view. By considering his pursuits in conjunction with Lady Rayleigh's involvement, the image of the solitary gentleman-scientist gives way to an interpretation of Terling science as the product of a marital partnership. Biographers and historians generally miss the importance of this defining characteristic of Lord Rayleigh's country-house science. The oft-reproduced painting by Sir Philip Burne-Jones shows Rayleigh working alone in his laboratory (Figure 5.2).[93] However, it only takes a visit to Terling Place to understand how scholars have uniformly removed this painting from its proper context; in the entrance hall of the house it hangs facing a second painting by Burne-Jones of Lady

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[90] Sir William Gavin, *Ninety Years of Family Farming: The Story of Lord Rayleigh's and Strutt & Parker Farms* (London: Hutchinson, 1967), p. 38.

[91] Strutt, "The Travelling Cyclone," *Scientific Papers* VI; Strutt, *Life*, p. 372.

[92] Gavin, *Ninety Years*, p. 70.

[93] The painting is reproduced as an illustration in Strutt, *Life*, between pp. 250 and 251; a rendition appears in Humphrey, "Lord Rayleigh," p. 175. Copies also hang in the Royal Institution, London, and Trinity College, Cambridge.

Figure 5.4. Sir Philip Burne-Jones's painting of Lady Rayleigh playing the Terling organ. Courtesy of Lord Rayleigh.

Rayleigh playing the organ (Figure 5.4).

The collaboration that occurred between the Rayleighs was only one instance of the assistance that John received from various family members, including Dick Strutt, Nora Sidgwick, and various Balfour brothers. Much of this broader family participation occurred not at Terling but at Cambridge during the period of Rayleigh's professorship at the Cavendish Laboratory. The hiatus of science from the country-house, to be discussed in the next chapter, shows the continued importance of the family network within other institutional spaces. The renewal of Cambridge as the social center for the family in the early 1880s proved to be a critical influence on the family's commitment to developing the sciences as professions, but ones bearing the mark of evangelical, religious respectability.

Chapter 6

"Lord and Professor": Aristocrats and the Professions at Cambridge, 1879-1885

> The successful Victorian intellectual commanded an income that enabled him to sustain the public identity of a gentleman, something that surely contributed to his sense of confidence in addressing those other gentlemen who ultimately disposed of power and wealth in that society.[1]

In analyzing the economic position of the "Victorian intellectual," historian Stefan Collini observed that while both the professional man and the landed aristocrat, by appearances, could qualify as learned "gentlemen," they nevertheless hailed from two distinct social classes. Collini argued, however, that "professional" associations and clubs, like the British Association for the Advancement of Science or the Athenaeum, placed these two type of gentlemen and even the most virulent of public opponents on intimate terms within a common social context. Adopting Collini's assumption of an intersection of the classes within a "social-cum-intellectual circle" consisting, broadly, of "the educated classes," I would like to bring into relief the influences which its members made by virtue of their class standing.

Collini made an essential point about the so-called "professionalization" of the educated classes: "Undoubtedly, 'professionalization' does helpfully describe much of what differentiated intellectual life in 1930 from that of 1850, but the implied assumption about a direct path of development between those two dates may lead us to misperceive what was actually happening in, let us say, 1890."[2] A rich historical literature

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[1] Stefan Collini, *Public Moralists: Public Thought and Intellectual Life in Britain* [1991], rpt. (Oxford: Clarendon Press, 2003), p. 35.

[2] Collini, *Public Moralists*, p. 203.

mushrooming around the late-Victorian movements to transform the sciences into professions and increase public endowments for research tend to portray a misleadingly coherent and teleological narrative. Told from the perspective of the most vocal lobbyists, these movements may seem largely indebted to the activism of "radicals" from the business and middle-classes, with "gentlemen of science" appearing as the rear-guard defenders of aristocratic power dominating the sciences in the early nineteenth century.[3] Only a casual observation of the role of the aristocrat William Cavendish, Seventh Duke of Devonshire, in the 1860s and 1870s calls to question this oversimplification. Devonshire, in chairing the Royal Commission investigating the national status of scientific research and teaching, called for sweeping reforms in science education and increases in government grants for research. He served as the first president of the Iron and Steel Institute, founded for the "promotion of science in its practical applications," and as noted in Chapter 4, personally funded the building of Britain's preeminent physics laboratory within a sea of Cambridge reform.[4] Granted, his generosity underlined the

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[3] Roy M. MacLeod, "The X-Club: A Social Network in Late-Victorian England," *Notes and Records of the Royal Society of London* 25 (1970): 305-322; MacLeod, "The Support of Victorian Science: The Endowment of Research Movement in Great Britain, 1868-1900," *Minerva* 4 (1971): 197-230; Robert H. Kargon, *Science in Victorian Manchester: Enterprise and Expertise* (Baltimore: Johns Hopkins University Press, 1977), esp. pp. 86-116, 234-237; Adrian Desmond, *The Politics of Evolution: Morphology, Medicine, and Reform in Radical London* (Chicago: University of Chicago Press, 1989), esp. pp. 1-24; 25-41, 101-151, 373-397; Bernard Lightman, "Introduction," and "'The Voices of Nature': Popularizing Victorian Science," in *Victorian Science in Context*, ed. Bernard Lightman (Chicago: University of Chicago Press, 1997), pp. 1-12 and 187-211.

[4] J.G. Crowther, *Statesmen of Science* (London: Cresset Press, 1965), pp. 219, 221-222; also, Chapter 4 above.

importance of private philanthropy for expanding institutions in the relative vacuum of institutional and state sponsorship. But, historians must also acknowledge the continuity of private support of science in an age of reform, making possible the transition to different institutional arrangements of a rapidly growing scientific enterprise. A deeper analysis of those cases demonstrates their character as localized reform initiatives mobilized by networks in which aristocrats commanded leadership.

As this chapter will emphasize, such financiers who were aristocratic men of science led the late-nineteenth century professional reforms by using their social privilege to marshal economic and public support for science. They also garnered academic and political support through private networking within social circles characterized by familial relations and friendships. Their advocacy in professional reforms reflected a diversity of perspectives, sometimes differing from middle-class views in ways evidencing their class interests. For example, whereas middle-class men of science often sought broad public and government support for the indiscriminate expansion of both the theoretical and practical sciences, the aristocratic lobby often promoted the expansion of a funding system that tended to limit state requests to practical (applied) science projects and relegated the expense of basic research to private individuals. At other times, however, the aristocratic and middle-class lobbies were indistinguishable. In academic initiatives, for example, advocates of endowments for teaching and research posts did not make class-based arguments privileging theoretical over practical research. In their arguments, lobbyists emphasized the need to compete with international rivals as well as to maintain the advance of university research, which had ramifications for the progress of knowledge as well as the welfare of the nation.

In light of past historiography on the question of science professionalization (see Chapter 2), a deeper analysis of aristocratic participation in professional reforms in the late-nineteenth and early-twentieth century is needed for at least three reasons. First, historians have increasingly recognized the importance of differentiating the parties and processes involved in British science policy decision-making. Peter Alter's seminal study argued for the disaggregation of not only the "scientific lobby" but also of the presumed antagonistic relationship between scientists and the state, often misrepresented as a dichotomy between public and private enterprise.[5] Second, a growing number of scholars have been emphasizing the need to reinterpret "professional" and "amateur" identities in science within the nineteenth century context. A growing consensus shows how the meanings of these terms evolved over the course of the century, with "amateur" becoming an increasingly pejorative label within the late-nineteenth century lobby for scientific professions.[6] Despite the shift in meanings, as several scholars have shown, amateur men and women of science continued to dominate the social landscape into the first decade of

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[5] Peter Alter, *The Reluctant Patron: Science and the State in Britain, 1850-1920* [1982], rev. ed., trans. Angela Davies (Oxford: Berg, 1987), especially pp. 246-255.

[6] Important statements of this thesis appear in the collection of essays: Adrian Desmond, "Redefining the X Axis: 'Professionals,' 'Amateurs' and the Making of Mid-Victorian Biology—A Progress Report," *Journal of the History of Biology* 34 (2001): 3-50; Richard Bellon, "Joseph Dalton Hooker's Ideals for a Professional Man of Science," *ibid.*, 51-82; John C. Waller, "Gentlemanly Men of Science: Sir Francis Galton and the Professionalization of the British Life-Sciences," *ibid.*, 83-114; and Samuel J.M.M. Alberti, "Amateurs and Professionals in One County: Biology and Natural History in Late Victorian Yorkshire," *ibid.*, 115-147; also, James A. Secord, *Victorian Sensation: The Extraordinary Publication, Reception and Secret Authorship of Vestiges of the Natural History of Creation* (Chicago: University of Chicago Press, 2000), pp. 403-405, 524-525.

the twentieth century, as true professional positions remained relatively few.[7] Third, historians have shown that an integral aspect to the professional lobby was the promotion of respectable images of the professional, largely accomplished by emphasizing gentlemanly virtues.[8] But, in their analyses of issues connected with social status, many scholars have focused primarily on middle-class figures while taking for granted an undifferentiated upper-class.[9] Moreover, persisting teleological narratives of science professionalization assume the rise of middle-class professionals alongside the decline of the upper classes, but the decline of aristocratic influence was by no means predestined. The well-documented crisis of the aristocracy did not fully take effect until the second decade of the twentieth century, indicating a need for us to account for its role through at least the turn of the century.[10]

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[7] Roy MacLeod and Kay MacLeod, "The Social Relations of Science and Technology, 1914-1939," in *The Fontana Economic History of Europe: The Twentieth Century – 1* (New York: Harper & Row, 1977), pp. 301-363, esp. 305-307.

[8] Bellon, "Joseph Dalton Hooker's Ideals"; Waller, "Gentlemanly Men of Science"; Robert A. Nye, "Medicine and Science as Masculine 'Fields of Honor'," *Women, Gender, and Science: New Directions*, ed. Sally Gregory Kohlstedt and Helen Longino, *Osiris* 12 (1997): 60-79.

[9] Critical of Desmond, *The Politics of Evolution*, on this point is Boyd Hilton, "The Politics of Anatomy and an Anatomy of Politics *c.* 1825-1850," in *History, Religion, and Culture: British Intellectual History, 1750-1950*, ed. Stefan Collini, Richard Whatmore and Brian Young (Cambridge: Cambridge University Press, 2000), pp. 179-197.

[10] Desmond's historiographical review, "Redefining the X-Axis," remains trapped within the teleological perspective; see esp. pp. 6-11. On the periodization of aristocratic decline, David Cannadine, *The Decline and Fall of the British Aristocracy* [1990] (New York: Vintage, 1999), pp. 35-87. Suggesting a late-nineteenth century pervasive aristocratic influence is Morris Berman, "'Hegemony' and the Amateur Tradition in British Science," *Journal of Social History* 8 (1974-1975): 30-50.

The particular admixture of men and women belonging to the network within which the Strutts, Balfours, Sidgwicks, and Campbells moved, constituted an influential microcosm of the broader extent of aristocratic influence. An analysis of this circle's relationship to professional reforms in the sciences demonstrates that a diversity of perspectives and approaches thrived; social influences extended in a number of directions, often bridging presumed boundaries within and between the sciences, social classes, the state, and the public; and aristocratic members' engagement as *professionals* contradicted contemporary norms for their usual public duties or "*noblesse oblige*." We have already seen evidence for these claims in previous chapters: Chapters 2 and 5 showed the diverse and yet local character of nineteenth century amateur scientific practices, Chapter 4 traced the formation and early development of the social relationships constituting the Strutt and Balfour families and their friendship circles, and Chapters 3 and 4 illustrated some of the tensions between contemporary expectations of aristocratic duty and the professional scientific interests of this circle's various members.

In the present chapter, I analyze two particular patterns of professional engagement and advocacy. In the late 1870s and early 1880s Frank Balfour and Lord Rayleigh assumed professorships at the University of Cambridge. In 1879, with the overriding support of the Cambridge scientific community, Rayleigh was elected second professor of experimental physics at the Cavendish Laboratory. He held this position until his resignation in 1884. Balfour, on the other hand, maintained a residence nearly continuously in Cambridge, taking up several posts until the year of his death, 1882. Historians have analyzed their respective university appointments in detail, but always separately. Here I propose to reinterpret both cases as part and parcel of the same narrative by emphasizing the common social context shared by the brothers-in-law, the similar functions they played in broader disciplinary developments, and their mutual contributions to professionalizing reform at Cambridge and other institutions.

Historians have noted the unusualness of these two aristocratic men taking professorial posts. The historiography generally narrates their respective appointments as the outcome of peer support and personal decisions driven by circumstances. In the case of Balfour, historians emphasized how the biological community at Cambridge, led by Michael Foster, rallied for his appointment out of a fear of losing a famed biologist to other institutions competing for his talents and the belief that Balfour's undervalued devotion to his alma mater and proximity to his family, residing between Cambridge and London, retained him in Cambridge only tenuously.[11] In Rayleigh's case, historians explained his decision to accept the Cavendish professorship as primarily motivated by his need for an income during the agricultural depression of 1879.[12] I find both

[11] Theodore Edmund Alexander, "Francis Maitland Balfour's Contributions to Embryology," University of California – Los Angeles: Ph.D. thesis, 1969, pp. 157-159; Gerald L. Geison, *Michael Foster and the Cambridge School of Physiology: The Scientific Enterprise in Late-Victorian Society* (Princeton: Princeton University Press, 1978), pp. 124-130; Roy MacLeod, "Embryology and Empire: the Balfour Students and the Quest for Intermediate Forms in the Laboratory of the Pacific," in *Darwin's Laboratory: Evolutionary Theory and Natural History in the Pacific*, ed. Roy MacLeod and Philip.F. Rehbock (Honolulu: University of Hawaii Press, 1994), pp. 140-164; H. Blackman, "A Spiritual Leader? Cambridge Zoology, Mountaineering and the Death of F.M. Balfour," *Studies in the History and Philosophy of Biological and Biomedical Sciences* 35 (2004): 93-117.

[12] J.G. Crowther, *The Cavendish Laboratory, 1874-1974* (London: Macmillan, 1874), p. 83; Simon Schaffer, "Rayleigh and the Establishment of Electrical Standards," *European Journal of Physics* 15 (1994): 277-285, esp. 280; Cannadine, *The Decline and*

interpretations unsatisfactory and limited, and, particularly in Rayleigh's case, unconvincing.

Here I shall argue that each man's election to a Cambridge post reflected the nexus of a diverse, grass-roots professional lobby's interests. At the heart of the lobby was a desire to advance Cambridge's international position in the sciences as well as to advance the progress of knowledge. Precisely because of their social standing and family connections, Balfour and Rayleigh promised to be ideal leaders in these ventures. On personal levels, both men saw these positions as part of their broader sense of aristocratic duty, but directed toward the advance of science at Cambridge, as opposed to the more usual call to political duty. This most important aspect to Balfour's and Rayleigh's appointments initiated a pattern of scientific lobby within their aristocratic circle over the next several decades, examples of which I analyze in Chapters 7 and 8. On a more pragmatic level, Balfour and Rayleigh each recognized the advantages that his position offered for the advancement of his personal research interests. These combination of factors diminish the role that circumstances of family and farming had in their elections and underline the importance of localized Cambridge lobbies under aristocratic leadership, and the men's individual senses of duty within these projects.

In establishing this thesis, I begin by explicating the aristocratic social networks at Cambridge that provided the common context to which Balfour and Rayleigh belonged. Next, I describe the events connected with their professorial appointments, with emphasis

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Fall of the British Aristocracy, p. 393; Christopher N.L. Brooke, *A History of the University of Cambridge*, vol. 4 of 4 (1870-1990) (Cambridge: Cambridge University Press, 1993), pp. 181-182.

on the role of aristocratic lobbying. The chapter concludes with an analysis of the functions served by their appointments for ends connected with advancing Cambridge's international scientific reputation.

The Balfour Cambridge Dynasty

The family's aristocratic assemblage in Cambridge in the late 1870s and early 1880s is well-documented, but the extent and influence of their social network has not been analyzed in depth.[13] Helen Blackman, for instance, juxtaposed Frank Balfour's aristocratic role in biology with the more "professional" model associated with Thomas Henry Huxley: "Despite portrayals of a newly professional biology promoted by T.H. Huxley as a middle-class warrior, in Cambridge this new profession was promoted by an aristocrat [Frank Balfour]." She argued, "The natural sciences in Cambridge were boosted by the wealth and status that the Balfours could provide."[14] Yet Blackman's analysis focused on the reactions to Balfour's death and the image of him that was created and used by his surviving students and colleagues. Similarly, Christopher Brooke identified the family circle as "one of the notable Cambridge dynasties," presenting their influence as a "small element" in the history of the Cavendish Laboratory.[15] Blackman's and

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[13] The domestic biographies provide the most detailed descriptions; the most important are A. [Sidgwick] and E.M. Sidgwick, *Henry Sidgwick: A Memoir* (London: Macmillan, 1906), pp. 125-583; Ethel Sidgwick, *Mrs. Henry Sidgwick: A Memoir* (London: Sidgwick and Jackson, 1938), pp. 27-186; and Robert John Strutt, Fourth Baron Rayleigh, *Life of John William Strutt, Third Baron Rayleigh* [1924], aug. ed. with an intro. by John N. Howard (Madison: The University of Wisconsin Press, 1968), pp. 99-148, 321-328.

[14] Blackman, "A Spiritual Leader?" p. 102.

[15] Brooke, *A History of the University of Cambridge*, p. 180.

Brooke's comments prompt the question of the extent of this dynasty's Cambridge network and of what they collectively accomplished.

As detailed in Chapter 4, many of their circle's social connections formed during the student days of the principal actors. Even after Arthur Balfour and the future third Baron Rayleigh departed Cambridge respectively in 1869 and 1871, their connections with the university continued through friends and the members of their families who remained in residence. "The conclusion of my undergraduate career and my departure from Cambridge," wrote Balfour in his autobiography, "made no sharp break in my connexion with the University."[16] His friendship with Henry Sidgwick, in particular, sustained this "connexion," which during the 1870s involved him in three notable ventures: the Metaphysical Society, founded in 1869, in which Sidgwick, Huxley, and the Duke of Argyll were also members; the Association for Promoting the Higher Education for Women at Cambridge and the Newnham Hall Company, merged as Newnham College in 1877; and psychical research, with seances conducted in Balfour's London home as early as 1874.[17]

In due course, Balfour began his political career, being elected a conservative Member of Parliament for a district in Hertfordshire (Hatfield's county) in 1874. His

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[16] Arthur James First Earl of Balfour, *Chapters of Autobiography*, ed. Mrs. Edgar Dugdale (London: Cassell and Co., 1930), p. 61.

[17] Sidgwick and Sidgwick, *Henry Sidgwick*, pp. 209-210, 220-223, 299; Sidgwick, *Mrs. Henry Sidgwick*, pp. 33, 37-42; Kenneth Young, *Arthur James Balfour: The Happy Life of the Politician, Prime Minister, Statesman and Philosopher, 1848-1930* (London: G. Bell and Sons, 1963), pp. 17-26; Alan Willard Brown, *The Metaphysical Society: Victorian Minds in Crisis, 1869-1880* (New York: Columbia University Press, 1947).

uncle Lord Salisbury, then Secretary of State for India, served as his mentor.[18] The low pressures of the Parliamentary office allowed him the latitude to travel and to write his first philosophical monograph.[19] Family gatherings at Balfour's houses in London and Whittingehame sustained intellectual workplaces for his siblings and in-laws under the able domestic management of his younger sister, Alice, the "mistress" of the house. He wrote to a religious friend during the winter of 1878, describing (in an oft-quoted passage) the reverent family industry underway at Whittingehame:

> At present this house is a "Temple of Research." Gerald and Cecil [Balfour] are not doing much – but Frank, thought he supposes himself to be taking a holiday, is I believe preparing his book for the press (in the smoking-room), Eustace [Balfour] (in the billiard-room) is drawing illustrations for *his* book, Henry Sidgwick is finishing his article on the Encyclopaedia and writing a paper for the Metaphysical Society in *his* sitting-room, while I, in mine, am working very hard at my "immortal work".... If I add to this that Alice is groaning over the iniquities of the household in her "boudoir" while Cecil is reading through the City articles in the Library and Gerald strumming on the P.F. [pianoforte] in the drawing-room, I shall have exhausted both the party and the house.[20]

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[18] As Prime Minister in 1904, Balfour said regarding a memorial to Salisbury: "All that comes into my thoughts on such a subject [comes] not merely by political agreement, but by personal relationship, and by a connection, a close connection, in politics which dates from my earliest political experience; since, indeed, I do not think that I should have ever been a Member of this House had it not been for Lord Salisbury's advice and influence"; Arthur James Balfour, *Arthur James Balfour as Philosopher and Thinker: A Collection of the More Important and Interesting Passages in his Non-Political Writings, Speeches, and Addresses, 1879-1912*, ed. Wilfrid M. Short (London: Longmans, Green and Co., 1912), p. 530.

[19] Arthur James Balfour, *A Defence of Philosophic Doubt, Being an Essay on the Foundations of Belief* (London: Macmillan, 1879).

[20] A.J. Balfour to E. Talbot, Whittingehame, 2 January 1878, quoted in Young, *Arthur James Balfour*, p. 39. A similar report of the family's work at Whittingehame in 1882 is quoted in Lady Frances Balfour, *Ne Obliviscaris: Dinna Forget*, 2 vols. (London: Hodder and Stoughton, 1930), I: 323-324. In 1878, Frank Balfour was preparing his monograph on elasmobranch fishes (discussed in the next section), and Arthur his

The Rayleighs of Terling often joined the Balfours in London, Whittingehame, and Hatfield.[21]

After Rayleigh (as the Hon. Strutt) left Cambridge to take up his life as a country squire in 1871, he also maintained both informal and formal connections with the university. In addition to maintaining a correspondence with Clerk Maxwell, he served as a member of Gladstone's second Royal Commission, appointed in 1872 to report on the financial resources of Oxford and Cambridge. He also served as an additional examiner in the 1876 Mathematical Tripos examination and as a member of the Statutory Commission, appointed by the Oxford and Cambridge Act of 1877 to rewrite the college and university statutes.[22] As already discussed in Chapter 5, the Balfours made periodic visits to Terling, with Nora sometimes assisting Strutt in his home laboratory.

But for much of the 1870s, Frank, Eustace, and Gerald Balfour formed the center of the family circle's Cambridge base. Each brother received bachelor's degrees obtained, respectively, in 1873, 1875 and 1877. Gerald became a Trinity Fellow in 1877 and Lecturer in Classics in 1878. Beginning in 1877, Eustace studied architecture under Basil Champneys, a champion of the Queen Anne style (and architect of Newnham's buildings), at Champneys' London office in Queen's Square. Champneys was a friend of Henry Sidgwick; both were members of the Savile Club, a leading literary and academic

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Defence of Philosophic Doubt. I have been unable to trace the reference to Eustace Balfour's book.

[21] Strutt, *Life*, pp. 65-68.

[22] Strutt, *Life*, pp. 70, 74; Brooke, *A History of the University of Cambridge*, pp. 82, 86.

club with strong Cambridge connections. Champneys also enjoyed aristocratic relations, as his father-in-law was the third Earl of Ribblesdale. (The Champneys' lived in a country cottage of Basil's own design – "Manor Farm," in Hampstead, a suburb of London.)[23] Eustace bought a London house in Addison Road, which, after his marriage to Lady Frances Campbell in 1879, continued to serve as his family's primary residence. At about this time he began a private architectural practice, obtaining much of his work from immediate family members and in-laws. His London base still kept him within a convenient proximity to Cambridge, where he joined the rest of the family for weekly dinners.[24]

Nora and Henry Sidgwick hosted these weekly dinners, until 1879 at any rate.[25] When they married in 1876, they set up a villa named Hillside, on Chesterton Road. Henry attributed its organization solely to Nora, illustrating again the wife's agency in matters of domestic management: "I wish you could see my study," Sidgwick wrote to his mother, "which I consider to be really Nora's great success. It is only 13 feet by 15, and her practised eye perceived that is was necessary to waste no space on bookcases, but

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[23] David Watkin, *The Architecture of Basil Champneys* (Cambridge: Newnham College, 1989), pp. 2, 22; Maurice B. Adams (ed.), *Artists' Homes: A Portfolio of Drawings Including the Houses and Studios of Several Eminent Painters, Sculptors, and Architects* (London: B.T. Batsford, 1883), p. 4; within the Strutt family, a great aunt of Rayleigh married into the Drummond family; E. Rayleigh, "Diary," I: 25, Terling.

[24] Balfour, *Ne Obliviscaris*, I: 186-250.

[25] Sidgwick and Sidgwick, *Henry Sidgwick*, p. 320.

instead to put up shelves all round, covering the whole wall."[26] Their charming home became a center for the family, as well as affairs connected with the establishment of the Society for Psychical Research and the rise of Newnham College. On Newnham business, Nora took "the science teaching, from the first, under her wing,"and she became the college's Treasurer in 1878. According to Ethel Sidgwick, "[C]ertain classes in physics were given at Hillside, with demonstrations (and much attendant splashing) in the bathroom."[27] By 1880 Newnham named her Vice-Principal, charging her with the responsibility of residence hall tutor. (She succeeded Anne Jemima Clough as Principal in 1894.)

Among the Balfour clan Lady Frances singled out Frank, who held successive appointments as Fellow, Lecturer, and Professor, as "the central figure at that time." Her reminiscences of Frank pose an interesting counterpoint to those of his friends and colleagues, who tended to emphasize his quiet demeanor: "He was a man of strong opinions, and he held them more tenaciously than was common with other members of the family."[28] Like his brothers and sisters, he was a regular guest at Hillside and joined in the gatherings at the family's various residences in town and country. He extended noted hospitality to his students and colleagues in his Trinity rooms. His student Arthur

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[26] H. Sidgwick to M. Sidgwick, Hillside, 27 October 1876, quoted in Sidgwick and Sidgwick, *Henry Sidgwick*, pp. 325-326.

[27] Sigwick, *Mrs. Henry Sigwick*, pp. 67-69; on Hillside, also Bart Schultz, *Henry Sidgwick: Eye of the Universe: An Intellectual Biography* (Cambridge: Cambridge University Press, 2004), pp. 302, 492-493.

[28] Balfour, *Ne Obliviscaris*, I: 311-312.

Sheridan Lea fondly recalled the parties:

> [A]ll those privileged to be his guests will feel only too keenly the loss of those delightful social gatherings at which he entertained them two or three times in every term. They were gatherings at which, I am sure, everybody felt they were welcomed with a cordiality and geniality scarcely to be surpassed. It is no wonder, then, that his class regarded him with a reverence and veneration such as it has been the lot of but few teachers to inspire.[29]

Rayleigh's election to the Cavendish professorship in 1879 completed the Cambridge assemblage. He bought a house, 5 Salisbury Villas, in Station Road, adding an alternative site for weekly dinners. As did the Sidgwicks at Hillside, the Rayleighs installed a tennis court in the garden. Eustace Balfour wrote to his wife, "Their new house is I am afraid not in a very nice situation, as far as appearance is concerned, being near the station, although it is much larger and better than [Hillside]."[30] But according to Rayleigh's son, "The establishment was somewhat cramped compared with what [Rayleigh] had been accustomed to, but this was nothing to him."[31] Rooms in the Cavendish Laboratory substituted for his Terling workshops, though he returned to his country laboratory to work at experiments during vacations. He transferred his scientific library to his Cambridge house and spent most mornings (when not lecturing) at the writing table. His brother Edward Strutt, who took an agricultural degree at Trinity in

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[29] *Balfour Memorial: Undergraduate Meeting at the Union. Cambridge, 30th October, 1882* (Cambridge: Fabb & Tyler, n.d.), BNL, p. 9. Balfour's rooms were in A4 New Court, consisting of two large rooms and a bedroom near the gatehouse; *Room Rent Books*, Trinity College Archives, Wren (courtesy of Jonathan Smith).

[30] E.J.A. Balfour to F. Balfour, Cambridge, 1881, quoted in Balfour, *Ne Obliviscaris*, I: 316.

[31] Strutt, *Life*, p. 128.

1875 and assumed management of the farms in 1876, occupied Terling's manor house with his family during Rayleigh's professorship.

The family's various domestic biographies reveal how their social network was imbued with a decidedly polite character. Since their undergraduate days, Darwin's sons, particularly Francis, George and Horace, remained good friends of the Balfour brothers and Rayleigh. The Darwins enjoyed access to two country seats, The Mount at Shrewsbury (belonging to Erasmus, Charles Darwin's older brother) and Maer Hall in Staffordshire (belonging to Josiah Wedgwood, Charles' cousin and brother-in-law). Charles Darwin's Down House in Kent, though of smaller scale, modeled a country house in every other respect.[32] Among Frank Balfour's friends, the Superintendent of the Museum of Zoology, John Willis Clark, was the only son of anatomy professor William Clark; his father-in-law Andrew Buchanan, second Baronet, lived at his country seat, Craigend Castle. Another friend, Marlborough Robert Pryor, inherited a country seat, Weston Park, near Hitchin in Hertfordshire. Similarly, Albert George Dew came into substantial properties in 1870. In connection to this, his name was changed to Dew-Smith (but friends continued to call him "Dew"). He helped to finance Michael Foster's teaching assistance and equipment needs when university funds fell short. Dew also backed the creation of Cambridge's scientific instrument shop, afterwards co-managed by Horace Darwin, and the *Journal of Physiology*, of the new Physiology Society of

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[32] Janet Browne, *Charles Darwin: Voyaging* (London: Pimlico, 1995); Browne, *Charles Darwin: The Power of Place* (Princeton: Princeton University Press, 2002); Louise Wilson (ed.), *Down House: The Home of Charles Darwin* [1998] (Westerham: English Heritage, 2000). For the Darwin brothers in Cambridge, see Gwen Raverat, *Period Piece: A Cambridge Childhood* (London: Faber and Faber, 1952), pp. 175-209.

London.[33] Michael Foster, a central figure in this circle, was, by family background, the only truly professional member of this gentlemanly circle of biologists.

Henry Sidgwick's extensive Cambridge network considerably augmented the Balfour dynasty. Some of the more important luminaries in Sidgwick's circle included John Frederick Denison Maurice (who died in 1872), Henry Graham Dakyns, George Otto Trevelyan, and Frederic William Henry Myers – all of whom held influential positions within the Cambridge reform movement, and some of whom (particularly Myers and Trevelyan) had family connections to the aristocracy. Many of these friends joined in the cause for women's higher education at Cambridge, in which other important allies included Henry and Millicent Garrett Fawcett, and Arthur Hugh and Anne Jemima Clough.[34]

As already noted, Rayleigh shared friendships with many of the same figures, particularly Henry Jackson, the Darwins, and Clerk Maxwell. Other important physical scientists in his circle included George Gabriel Stokes, Coutts Trotter, and James Stuart.

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[33] On Clark and Buchan, *DNB*; on Pryor, *Alum. Camb.*; M.J.G. Cattermole and A.F. Wolfe, *Horace Darwin's Shop: A History of The Cambridge Scientific Instrument Company, 1878 to 1968* (Bristol: Adam Hilger, 1987), pp. 9-10, 13-14; Sir Edward Sharpey-Schafer, *History of the Physiology Society during its First Fifty Years, 1876-1926* (London: Cambridge University Press, 1927), p. 26.

[34] Sidgwick and Sidgwick, *Henry Sidgwick*. On Maurice, Dakyns, Trevelyan and Myers, *Alum. Camb.* Also on Maurice, Sheldon Rothblatt, *The Revolution of the Dons: Cambridge and Society in Victorian England* (Cambridge: Cambridge University Press, 1968), esp. pp. 143-151. Also on Myers, Frank Miller Turner, *Between Science and Religion: The Reaction to Scientific Naturalism in Late Victorian England* (New Haven: Yale University Press, 1974). On women's education at Cambridge, Rita McWilliams Tullberg, *Women at Cambridge* [1975] (Cambridge: Cambridge University Press, 1998); Sidgwick, *Mrs. Henry Sidgwick*; B.A. Clough, *A Memoir of Anne Jemima Clough* (London: Edward Arnold, 1897); Schultz, *Henry Sidgwick*, pp. 470-508.

Clerk Maxwell and Stokes both qualified as country squires, and the others belonged to middle-class families.

More illustrative of the social interconnections are the elite societies in which these various individuals associated.[35] Most of the men in Balfour's, Sidgwick's, and Rayleigh's circles were elected as members or officers of the Cambridge Apostles, Cambridge Philosophical Society, the Society for Psychical Research, and the Athenaeum Club (of London); several also belonged to the small Cambridge discussion society, Eranus. Many of the men and women, like Nora Sidgwick and Ellen Crofts (Henry's cousin), served in the development of Newnham College – whether as members of the governing body, donors, lecturers, or students. These examples only hint at the panorama of ways in which they associated at Cambridge, notwithstanding the numerous specialized scientific, philosophical, and literary societies to which they also belonged.

The Stazione Zoologica at Naples

The earliest illustration of the Balfour dynasty's pattern of aristocratic lobby for science began with Frank Balfour's appointment to a table at the Stazione Zoologica at Naples. After taking his degree in 1873, Balfour spent several months at Anton Dohrn's

[35] For details of membership and background to the societies, Richard Deacon, *The Cambridge Apostles: A History of Cambridge University's Elite Intellectual Secret Society* (New York: Farrar, Straus & Giroux, 1985), pp. 200-205; William C. Lubenow, *The Cambridge Apostles, 1820-1914: Liberalism, Imagination, and Friendship in British Intellectual and Professional Life* (Cambridge: Cambridge University Press, 1998); A. Rupert Hall, *The Cambridge Philosophical Society: A History, 1819-1969* (Cambridge: Cambridge Philosophical Society, 1969); Alan Gauld, *The Founders of Psychical Research* (New York: Schocken Books, 1968); Sidgwick and Sidgwick, *Henry Sidgwick*, p. 223; F.R. Cowell, *The Athenaeum: Club and Social Life in London, 1824-1974* (London: Heinemann, 1975).

newly-established marine zoological station.[36] Cambridge leased two tables for use by Balfour and his classmate, Albert George Dew-Smith. Huxley assured Dohrn of their abilities:

> I am glad that Balfour & Dew-Smith are with you. I do not know the former personally but hear good of him in all order. Dew Smith is very modest & retiring – but has good abilities and is a thorough gentleman – which as you know in English – means a good deal.[37]

These "tables" included laboratory space, fresh supplies of animal specimens, chemicals, and the use of the library and other facilities.[38] The time Balfour spent on Mergellina Bay must have appealed to the young naturalist who grew up dredging on the Scottish coast of the North Sea. His tenure in Naples lasted from February to June, 1874, overlapping with visits by Oxford professor Edwin Ray Lankester, Jr., and German professor Nicholas Kleinenberg. Both zoologists became correspondents and allies of Balfour as a result of their meetings in Naples.

In his studies, Balfour departed from the work on chicks that occupied him at Cambridge and turned to the elasmobranch fishes (sharks and rays). His decision to study the most primitive of vertebrates was consistent with his interest in tracing phylogenetic

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[36] On the Stazione Zoologica and Dohrn's role, Theoder Heuss, *Anton Dohrn* [1940], 3rd edn (Tübingen: Rainer Wunderlich, 1962); Karl Josef Partsch, *Die Zoologische Station in Neapel: Modell internationaler Wissenschaftszusammenarbeit* (Göttingen: Vandenhoeck and Ruprecht, 1980); Jane M. Oppenheimer, "Some Historical Backgrounds for the Establishment of the Stazione Zoologica at Naples," in *Oceanography: The Past*, ed. M. Sears and D. Merriman (New York: Springer-Verlag, 1980), pp. 179-187; Christiane Groeben, "Anton Dohrn – The Statesman of Darwinism," *Biological Bulletin* 168 (supplement) (June 1985): 4-25.

[37] T.H. Huxley to A. Dohrn, London, 5 March 1874, HP, ICA.

[38] Groeben, "Anton Dohrn," p. 10.

relationships. He continued to apply the comparative morphological method, using careful microscopic procedures that set him apart from his more speculative contemporaries.[39] Dohrn, a Darwinian also strongly influenced by Haeckel, created an institution characterized by Oppenheimer as "a citadel of freedom of thought."[40] Dohrn's enthusiasm for the new experimental techniques of comparative embryology, though he rejected his teacher Haeckel's theory of recapitulation (which Balfour accepted), created a highly supportive research environment.[41] In a statement made a couple of years later, Balfour acknowledged how the station "furnished me in a much more ample manner with all I required than any private individual could possibly have done for himself."[42]

Within months, Balfour provided a detailed interpretation of the development of selachii embryos, noting their differences from chick embryos and challenging received views on the development of the selachii's several layers. As Theodore Alexander has shown, Balfour rigorously adhered to a germ-layer theory, which explained embryonic development as proceeding from a single cell center, despite the apparent multiple centers of cellular development in the selachii. This orientation guided his contentious argument that the notochord – the supporting rod present in all vertebrate embryos – derived from

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[39] F.B. Churchill, "Balfour, Francis Maitland," *Dictionary of Scientific Biography*, ed. Charles Coulston Gillispie (New York: Scribner's Sons, 1970), I: 420.

[40] Oppenheimer, "Some Historical Backgrounds," pp. 184-185.

[41] Groeben, "Anton Dohrn," p. 6.

[42] A.G. Dew-Smith, "Report of the Committee Appointed for the Purpose of Arranging for the Occupation of a Table at the Zoological Station at Naples," *BAAS Reports* 48 (1879): 151.

the hypoblast, the lower of the embryo's three layers, rather than from the mesoblast, the middle layer, as embryologists generally believed. He drew this reactionary conclusion cautiously, and only after having consulted Huxley, who concurred with Balfour's interpretation.[43]

Balfour announced his discovery at the BAAS meeting in Belfast in August and followed with a publication in October.[44] Even though he reported only "preliminary" results, his paper contained the germ of his more detailed subsequent studies. His contemporaries, whether agreeing or disagreeing with his reinterpretations of features like the notochord, recognized the promising significance of his research. Allen Thomson, a noted embryologist, admitted to Foster, "What you tell me of Mr Balfours [sic] observations on the chorda [notochord] of the shark surprises me and I shall be much interested in seeing it fully made out."[45] Lankester wrote to Balfour, "I am in some excitement – I think I just found out the trick in vertebrates through your drawings of the shark's embryos."[46] Darwin praised Dohrn for his "influence on the progress of Zoology throughout Europe," singling out the "capital work...already been done at the Station by

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[43] Alexander, "Francis Maitland Balfour's Contributions," pp. 81-99.

[44] F.M. Balfour, "On the Development of the Elasmobranch Fishes," *BAAS Reports* 43 (1874): 138; Francis M. Balfour, "A Preliminary Account of the Development of the Elasmobranch Fishes," *Quarterly Journal of Microscopical Science* 14 (1874): 323-364.

[45] A. Thomson to M. Foster, 2 August 1874, quoted in Blackman, "A Spiritual Leader," p. 97.

[46] E. R. Lankester to F. M. Balfour, 30 May [1874?], BP, NAS GD433/2/103A/11.

Balfour & Ray Lankester."[47]

Balfour's elasmobranch work, upon Huxley's recommendation, earned him a Trinity fellowship in October, 1874; this signaled the beginning of a brilliant period of professional development. Although he spent the initial months of his fellowship traveling with Marlborough Pryor in South America (see Chapter 4), and again at the Stazione in Naples (from March to May 1875), he returned to Cambridge in the summer of 1875 to teach a course in embryology for Foster. By the end of the summer, with Clark's backing and zoology professor Alfred Newton's approval, Balfour began his proposed course in animal morphology: "All I had to do was to place in his service, with the consent of the Vice-Chancellor [Samuel George Phear] for the time being, my private room in the New Museums, which I was glad to see turned to so good a purpose, for hitherto but little use had been made of it."[48] Cambridge's school of animal morphology, later commonly known as the Morphological Laboratory, had been launched.

Balfour developed an enduring friendship with Dohrn, hosting him in Cambridge in 1875 and visiting him again in Naples in 1877 and 1881. Their relationship clearly benefitted Balfour's early career, yet it also benefitted Dohrn through an instance of aristocratic grass-roots philanthropy led by Balfour. Upon his arrival to Naples in 1874, he discovered Dohrn in the midst of financial difficulties, owing to unexpected expenses associated with equipping the station. The historical record is inconsistent about whether

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[47] C. Darwin to A. Dohrn, Down, [10-12? February 1875], *Charles Darwin, 1809-1882, Anton Dohrn, 1840-1909: Correspondence*, ed. Christiane Groeben [hereafter "Groeben, *Darwin - Dohrn Correspondence*"] (Napoli: Macchiaroli, 1982), p. 62.

[48] Alfred Newton, "The Late Prof. Balfour," *Nature* 26 (1882): 342.

Balfour approached Dohrn or vice-versa, but either way Balfour negotiated an English campaign to raise money for the station in addition to providing private contributions of his own.[49] Huxley wrote to Dohrn in March:

> Michael Foster has just been with me and we have been talking over your affairs. He is of course quite ready to be of any use he can – but he very strongly counsels that you should take Balfour into your confidence – Foster tells me that Balfour has a very old head on his young shoulders.... His people are all very wealthy and I believe he hoped to have been able to do something with them.... I think you cannot do better than discuss the matter freely with Balfour.[50]

Dohrn took Balfour into his confidence; he and his brother Gerald provided Dohrn with emergency funds to help offset the financial crisis.[51] In addition, Frank wrote to Foster confirming the station's needs and the appropriateness of an English campaign. In response, Foster and Huxley drafted and circulated a petition for English "subscriptions" to the station. Foster wrote to Balfour, "It is entirely upon your report that [as] you think that if we at present raise the money required for the Station that it will ultimately succeed, & that if it succeeds, it will be of *real service to science* that we are getting up

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[49] Groeben stated that "At the end of 1873 Darwin and Huxley had already proposed a collection to help Dohrn out of his financial difficulties" (Groeben, *Darwin-Dohrn Correspondence*, p. 102), but elsewhere stated, "Huxley had learned from F.M. Balfour, who worked as a guest investigator at Naples from February to June 1874, that Dohrn lacked funds for equipping the laboratories"; *Karl Ernst von Baer [1792-1876], Anton Dohrn [1840-1909]: Correspondence*, ed. Christiane Groeben, vol. 83, part 3 of *Transactions of the American Philosophical Society* [hereafter "Groeben, *Von Baer-Dohrn Correspondence*"] (1993), p. 61. Further correspondence between Huxley and Dohrn, which I discuss shortly, suggests that Dohrn approached Balfour rather than vice-versa.

[50] T.H. Huxley to A. Dohrn, London, 6 March 1874, HP, ICA 13.262-63.

[51] Groeben, *Darwin-Dohrn Correspondence*, p. 102.

the present subscription."[52] The first to sign the circular was Charles Darwin who, learning of the crisis from Huxley, contributed £100; George and Francis Darwin added an additional £10 each. Darwin passed the circular to Sir Charles Lyell and Sir John Lubbock, who also signed. Within a few months, the goal of £1,000 was reached, with £850 of the subscriptions sent by December.[53]

Part of Dohrn's financial strategy was to consign specimens from the station's aquarium for foreign naturalists' research needs. Initially he complained to von Baer, "the profits of the aquarium have also remained lower than expected," but by 1876 Balfour noted "the department for supplying naturalists and museums with preserved specimens has now been fully organized."[54] As a result, Balfour regularly bought specimens from Dohrn for his own continued investigations back at Cambridge.[55] In 1876 Balfour testified in favor of renewing the BAAS's initial lease of a table. Noting the acting-director's "unceasing kindness and willingness to assist naturalists," Balfour urged "the desirability of renewing the grant of the Association."[56]

Back at Cambridge, Balfour taught his first morphology courses with Alfred

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[52] Quoted in a letter by F.M. Balfour to A. Dohrn, 17 July 1894, ASZN Ba 231, reprinted in Groeben, *Darwin-Dohrn Correspondence*, p. 102.

[53] Groeben, *Von Baer-Dohrn Correspondence*, p. 61; Groeben, *Darwin-Dohrn Correspondence*, pp. 55, 102-103.

[54] Dew-Smith, "Report," p. 151.

[55] Alexander, "Francis Maitland Balfour's Contributions," pp. 78-79; A.E. Shipley, *"J": A Memoir of John Willis Clark* (London: Smith and Elder, 1913), p. 274.

[56] Dew-Smith, "Report," p. 151.

Milnes Marshall (afterwards professor of zoology at Owens College, Manchester), but within two terms Balfour assumed sole responsibility for the course. His classes "grew rapidly" in numbers of students, from an initial ten "scanty band of students" in 1875 to as many as 75 by 1882.[57] As the numbers grew, he divided the course into elementary and advanced sections and added practical classes for which Marshall and, afterwards, Adam Sedgwick served as demonstrators. Like many of his network, Balfour opened his lectures to the women students of the newly-established women's colleges, Girton and Newnham. A rare glimpse of his classroom scene comes from one of the female students' letters:

> May I add a word about Mr. Frank Balfour? I attended his lectures on embryology one May term, in a tiny room, where men and women were squeezed together.... [T]he lecturer towered above us, in height, and in everything else. I remember specially his long, delicate hands and beautiful manipulation of sections, but also his marvellous and stimulating teaching, not hindered by hesitating speech, and his power of making his pupil feel – oh, *so* small![58]

Lea recalled how "he did not simply superintend the class, but entered into the closest possible contact with his students."[59]

Despite his popularity as a lecturer, some viewed Balfour's teaching as a drain on his research energies. Robertson noted, "Mr. [Charles] Darwin...used to regret that any of

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[57] *Balfour Memorial*, p. 5; J. Stanley Gardiner, *The Zoological Department* (Cambridge: Cambridge University Press, 1934), p. 2, BNL; M. Foster and F.M. Balfour, "Museums and Lecture-Rooms Syndicate Report to the Senate," 28 April 1882, Cambridge University Register 39.36, CUL.

[58] Quoted in Marsha L. Richmond, "'A Lab of One's Own': The Balfour Biological Laboratory for Women at Cambridge University, 1884-1914," *Isis* 88 (1997); 422-455, 427.

[59] *Balfour Memorial*, p. 9.

Mr. Balfour's time and strength should be expended on teaching."[60] But Balfour's teaching in fact benefitted his research; in Fosterian fashion, he used his classes as pools from which to recruit research assistants. According to Lea, "He, moreover, engaged in a number of investigations, which he carried out through his students, assisting them to the utmost with all the powers of his manner and knowledge, encouraging them in their difficulties, and, finally, praising to the utmost any success achieved."[61] Despite historical interpretations of Balfour's remarkable research productivity as a product of his genius and creativity, Lea's observation offers an alternative explanation.[62]

During these years, Balfour continued his personal research on the elasmobranch fishes, completing a series of papers which he prepared for a monograph.[63] While Cambridge served as the site for most of his work, he spent holidays at home in Whittingehame, where he could take advantage of the congenial work environment that was once his childhood classroom, and where he could rely on his sister Alice for help

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[60] Rev. J. Robertson, "The Late Professor F.M. Balfour," Supplement for Whittingehame Parish, August 1882, BP, NAS GD433/2/101.

[61] *Balfour Memorial*, p. 9; also M. Foster, "Francis Maitland Balfour," *Nature* 26 (1882): 314.

[62] M. Foster, "Introduction," in Francis Maitland Balfour, *The Works of Francis Maitland Balfour*, mem. ed. by M. Foster and A. Sedgwick, 4 vols. (London: Macmillan, 1885), I: 1-25, esp. 18-19; Henry Fairfield Osborn, *Impressions of Great Naturalists: Reminscences of Darwin, Huxley, Balfour, Cope and Others* (New York: Charles Scribner's Sons, 1924), pp. xii-xiii.

[63] The series of articles dating between 1874 and 1878 are reprinted in Balfour, *The Works of Francis Maitland Balfour*; Balfour, *A Monograph on the Development of Elasmobranch Fishes* (London: Macmillan, 1878).

with figures.[64] In 1876, Darwin proposed his membership to the Royal Society, sending his nomination to Rayleigh, a Fellow "though not a naturalist": "I shall have real pleasure in proposing you for the Roy. Soc."[65] Also in that year, Cambridge elected him Lecturer on Animal Morphology. His elasmobranch monograph appeared in publication in 1878.

The Cavendish Laboratory

In late 1879, the Cambridge physical sciences community called upon Balfour to communicate their wish for Rayleigh to stand for the Cavendish chair, vacated upon Maxwell's death on 5 November.[66] "Deputed from Cambridge," Frank came to Terling to impress upon Rayleigh "the importance of the cause of Physics."[67] Initially unconvinced, Rayleigh sought the counsel of further friends and relatives. Later in the week, he wrote from London: "Stokes had a good opportunity last night at the Athenaeum of sounding me about the Professorship, and as he did not take it I rather conclude that I am not so necessary to the welfare of the university as Frank supposes."[68] Despite Stokes's silence, within days Rayleigh learned of a memorial signed by the University Senate's Electoral Roll petitioning for his candidacy. Among the many scientific endorsements appeared the

[64] Donald L. Opitz, "'Behind folding shutters in Whittingehame House': Alice Blanche Balfour (1850-1936) and Amateur Natural History," *Archives of Natural History* 31 (2004): 330-348.

[65] C. Darwin to F.M. Balfour, Down, 13 December 1876, BP, NAS GD433/2/103C/1.

[66] Technically, the chair terminated upon Maxwell's death. The University Senate reinstalled it in view of its success. Strutt, *Life*, p. 101.

[67] E. Rayleigh, "Notes," p. 62, Terling.

[68] J.W.S. Rayleigh to E. Rayleigh, London, 12 November 1879, quoted in Strutt, *Life*, p. 100.

signatures of his Cambridge intimates – George Howard Darwin, Richard Tetley Glazebrook, Edward John Routh, William Napier Shaw, George Gabriel Stokes, and Isaac Todhunter. The Chancellor, Devonshire, wrote Rayleigh to offer his personal views:

> I feel so strongly the advantage the university would derive from your acceptance of the office, that I hope you will allow me as Chancellor of the university, and also as taking a special interest in this Professorship, to support the appeal which I am told is about to be made to you, and to express a hope that you will consent to take the proposal into your favourable consideration.[69]

At the same time he received this stream of petitions, Rayleigh was dealing with a shortfall of farming income and arrears in rents owed by his estate's tenant farmers during the initial seasons of a protracted agricultural depression. While the financial pressures mattered, family letters suggest they played only a secondary role in his deliberations over the Cavendish position, contrary to the popular historical assessments. According to Cannadine, "[I]t was patrician poverty rather than scholarly ambition that had impelled [Rayleigh] to take up paid university employment."[70] Henry Sidgwick, staying at Terling Place during this time, offered a different view in a letter to his sister:

> As for other news, we are just now anxious about Rayleigh's coming to Cambridge. Perhaps you saw that a memorial signed by all the Mathematical professors had been sent to urge him to come and succeed Maxwell as Professor of Experimental Physics. He has not yet decided. It is rather a wrench to give up leisure and the comforts of a country-house—unless one is quite sure that one's duty to society requires it.[71]

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[69] W. Devonshire to J.W.S. Rayleigh, Chesterfield, 15 November 1879, quoted in Strutt, *Life*, pp. 100-101.

[70] Cannadine, *The Decline and Fall of the British Aristocracy*, p. 393.

[71] H. Sidgwick to M. Benson, Terling, 29 November 1879, Add. Ms. c. 100[51], SP, Wren; Sidgwick and Sidgwick, *Henry Sidgwick*, p. 342.

The testimonies of men of science were critical to Rayleigh's decision. Like Devonshire's personal letter, the Electoral Roll's memorial advocated for the welfare of both physics and the university in its petition: "[I]t would tend greatly to the advance of Physical Science and the advantage of the University that Lord Rayleigh should occupy the Chair."[72] Sir William Thomson wrote, "If you could see your way to take the Chair it would I am sure be much for the benefit of the university, and of science too."[73] By the end of November, a number of friends and family members also counseled Rayleigh. He reported, "Arthur [Balfour] seems very pleased with the idea," and "Lord S[alisbury]'s idea seems to be that if I failed with the Professorship I should lose my scientific reputation with the world."[74] Rayleigh wrote to his mother on 1 December:

> After much consideration I have made up my mind to stand for the Professorship. I quite feel that there is a good deal to be said against it, but the arguments in favour seem to me to have the preponderance, and if I refused merely on grounds of convenience, I should be ashamed of myself afterwards.[75]

A sense of duty, not finances, guided his final decision. He was elected on 12 December.

Rayleigh acknowledged that the professorship "fit pretty well with the agricultural depression,"and worried, "It is open to question whether in any case I could have gone on

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[72] Quoted in Strutt, *Life*, p. 101.

[73] W. Thomson to J.W. Rayleigh, Glasgow, 17 November 1879, quoted in Strutt, *Life*, p. 100.

[74] Quoted in Strutt, *Life*, p. 102.

[75] J.W. Rayleigh to C. Rayleigh, Terling, 1 December 1879, quoted in Strutt, *Life*, p. 102.

living here [at Terling] as hitherto, as my financial difficulties seem rather to increase."[76]

The appointment, however, contributed negligibly to Terling's financial recovery. Lady Rayleigh recalled how loans and help from her husband's family played a greater role during the initial crisis:

> In 1879-80 after a year so disastrous to farming that all rents had to be reduced, some tenants went bankrupt, & we ourselves lost heavily by the home farms we had somehow to raise money to go on & to reduce our expenditure. R[ayleigh] would not hear of mortgaging the estate, but succeeded in borrowing a certain amount (I presume on his personal security) from his brother in law John Paley – & possibly from the bank, though they made difficulties which infuriated him.... [H]is pecuniary difficulties came to the support of the belief that no one else could do what he could for Physics at Cambridge & he accepted the post. The salary then only £500 per an[num] he gave to the Cavendish lab. & the only pecuniary advantage was the greater cheapness of living at 5 Salisbury Villas Station Rd., Cambridge than at Terling Place.[77]

Over the longer term, the management of the farms in the hands of Edward Strutt (Rayleigh's brother) proved decisive.

With his wife Lisa's help, Edward Strutt economized at Terling, beginning in the household:

> Early in 1880 Rayleigh took up the appointment of Cavendish Professor at Cambridge and asked Edward and Lisa to live at Terling to keep it going, so that the Rayleighs could come there for part of the vacation.... By a triumph of domestic management Lisa Strutt succeeded in running the large house with only one in the kitchen, two housemaids, a young footman and the children's nurses.[78]

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[76] J.W. Rayleigh to C. Rayleigh, Terling, 17 November 1879; J.W. Rayleigh to C. Rayleigh, Terling, 1 December 1879; both quoted in Strutt, *Life*, pp. 100, 102.

[77] E. Rayleigh, "Notes," pp. 61-62, Terling.

[78] Robert John Strutt, fourth Baron Rayleigh, "Edward Gerald Strutt," in *The Strutt Family of Terling, 1845-1973* (Marks Tey, Essex: C.W. Poole & Sons, 1980), p. 49, Wren. A comparison of 1871 and 1881 census records shows a substantial diminution of the household (including family members and servants) from 23 to 12; ERO R.G.

The evacuated tenant farms increased the acreage of Terling's home farms from 872 to 2,639 acres between 1879 and 1884. (Including leased lands, the Terling farms comprised nearly 9,000 total acres of land at this time.) Strutt continued to till the evacuated farms but also steadily increased milk production, leading to the establishment of a shop (in Great Russell Street, London), "Lord Rayleigh's Dairies," that was independent of middlemen. Profits from the dairies helped overcome the decreases in farming income and the arrears in rents owed by tenants, which remained a problem into the 1890s. By 1884 he also pursued land agency for alternative sources of income. His friend Charles A. Parker joined him in partnership in the following year. Together, they negotiated agreements with other landowners to manage their farms and share in the profits, leading to the recovery of many family farms during the depression years. The income from profit-sharing substantially helped Terling's own recovery.[79]

By pursuing the resolution of his estate's financial burden by these other means, Rayleigh used his Cambridge income to help develop the laboratory. Upon assuming his chair, he "found the physical laboratory very imperfectly provided with apparatus" and instituted an apparatus fund, to which he personally donated £500, an amount matched by Devonshire. He petitioned for contributions "from those who take an interest in

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9/1108 f. 64; R.G. 11/1809 f. 134.

[79] Strutt, *Life*, pp. 184-185; Sir William Gavin, *Ninety Years in Family Farming: The Story of Lord Rayleigh's and Strutt & Parker Farms* (London: Hutchinson, 1967) pp. 71-111, Appendices A and B.

Cambridge and in the promotion of science."[80] Another £1000 came from various other subscribers, which included Alice Balfour, who pledged an initial £10 and gave another £25 later in the drive. She sent her contributions despite having to economize with household expenses, as Whittingehame also suffered the effects of the agricultural depression; she wrote to Lady Rayleigh in December, 1879: "Now that we economize, the Times & Courant are the only daily papers we take in."[81] Rayleigh's fund-raising campaign is strikingly similar to the private, philanthropic initiative spurred by Frank Balfour and his allies to help the Naples station. These instances of philanthropy are especially noteworthy amid the growing agricultural crisis, from which even Cambridge's colleges felt the effects.[82]

Rayleigh's success in positioning the Cavendish as a premier teaching and research laboratory has been analyzed in numerous studies.[83] His strategy to "identify the laboratory with some research planned on an extensive scale" and selection of the redetermination of electrical units of measure (the ohm and ampere) as a "common interest" that "might unite a number of men sharing in the work" is well-documented.[84]

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[80] Lord Rayleigh to 'Sir', 10 Mar. 1880, Maxwell Papers 7655/IIIc[1] CUL; Strutt, *Life*, p. 103, 412.

[81] A.B. Balfour to E. Rayleigh, London, 18 February 1881, Terling; A.B. Balfour to E. Rayleigh, Whittingehame, 15 December 1879, Terling.

[82] Brooke, *A History of the University of Cambridge*, pp. 78-80.

[83] Strutt, *Life*, pp. 99-148; Crowther, *The Cavendish Laboratory*, pp. 80-102; see also Chapter 4 and below, this chapter.

[84] Arthur Schuster, "John William Strutt, Third Baron Rayleigh, 1842-1919," *Proceedings of the Royal Society of London*, series A, 93 (1921): i-l, on xx; also Simon Schaffer, "Late Victorian Metrology and its Instrumentation: A Manufactory of Ohms,"

Arthur Schuster, Horace Darwin, Eleanor Sidgwick, Arthur Balfour and Lady Rayleigh numbered among the "volunteers" assisting in the experiments. On three of the more important publications, Sidgwick appeared as coauthor.[85] Lady Rayleigh later recalled, "He always lunched at home & I used to have tea with him at the lab. Occasionally friends & fellow workers joined us – but we continued to use a broken spouted earthenware teapot – which R[ayleigh] considered adequate."[86] Schuster attributed the afternoon teas as "an innovation which may appear to be trivial, but the custom, which affords opportunities for informal discussion of scientific matters and encourages friendly personal intercourse, has been copied in many laboratories."[87] Lady Rayleigh's participation created another legacy continued by J.J. Thomson's wife, Rose, during his tenure – the companionate support of the professor's wife as a social hostess.[88] But it would be misleading to consider Lord Rayleigh's style of leadership as conservative or

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in *Invisible Connections: Instruments, Institutions, and Science*, ed. Robert Bud and Susan E. Cozzens (Bellingham, WA: SPIE Optical Engineering Press, 1992), pp. 23-56; Schaffer, "Rayleigh and the Establishment of Electrical Standards."

[85] Lord Rayleigh and Mrs. H. Sidgwick, "On the Specific Resistance of Mercury," "Experiments, by the Method of Lorenz, for Further Determination of the Absolute Value of the British Association Unit of Resistance, with an Appendix of the Determination of the Pitch of a Standard Tuning-Fork," "On the Electro-Chemical Equivalent of Silver, and on the Absolute Elecromotive Force of Clark Cells," in Strutt, *Scientific Papers*, II: 78-91, 155-183, and 278-332. Sidgwick's contributions are detailed in John N. Howard, "Eleanor Mildred Sidgwick and the Rayleighs," *Applied Optics* 3 (1964): 1120-1122, and Raymond W. Schmitt, "The Salt Fingers of Jevons (1857) and Rayleigh (1880)," *Journal of Physical Oceanography* 25 (1995): 8-17.

[86] E. Rayleigh, "Notes," p. 64, Terling; compare Strutt, *Life*, pp. 128-129.

[87] Schuster, "John William Strutt," p. xxiii.

[88] M. Jeanne Peterson, *Family, Love, and Work in the Lives of Victorian Gentlewomen* (Bloomington: Indiana University Press, 1989), pp. 171-172.

authoritarian. Unlike Clerk Maxwell, who refused to allow women access to the laboratory, except during a few short weeks while he was on vacation, Rayleigh opened the laboratory to classes of women students from Girton and Newnham. He wrote to Evelyn in 1880, "Frank & Gerald [Balfour] came to dinner last night & seemed well...I have decided to admit women to the lectures in the Cavendish."[89]

During his residence in Cambridge, Rayleigh took advantage of the presence of his many in-laws and friends to carry forward his research on color perception (see Chapter 4). Gerald Balfour recalled how Rayleigh discovered a peculiar color-blindness based on variations in the Balfour brothers' responses to color combinations:

> I remember the experiments quite well. My impression is that the observations were first made with me and then with Frank, and afterwards with Arthur; that we all three shared the peculiarity, wherein Eustace and Cecil were normal. But I am not absolutely certain of the order. I think the original observations were made at the Cavendish; but further tests were also made at Terling.[90]

Rayleigh used an apparatus that enabled an observer to determine the proportion in which spectral red and green must be combined to match a pure yellow. Testing a total of twenty-three observers, sixteen made matches consistent with each other while five, including three of the Balfour brothers, required twice as much green to convert red into yellow. Based on this study, Rayleigh proposed an hereditary influence producing this

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[89] J.W.S. Rayleigh to E. Rayleigh, Cambridge, 30 June 1880, Terling; Paula Gould, "Women and the Culture of University Physics in Late-Nineteenth Century Cambridge," *British Journal for the History of Science* 30 (1997): 127-149.

[90] G.W. Balfour to R.J.S. Rayleigh, Woking, 31 October 1923, Terling.

peculiarity in color perception.[91] His discovery attracted curiosity. Lady Rayleigh wrote, "Alice [Balfour] is longing to have her colour vision tested in the hopes of proving certain differences of opinion from other artists may prove to be founded on differences of perception. I almost begin to think you were born to bring peace into the artist world."[92]

Rayleigh's interesting results stimulated Schuster to follow up with a more rigorous statistical study of seventy-two subjects that confirmed Rayleigh's conclusions.[93] On the merit of his work, in 1890 Rayleigh was appointed chair of the Royal Society's Committee on Colour Vision, which issued a report to the Board of Trade advising on new methods and standards for testing the color vision of candidates for railway employment or service in the Mercantile Marine Service. The new tests, which the Board adopted, helped identify individuals with the color vision peculiarity, and thus preventing their susceptibility to misinterpreting green signal lights.[94]

The color perception study, like the electrical units of measure project, required a broad spectrum of participants. Members of his own family played central roles both in the research and social setting surrounding Rayleigh's professorship, reflecting how a

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[91] Strutt, "Experiments on Color," *Scientific Papers*, I: 542-550; Schuster, "John William Strutt," pp. xxv-xxvi. Rayleigh's data and notes for these experiments are recorded in Rayleigh, "Experimental Notebook, 1878-1889, Part 11," RA, AFRL.

[92] E. Rayleigh to J.W.S. Rayleigh, London, 31 May 1880, Terling.

[93] Arthur Schuster, "Experiments with Lord Rayleigh's Colour Box," *Proceedings of the Royal Society of London* 48 (1890): 140-149.

[94] Strutt, *Life*, pp. 174-178.

familial infrastructure supported his professional role in much the same manner as it did his private research at Terling. His expansion and standardization of classes in practical physics, augmentation of the laboratory's outfit of apparatus, and opening of the laboratory to women students all reflect his contributions to Cambridge's broader reform movement. His election to the chair was entangled with matters of aristocratic duty and his image as a country squire. *Punch* noted the irony in his dual identity as "Lord and Professor":

> "*Don*," they say, comes from "Dominus"; and Dominus is Latin for "Lord." But when before was Lord seen in gown of Don, or Don in robe of Lord? The House of Cavendish has supplied Devonshire with Dukes, and science with discoveries, and Boyle was the scion of a noble House, as well as a world-renowned Chemist; but neither Cavendish nor Boyle ever wrote himself down as Professor.
>
> The name [Strutt] is of happy augury. Such blended rays of rank and science blend in this Lord-high Professor's aureole, that he would be more than mortal, did not his very gait proclaim his race, – "*Verus et incessu patuit Strutt!*"[95]

The Professor of Animal Morphology and the Balfour Studentships

Balfour's own election to a professorial post soon followed. He made his crowning achievement between 1880 and 1881. Assembling the mass of experimental data that he and his students accumulated, Balfour issued his two-volume text, *A Treatise on Comparative Embryology*.[96] The volumes provided a welcomed and unparalleled synthesis of morphological studies within a Darwinian evolutionary paradigm. It was

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[95] *Punch, or the London Charivari* 76 (1879): 273. the Latin is an allusion to Virgil's line on Venus, *Aeneid* I.402: "*vera et incessu patuit dea*," *i.e.*, "the way she walked showed she was a goddess." I owe this reference to Christopher Stray, pers. comm., 28 Nov. 2004.

[96] Francis M. Balfour, *A Treatise on Comparative Embryology*, 2 vols. (London: Macmillan, 1880-1881).

quickly translated into German and French.[97] The eminent Oxford entomologist Edward Bagnall Poulton acknowledged it as the requisite sequel to Foster's and Balfour's introductory text in any course in embryology.[98] Darwin, upon receiving a complimentary copy, wrote to Balfour:

> I do not feel that I am worthy of your present, unless indeed the fullest conviction that it is a memorable work makes me worthy to receive it….Once again accept my thanks, for I am proud to receive a book from you, who, I know, will some day be the chief of English Biologists.[99]

Following the publication of the first volume, Balfour received nominations for the highly prestigious Linacre Chair in Comparative Anatomy and Physiology at Oxford (to succeed the late George Rolleston) and the Regius Chair of Natural History at Edinburgh (to succeed the late Wyville Thomson). Arriving in succession in 1881, these offers – both of which Balfour declined – worried his Cambridge colleagues that the university would not be able to retain him much longer. Meanwhile, the BAAS elected Balfour as its general secretary (a post he deferred until 1882); the Royal Society elected him a member of its Council and awarded him its coveted Royal Medal; the University of Glasgow conferred upon him an honorary Doctor of Law degree; and the Cambridge Philosophical Society elected him as its president. "At the instigation of Balfour's

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[97] Francis M. Balfour, *Handbuch der Vergleichenden Embryologie*, trans. B. Vetter, 2 vols. (Jena: Verlag von Gustav Fischer, 1881-1882); Balfour, *Traité d'embryologie et d'organogénie comparées*, trans. H.A. Robin, 2 vols. (Paris: Baillière, 1883-1885).

[98] Leon Stephen Jacyna, "Scientific Naturalism in Victorian Britain: An Essay in the Social History of Ideas," University of Edinburgh: Ph.D. thesis, 1980, p. 260.

[99] C. Darwin to F.M. Balfour, Down, 6 July 1881, quoted in Foster, "Introduction," p. 23.

friends," Foster swiftly campaigned for a more permanent Cambridge chair for his celebrated colleague.[100]

Foster presented his case to the Senate Council in a letter to the Vice-Chancellor, James Porter, in January 1882. He emphasized Balfour's merit in the "scientific world" as well as an awareness of statutory reform underway in the University (propelled by the Royal Commission), which portended changes to the professorate (and similarly delayed Foster's own promotion from college Lecturer to Professor until the following year). He wrote,

> If the Council can devise some action, consistent with present regulations and not productive of future entanglements, which should give him a recognized position in the University until the new statutes come into force – making him for instance a Professor Extraordinary or something of the kind, I am sure such a step would be greatly approved not only in the University but in the scientific world outside.[101]

The Council responded within weeks by passing a resolution which created a Professorship of Animal Morphology terminable upon the completion of Balfour's tenure. According to its report, "The Council have been in communication with the Board of Natural Science Studies, who have expressed their hearty concurrence with the proposal" – signaling again the endorsement of Balfour's colleagues.[102] Balfour was

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[100] M. F[oster], "Francis Maitland Balfour," *Proceedings of the Royal Society of London* 35 (1883): xx-xxvii, on xxiv.

[101] Council of the Senate Report, May 3, 1882, Cambridge University Register, 39.36, CUL; Alexander, "Francis Maitland Balfour's Contributions," p. 158.

[102] Council of the Senate Report, March 27, 1882, Cambridge University Register, 39.36, CUL; John Willis Clark, *Endowments of the University of Cambridge* (Cambridge: Cambridge University Press, 1904), p. 347.

officially elected to the chair on 31 May 1882. The swiftness of the Council's actions was reminiscent of its creation of the Cavendish chair and election of Clerk Maxwell to it.

Just prior to this campaign, Balfour had paid visits to Kleinenberg in Messina, Sicily, at Christmas, Dohrn in Naples in January, and his friend William Hay Caldwell, lying sick with typhoid at Capri. After nursing Caldwell until other friends arrived, Balfour came down with typhoid himself. He returned to Cambridge where Alice cared for him in February and March, 1882. During this time, he became aware of Foster's campaign. He wrote to his sister-in-law:

> Eustace may be interested to hear that the Edinburgh Professorship has been given to Lankester. The fact that both it and the Oxford post were offered to me has however rather stirred up the Cambridge people, and it is possible that before long they will give me some post. In any case it is almost certain they will build for me a new Laboratory, which I most imperatively require.[103]

By this time, following the example of Foster's Physiological Laboratory, Balfour called his modest research rooms the "Morphological Laboratory" and edited reprints of publications issuing from it.[104]

While still recovering, in late March Balfour received the news of the Council of

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[103] Balfour, *Ne Obliviscaris*, I: 333. Lankester resigned the position within a fortnight of his acceptance of it, owing to misunderstandings over the laboratory resources and required teaching load. He wrote to his mother, "As far as I can make out, there is no lecture room or museum of any kind for me: they want me to make bricks without straw, and will try to make me lecture in the winter as well as the summer… I dislike the whole business intensely"; Edinburgh, 3 April 1882, quoted in Joseph Lister, *E. Ray Lankester and the Making of Modern Biology*, ed. by Peter J. Bowler (Oxford: British Society for the History of Science, 1995); also E. Ray Lankester, *Nature* 25 (1882): 607. James Cossar Ewart succeeded him.

[104] F.M. Balfour (ed.), *Studies from the Morphological Laboratory* (London: Williams and Norgate, 1880), Whipple.

the Senate's resolution. With improved health, in April Balfour set sail for the Channel Islands, accompanied by his sister Alice and his demonstrator Adam Sedgwick. But Sedgwick left the party early to return to Cambridge to teach Balfour's classes for him during the Easter term. Alice sent reports of their tour to relatives, describing her part in assisting with his research:

> Frank & I are enjoying life here, – at least I am, & I believe he is. Mr. Adam Sedgwick is here also, & we share a sitting room & laboratory together. He goes back to Cambridge on Thursday. This last week the tides have not been favourable, so we have not collected anything, but they will be good the next few days, so I expect we shall work hard. Frank & Mr. Sedgwick went across the island today, but did not find much. Tomorrow we are going to Bordeaux harbour, which is supposed to be the best place for sea beasts in Guernsey. We may go over to Herin for the day once or twice. We have had good weather on the whole, tho' there have been three bad days. I think we shall probably stay here till about the 25th & then very likely go to Sark for a few days. We think of returning to England about the 1st, weather permitting. I have not sketched much. I did 3 at Herin, none very good, & have begun the view from my window here: it is rather like the view from the Hotel at Madeira, only very inferior in every way.... I have not drawn very much for Frank, except an elaborate diagram of the structure of Haliotis (Venus' ear) & Peripatus. The last takes a fearful amount of time to do.[105]

Alice's report acknowledged their study of the *Peripatus capensis* (as MacLeod explained, "a genus of tropical terrestrial invertebrates thought to lie between the annelids and the arthopods"), whose embryonic development Frank carefully noted and Alice faithfully drew in remarkable sketches. Upon their publication, Sedgwick and Henry Nottidge Moseley observed, "It is due to her skill that the first really serviceable and accurate representation of any species of Peripatus is available for scientific purposes."[106]

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105 A.B. Balfour to E. Rayleigh, Guernsey, 16 April 1882, Terling

106 MacLeod, "Embryology and Empire," p. 149; H.N. Moseley and A. Sedgwick, "Introduction," in Francis Maitland Balfour, "The Anatomy and Development of Peripatus capensis," *Quarterly Journal of Microscopical Science* 23 (1883): 213-259, on

Frank Balfour's attention to this species, benefitting from specimens that Huxley gave to him, inspired a line of research carried on by his students for several years. His studies uncovered aspects missed in earlier observations by Moseley, including a description of the urogenital organs and the nervous system. In honor of his teacher, Sedgwick named a newly-discovered species *Peripatus balfouri*.[107]

In June, Balfour was appointed to the Degrees in Science and Letters Syndicate at Cambridge; this was one of several syndicates on which he served during his Trinity career. (He served with Foster and Rayleigh, for example, on the Museums and Lecture Rooms Syndicate.)[108] Lea noted how Balfour's involvement in college and university reform measures was "actuated by a keen sense of duty."[109] Another colleague, J.E.C. Welldon, judged him "a keen University politician": "He believed that, great as has been the past of Cambridge, still greater and more beneficent will be its future. He was anxious to widen and extend its influence."[110] Within weeks Balfour departed for his annual summer climb in the Alpine mountains. News of his tragic death, resulting from a fall,

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214; Opitz, "Behind folding shutters in Whittingehame House"; Brian K. Hall, "Francis Maitland Balfour (1851-1882): A Founder of Evolutionary Embryology," *Journal of Experimental Zoology* 299B (2003): 3-8.

[107] F.M. Balfour to H.T. Huxley, Cambridge, 28 October 1880, HP, ICA; MacLeod, "Embryology and Empire," p. 149; Adam Sedgwick, *A Monograph of the Development of Peripatus Capensis* (London: C.J. Clay and Sons, 1888), pp. iii-iv, 1-2.

[108] Minutes of Syndicates, University Archives, CUL.

[109] *Balfour Memorial*, p. 8.

[110] *Balfour Memorial*, p. 5.

reached Whittingehame by 23 July 1882 and quickly spread to Cambridge.[111]

In her analysis of the conditions surrounding Balfour's death and the images projected of his memory, Helen Blackman suggested that "as an aristocrat able to participate in the leisure pursuits of the middle classes," he managed to reconcile tensions between an "established university" and "an upstart profession." "He continued to do so even after his death, his image a resource for his successors in their promotion of a new science."[112] Balfour's noble image inspired significant memorials, including a biological laboratory for the women students of Newnham and Girton; a zoological library of 500 volumes and 1100 pamphlets; a cabinet of apparatus; a bronze bust of Balfour (in climbing attire) by Adolf von Hildebrand; and an endowment totaling £8,451 from international subscriptions to establish the Balfour Studentship, "by which his memory was to reach beyond Cambridge and encompass the world for Darwinian biology."[113]

But instead of Balfour's role as a reconciler of the establishment and upstarts, I

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[111] Corus D. Cunningham to the Legal Advisors of the Balfours of Whittingham, Hotel des Motanvert pres Chamonix, 23 July 1882, Add. Mss. 49838/108-09, BP, BL; Balfour, *Ne Obliviscaris*, I: 348-349; Blackman, "A Spiritual Leader?" p. 110.

[112] Blackman, "A Spiritual Leader?" p. 115.

[113] MacLeod, "Embryology and Empire," p. 148; Marsha L. Richmond, "'A Lab of One's Own': The Balfour Biological Laboratory for Women at Cambridge University, 1884-1914," *Isis* 88 (1997): 422-455; Clark, *Endowments*, p. 347-350. MacLeod reports a sum of £8,446 collected for the Balfour Studentships, which differs from the total reported by Newton; Alfred Newton (Treasurer of the Balfour Fund) to Vice Chancellor [Charles Edward Searle], Cambridge, 6 March 1888, "Balfour Memorial," Cambridge University Register 100, CUL. The apparatus and bust are extant in the Balfour and Newton Library, Department of Zoology, Cambridge. The bust is engraved "Given by J.W. Clark MA Trin. Coll, G.H. Darwin MA Trin. Coll." and was presented in 1883; Clair Castle (Librarian), personal communication, 16 April 2003.

find it more accurate to interpret Balfour's role as a leading aristocratic influence within Cambridge's broader reform movement coordinated by a diverse coalition of individuals representing both the *reforming* university and the professional interests of practitioners in the physical and biological sciences. Balfour was not unique and should be regarded within a broad network of like-minded individuals comprising the Balfour dynasty in Cambridge. The Balfour Fund, establishing the Studentship, illustrates again aristocratic leadership and a tradition of private, philanthropic initiative. Balfour's noble image, even without his physical presence, both enabled and inspired the movement.

In the appeals for contributions to the fund, his friends emphasized his gentility, imbuing their rally for a student research endowment with respectable purpose. At an undergraduate meeting, organized for the memorial in October 1882, Weldon opened the proceedings by describing Balfour's ability to devote himself to research:

> But there are certain broad patent facts of his life which arrest the attention, and one of those, if I mistake not, is that it offers a single instance of the benefit of free specialization in study. It would have been possible, I do not say to defeat, but at least to cramp and thwart his genius by artificial educational restrictions. We may well be glad to think that this was never done. Circumstances, as you know, delivered him from the hard necessity of working for his daily bread.[114]

Later in the meeting, expressing one common complaint of contemporary professionals in science. Foster asked, "Now, of those who have passed their student days at Cambridge, how many are able by circumstances to do what Balfour did, to throw themselves at once into original work?" He explained the fund's scheme:

> Now, the Memorial that it is proposed to institute to Frank Balfour takes this shape, that it shall provide for a man at the conclusion of his student's days, a

[114] *Balfour Memorial*, p. 4.

> competency, a means of clothing himself and feeding himself for two, three, or more years, in order that he may devote those years to undivided research.[115]

While the appeals gained broad support, the most generous contributions came from the Balfour family – a sum of £3,000. Another £1,000 from Michael Foster actually originated from a bequest by Balfour. Devonshire contributed £250. With these contributions alone, more than half the total endowment resulted from aristocratic philanthropy.[116]

Conclusion

Lobbies for developing the biological and physical science professions flooded the public affairs beyond Cambridge throughout the 1870s and 1880s. In the early years of reform, gentlemanly leadership proved effective where professional lobbies otherwise failed. Whereas Foster, invited by Cambridge to launch the department of physiology in 1870, its gains progressed slowly and gradually, culminating in his promotion to a professorship only as late as 1883. In contrast, Balfour created the department of morphology by his own initiative in 1875 and, with the support of his network, received university affirmation by 1882. Upon the establishment of the Balfour Studentship, Foster explained how he and Balfour had envisioned the same for physiology: "For some five or six years he and I were together concerned in the carrying out of a Studentship on these same lines for physiology; and I feel sure Francis Balfour himself would have wished for

[115] *Balfour Memorial*, p. 12.

[116] Clark, *Endowments*, p. 349.

any one else something like what we are now trying to do for him."[117] When guided by an aristocratic spirit – and backed by aristocratic philanthropy – professionalizing initiatives like the funding of the Naples zoological station, foundation of the Cavendish laboratory, expansion of the Cavendish's outfit of apparatus, and creation of the Professorship of Animal Morphology and Balfour Studentship were swiftly executed while parallel middle-class lobbies at Cambridge and elsewhere remained unheeded. Lankester noted this disparity in his plea for the support of professional men:

> If those few of our countrymen who by accident are placed in an independent position show such success in the prosecution of scientific research, how much more would be achieved in the same direction were the machinery provided to enable those also who are not accidentally favoured by fortune to enter upon the same kind of work. The number of wealthy men who have distinguished themselves in scientific research in England is simply evidence that there is a natural ability and liking for research in the English character, and is a distinct encouragement to those who have it in their power to do so, to offer the opportunity of devoting themselves to science as a larger number of the members of the community. It is impossible to deny that there are hundreds of men amongst us who have as great capacity for scientific discovery as those whose fortune has favoured with leisure and opportunity.[118]

Yet despite the rhetorical strategies, more definite gains resulted when those very "wealthy men" acted on behalf of the reforms.

The involvement of Rayleigh and Balfour in professional science at Cambridge benefitted the university's science culture, but they, too, benefitted beyond modest incomes. Both men emerged from their short-lived posts with preeminent reputations in the scientific community and expanded capacities to influence the directions of future

[117] *Balfour Memorial*, p. 14.

[118] E. Ray Lankester, "Address," *BAAS Report*s 52 (1883): 512-529, on 515.

professional developments. In Rayleigh's case, his new identity as a man of science that blended amateurism and professionalism gave him a distinctive position for negotiating science policy-making. Balfour, who died before he could carry out his professorial duties, left a legacy carried on by his students, and a "spirit" in whose name his family and colleagues continued to advocate for biology.[119] Whereas Rayleigh exerted his influence personally, Balfour accomplished his through martyrdom, perceived in emotional terms by one student:

> The power of Balfour still lives, lives in the lives of those whom he inspired. And when I say this I mean it. Nothing since I came to this University has impressed me more profoundly than the many proofs we have that the spirit of Balfour rests upon his pupils.... The personal influence of Balfour! who can estimate the effect which it will have upon the future of Cambridge?[120]

As we will see, this influence extended within and beyond Cambridge in the ensuing decades.

[119] Chapter 8 of this dissertation.

[120] *Balfour Memorial*, p. 16.

Chapter 7

The Aristocratic Challenge to Scientific Naturalism, 1879-1904

> A member of the outer circle of our vast family connection, observed "I did like you all. You were so individual." Strong individuality, does not lead to family agreement, and we never achieved that peaceful estate. On the other hand, let any outsider attack us, then we stood "Shoulder to shoulder," and the interferer suffered severely.[1]

As the British Association for the Advancement of Science prepared for its first overseas meeting in Montreal, Canada, the council unanimously elected Rayleigh as President. This selection reflected the society's desire for him to represent both British science and the British Empire; a noble who held a prestigious professorship and a seat in the House of Lords could accomplish this end by his dual status. Arthur Balfour noted his brother-in-law's multiple charges: "Your responsibilities are appalling; for you represent not only Science but England and the Peerage!"[2] Rayleigh's election marked another facet to his family network's developing relationship to science, the family's opportunities to publicly speak in the name of science.

Rayleigh's presidential speech offered his judgment of the physical sciences' current state and the future directions he envisioned for their growth. His comments reflected an ambivalence toward specialization and professionalization based, in part, on his awareness of public debates in the philosophy and ethics of science. True, he was a

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[1] Lady Frances Balfour, *Ne Obliviscaris: Dinna Forget*, 2 vols. (London: Hodder and Stoughton, 1930), I: 79-80.

[2] A.J. Balfour to J.W.S. Rayleigh, Whittingehame, 15 August 1884, quoted in Robert John Strutt, Fourth Baron Rayleigh, *Life of John William Strutt, Third Baron Rayleigh* [1924], aug. ed. with an intro. by John N. Howard (Madison: The University of Wisconsin Press, 1968), p. 139.

Cambridge professor who demanded exacting precision in electrical measurements and the standardization and expansion of academic laboratory teaching, but he tempered his enthusiasm for these developments by offering advice to aspiring men of science that emphasized the importance of learning much in the spirit of traditional amateur science at home:

> Much of the best original work has been done with the homeliest appliances; and the endeavour to turn to the best account the means that may be at hand develops ingenuity and resource more than the most elaborate determinations with ready-made instruments. There is danger otherwise that the experimental education of a plodding student should be too mechanical and artificial, so that he is puzzled by small changes of apparatus much as many school-boys are puzzled by a transposition of the letters in a diagram of Euclid.[3]

The scientific lord, who favored working in his private laboratory in stable lofts facing the nearby village church, stressed the value of simplicity for inspiring creativity in science. He also advised would-be men of science against overextending one's claims to authority on matters that ultimately required theistic explanations:

> So far the opinion of a scientific worker may have a special value, but I do not think that he has a claim, superior to that of other educated men, to assume the attitude of a prophet. In his heart he knows that underneath the theories that he constructs there lie contradictions which he cannot reconcile. The higher mysteries of being, if penetrable at all by human intellect, require other weapons than those of calculation and experiment.[4]

He further criticized those "writers, speaking in the name of science," who fostered an "apprehension" among "many excellent people" that science was "tending towards

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[3] John William Strutt, Third Baron Rayleigh, *Scientific Papers*, 6 vols. (Cambridge: Cambridge University Press, 1899-1920), II: 352

[4] Strutt, *Scientific Papers*, II: 354.

materialism."[5] Rayleigh did not define what he meant by "materialism," nor whom he counted among materialist "writers," but he probably followed the popular understanding of materialism as the denial of divine intervention in nature and had in mind such popularizers as Thomas Henry Huxley and John Tyndall.[6] But his consideration of the "foundations of belief" question marked his entre into the contemporary public war between science and religion. In this war, the contenders dressed their contests for professional authority as epistemological concerns.[7] As I will explicate further in this chapter, Rayleigh and his in-laws, Arthur Balfour and Lord Salisbury, provided a vision for the scientific disciplines that retained the importance of Anglican theism, drawing directly from their value of amateur practice as well as religious devotion.

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[5] Strutt, *Scientific Papers*, II: 353.

[6] Strictly speaking, as Bernard Lightman has argued, in the nineteenth century "European materialism was limited almost exclusively to Germany," where philosophers rejecting the older German transcendentalist tradition made "extensive claims for the power of science to explain all phenomena." The usual British targets of the materialist label, men like Huxley, Tyndall, Leslie Stephen, and William Kingdon Clifford, patently repudiated it. The distinctly British version of materialism became known in the contemporary debates as "naturalism." Bernard Lightman, *The Origins of Agnosticism: Victorian Unbelief and the Limits of Knowledge* (Baltimore: Johns Hopkins University Press, 1987), p. 25.

[7] The phrase "the foundations of belief" appeared within the titles of Arthur Balfour's two monographs, *A Defence of Philosophic Doubt, Being an Essay on the Foundations of Belief* (London: Macmillan, 1879), and *The Foundations of Belief, Being Notes Introductory to the Study of Theology* (London: Longmans, Green and Co., 1895). On the idea that the debates surrounding the foundations of scientific belief as a battle-ground for authority, Frank M. Turner, "The Victorian Conflict between Science and Religion: A Professional Dimension," *Isis* 69 (1978): 356-376, reprinted in Turner, *Contesting Cultural Authority: Essays in Victorian Intellectual Life* (Cambridge: Cambridge University Press, 1993), pp. 171-200; on Huxley's role, Adrian Desmond, *Huxley: From Devil's Disciple to Evolution's High Priest* [1994] (Reading, MA: Helix Books, 1997), p. 389.

My chapter begins with this circle's earliest public statement of an anti-materialist (or naturalist) philosophy; this was Arthur Balfour's philosophy of scientific skepticism. I then position Rayleigh's Montreal address within the terms set by Balfour, as well as consider Salisbury's own 1894 address to the BAAS in Oxford. As Balfour's second, more famous, statement of his philosophy was published in that same year, I analyze the public reaction that tended to yoke these two theistic visions for science as voices for the same conservative political agenda. I conclude by examining Balfour's return to the public stage in the first decade of the twentieth century, suggesting how his ideology positioned him within professional scientific lobbies in which he increasingly engaged himself. This engagement, as it did for Rayleigh and Salisbury, allowed Balfour to influence the character of the professional development of the sciences in a direction that reconciled them with evangelical, aristocratic values.

Balfour and Rayleigh in the late 1870s and 1880s: Challenging the Tendency toward "Materialism"

Up to this point, we have examined the private side to Rayleigh's and the Balfour network's country-house practices and early professional engagement (Chapters 5 and 6). As the network's members assumed greater visibility within public roles, their conservative Anglican values for science increasingly shaped their public discourse and professionalizing strategies. Their polite, theistic perspectives had precedents among the writings of the older aristocratic generations with whom they increasingly became associated over the decades. Laurence Parsons, second Earl of Rosse, his son William, third Earl of Rosse, and George Campbell, the eighth Duke of Argyll, all issued public statements that emphasized the synergy between the sciences and theism, as well as the value of amateur practice.[8] Behind their views lay allegiances to liberal party politics and the confidence of landholding in areas remote from Cambridge's intellectual society within which the liberal-conservative Balfours and Strutts were operating. Despite the political differences, their generational views on the relation between science and religion tended to bear many similarities.[9] Continuities also existed in the public perceptions of their writings, the country-house foundations of their intellectual work, and the social

[8] The [second] Earl of Rosse, *An Argument to Prove the Truth of the Christian Revelation* (London: John Murray, 1834); The [third] Earl of Rosse, "Presidential Address," in William Parsons, Third Earl of Rosse, *The Scientific Papers of William Parsons, Third Earl of Rosse, 1800-1867*, ed. The Hon. Sir Charles Parsons, K.C.B., F.R.S. (Bradford: Percy Lund and Co., 1926), pp. 44-49; The Duke of Argyll, *The Reign of Law* (London: Strahan and Co., 1867); "What is Science?" *Good Words* (1885): 236-245. On Argyll's role in the debates, Thomas Lee Anderson, "The Duke of Argyll and A.J. Balfour an the Science-Religion Controversy in Late-Nineteenth Century England," M.A. thesis: University of Connecticut, 1971.

[9] The liberal academic climate of Cambridge encouraged a moderation in the conservative views of the network. For their views, Lady Frances Balfour, *Ne Obliviscaris: Dinna Forget*, 2 vols. (London: Hodder and Stoughton, 1930), I: 201-202, 216, 218-219, 312, 315, 382-383, 438. Henry Sidgwick, Lady Frances Balfour, and Frank Balfour generally sided with the liberal party, though Sidgwick and Lady Balfour later supported the conservative-leaning Liberal Unionist party. Gerald Balfour went further in his conversion from a liberal to conservative position. Biographers generally explained Arthur Balfour's conservativism as "inherited," but during his residence in Cambridge, his position was less clear as he admitted himself: "In the 'sixties the line between the moderate Liberal and the moderate Conservative was more than usually blurred"; Arthur James First Earl of Balfour, *Chapters of Autobiography*, ed. Mrs. Edgar Dugdale (London: Cassell and Co., 1930), p. 85. Rayleigh, always a conservative, nonetheless showed liberal tendencies: "He imbibed from [John Stuart] Mill a belief in laissez faire, which did not quite fit in with the Conservative Party views of his youth"; E. Rayleigh, "Notes," Terling.

relations between their families, strengthened through intermarriages among them.[10]

Arthur Balfour, the upstart conservative Member of Parliament destined for political eminence, led the younger generation's charge into the science philosophy debates by issuing a series of articles that previewed his monograph, *A Defence of Philosophic Doubt*, published in 1879.[11] With a circulation of only 1,000 copies, the work attracted little public notice, yet it did illicit responses from the key intellectuals involved in the debates. It favorably impressed the Harvard botanist, Asa Gray, a Christian Darwinist, who asked a friend about the author as he prepared a series of lectures at Ball College on "Science & Religion, a topic which calls for wise speaking": "It is the most masterly essay I have seen of late years, & I should like to know who the man is, & what you think of his book."[12] Another admirer was Walter Raleigh Browne, an engineer and

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[10] As noted in Chapter 6, Eustace Balfour married Lady Campbell, daughter of the eighth Duke of Argyll, in 1879. Rayleigh's niece, Clara Helena (Lena) Strutt, married the third Earl of Rosse's great-nephew, Lt. Col. William Frederick Parsons, in 1915. The family intimacies between the Parsons' and Strutts are described in [Robert John Strutt], Lord Rayleigh, "Some Personal Reminiscences of Sir Charles Parsons," in The. Hon. Charles A. Parsons, *Scientific Papers and Addresses*, ed. The Hon. G.L. Parsons (Cambridge: Cambridge University Press, 1934), pp. xv-xviii; also, Sir William Gavin, *Ninety Years of Family Farming: The Story of Lord Rayleigh's and Strutt & Parker Farms* (London: Hutchinson, 1967), pp. 196-197.

[11] Arthur James Balfour, "A Speculation on Evolution," *Fortnightly Review* 28 (1877): 698-704; Balfour, "The Philosophy of Ethics," *Mind* 3 (1878): 67-86, 276-277; Balfour, "Transcendentalism," *Mind* 3 (1878): 480-505; Balfour, *A Defence of Philosophic Doubt*.

[12] A. Gray to [Theobald William?] Church, 11 Nov. 1879, "Copy" on Keble College, Oxford stationery, Add. Mss. 49838/74-75, BP, BL; Asa Gray, *Darwiniana: Essays and Reviews Pertaining to Darwinism*, ed. A. Hunter Dupree (Cambridge, MA: Belknap, 1963); A. Hunter Dupree, *Asa Gray, 1810-1888* (Cambridge, MA: Belknap, 1959); James R. Moore, *The Post-Darwinian Controversies: A Study of the Protestant Struggles to Come to Terms with Darwin in Great Britain and America, 1870-1900*

former Trinity fellow, who sent his praise directly to Balfour: "As a Trinity man, & a friend of Lord Rayleigh's (you may possibly remember seeing me at Carlton Gardens) I hope I may be allowed to write to you on your Defence of Phil. Doubt, which I have just read with much pleasure. I think it far the best book in metaphysical subjects I have ever read."[13]

Balfour's book covered a wide terrain of philosophy, rejecting both Kantian transcendentalism and Mill's empiricism while criticizing arguments from "popular philosophy" and the "School of Common Sense" (focusing on William Hamilton). Balfour's criticisms exposed the uncertainties and logical fallacies of scientific reasoning based on these philosophical schools and such fundamental postulates like the uniformity of nature, the Law of Universal Causation, and the "law of Evolution." His goal was the "encouragement to the compromise...between theoretical skepticism and practical faith."[14] He attacked the growing dogmatism that placed too much certainty in scientific explanation and inflated science as the singular standard of truth. He applied his conclusions to (and thus registered his position within) the "conflict between Science and Religion."[15] He argued,

> Has Science any claim to be thus set up as the standard of belief? Is there any ground whatever for regarding conformity with scientific teaching as an essential

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(Cambridge: Cambridge University Press, 1979), pp. 269-280.

[13] W.R. Browne to A.J. Balfour, London, 19 November 1880, Add. Mss. 49838/81-82, BP, BL; on Browne, *Alum. Camb.*

[14] Balfour, *A Defence of Philosophic Doubt*, p. 146.

[15] Balfour, *A Defence of Philosophic Doubt*, p. 302.

> condition of truth; and nonconformity with it as an unanswerable proof of error? If there is, it cannot be drawn from the nature of scientific belief itself. We have seen in the preceding pages how a close examination of its philosophical structure reveals the existence of almost every possible philosophical defect. We have seen that whether Science be regarded from the point of view of its premises, its inferences, or the general relation of its parts, it is found defective; and we have seen that the ordinary proofs which philosophers and men of science have thought fit to give of its doctrines are not only mutually inconsistent, but are such as would convince nobody who did not start (as, however, we all do start), with an implicit and indestructible confidence in the truth of that which has to be proved. I am far from complaining of the confidence. I share it. My complaint rather is, that of two creeds [Science and Religion] which, from a philosophical point of view, stand, so far as I can judge, upon a perfect equality, one should be set up as a standard to which the other must readily conform.[16]

Balfour took care not to falsely aggregate the targets of his criticism under the label of "materialists" or other related misnomers; rather he called his attack an "indictment against the general body of anti-religious controversialists" – by which he meant the agnostics.[17] While he disclaimed an interest in "making any special attack on individuals," he named both "Mr. Leslie Stephen" and "Professor Huxley" among those confidently trusting the "dogmatic system" of scientific claims to certainty.[18] Balfour singled out Stephen as one of "the two most recent assailants of Theology" (the other being Walter Richard Cassels, the author of *Supernatural Religion*), and directly challenged Stephen's denial of Divine interference based on the principle of the uniformity of nature.[19]

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[16] Balfour, *A Defence of Philosophic Doubt*, pp. 302-303.

[17] Balfour, *A Defence of Philosophic Doubt*, pp. 309-310.

[18] Balfour, *A Defence of Philosophic Doubt*, p. 309.

[19] Balfour, *A Defence of Philosophic Doubt*, p. 309, 328-334; Walter Richard Cassels, *Supernatural Religion: An Inquiry into the Reality of Divine Revelation*, 5th ed.,

Stephen was not convinced by Balfour's critique but admitted the force of his argument. He wrote to Balfour, "I dissent (as you will not be surprised to hear) from some of your conclusions & may perhaps take an opportunity of giving my own view in 'Mind'.... But in any case I shall feel the highest respect for the acuteness of your criticism."[20] Stephen's article in *Mind* followed promptly.[21] His rebuttal denied three aspects to Balfour's criticism, namely the absence of a rigorous "constructive part of [his] theory," which posits a "practical cause of belief" underpinning both science and theology; the distinctness of theology and science as "two different codes of belief, each perfectly coherent, each resting on its own base – logical or otherwise"; and the untenableness of the doctrines of the empirical school, which "make nonsense of the scientific conclusions."[22]

Stephen called Balfour's argument against the empirical school "most ingenious" and admitted "indeed, there is a great difficulty in the theory."[23] The difficulty involved the limits of human perception to conclusively establish first causes (like the uniformity of nature), but Stephen, even without a satisfactory theory of perception, held "this to be

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3 vols. (London: Longmans, Green & Co., 1875).

[20] L. Stephen to A.J. Balfour, London, 13 July 1879, Add. Mss. 49838/67-68, BP, BL.

[21] Leslie Stephen, "Philosophic Doubt," *Mind* 5 (1880): 157-181.

[22] Stephen, "Philosophic Doubt," pp. 158-159, 165, 171.

[23] Stephen, "Philosophic Doubt," pp. 171, 165.

one of the metaphysical difficulties which are not fatal to any further advance."[24] Adopting a pragmatic position (not unlike Balfour's own method), he argued that in scientific explanations of phenomena, such as the "whole theory about molecules" – which "does not involve any real knowledge of the unperceivable objects" – we must be content with a theory that gives verifiable results. "I believe that I can attain to truths which will remain, although their significance is not yet unfolded."[25] But Stephen's rebuttal fell short of an effective defense of the empirical scientific philosophy, which as Lightman has argued, posed grave problems that Stephens and his agnostic allies continually "struggled in vain to overcome."[26]

Among Balfour's most dedicated readers were the members of his own family, several of whom read parts of the book in draft form and provided advice prior to publication. Henry Sidgwick provided the most important counsel, receiving the only acknowledgment in the preface for his "criticising the various portions of the Essay." But Salisbury also provided advice on the title. Nora Sidgwick and the Rev. James Robertson (the evangelical Whittingehame minister and lifelong family friend) gave their approval of sections they read.[27]

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[24] Stephen, "Philosophic Doubt," p. 165.

[25] Stephen, "Philosophic Doubt," pp. 165-166.

[26] Lightman, *The Origins of Agnosticism*, p. 164; also 161-176.

[27] Balfour, *A Defence of Philosophic Doubt*, p. vi; H. Sidgwick to A.J. Balfour, Cambridge, 26 April 1879, Add.49832/22-23, BP, BL; Rev. J. Robertson to A.J. Balfour, Whittingehame, 3 July 1879, Add. Mss. 49790/102-103, BP, BL; Balfour, *Chapters of Autobiography*, p. 65. The paramount influence of Sidgwick in shaping Balfour's philosophy is analyzed in James Alistair McGeachie, "'Mr. Balfour's Apologetics':

One sticking point for some critics, including his brother Frank, was Arthur's emphasis on the untrustworthiness of the senses and, concomitantly, the uncertainty in science's interpretations of observations. Arthur Balfour argued that science's conclusions, when faced with differing observations, are based on a "principle of distinction" which itself has no justification. To illustrate this, he noted the dependence of the color of objects on human perception, and the apparent philosophical paradox this posed. He wrote, "Observations of the external world assure us (if they assure us of anything) that bodies exist which are coloured." But he pointed out that other observations also "show us that bodies are not coloured, but that the appearance of colour is produced by motions or other changes in the uncoloured particles composing the object perceived and the organism of the percipient." He concluded, "From this it follows that some of the immediate knowledge given in observation must be untrustworthy."[28] He further explained that there is no empirical or scientific (rational) basis for deciding which observations are trustworthy or not. He suggested that the discriminating principle rests on mere hypothesis or other belief independent of the observations. To underline this point, he contrasted how the senses can be judged to be "normal," for example when sighting the moon and concluding that the moon caused the sensation; or "deceived by an illusion," for example when seeing a ghost but judging it as an "optical illusion," because

Excoriation and Accommodation in the Intellectual Formation of Arthur James Balfour," Ph.D. thesis: University of Cambridge, 1995.

[28] Balfour, *A Defence of Philosophic Doubt*, pp. 252-253.

by hypothesis the ghost could not have caused the sensation.[29] Arthur, who was an active host of seance sittings and aware of Rayleigh's extensive work on color during the 1870s, chose examples familiar to him.[30]

As did Leslie Stephens and Walter Browne, Frank Balfour, while admiring other aspects to the book, criticized this argument. Generally, the reactions missed the subtlety of Arthur's point which explicitly does not refute color theory but rather exposes the philosophically irrational premises upon which it rests.[31] Frank wrote,

> I have read thro' your work with great interest....I shd. be inclined to make some criticism of Chap. XII. subject to your term "not trustworthy" as applied to our colour sensations. The colour terms we use are merely ways of expressing certain facts about the physical constitution of a body in terms of our own sensations, & I do not believe that where we speak of resistance in a body, we do anything else.... Ghosts are objects, the appearance of which I should speak of as untrustworthy but I do not think you can apply 'untrustworthy' in the same very analogous sense to colour sensations.[32]

It is not recorded whether Rayleigh also read the book, but it was certainly a subject of conversation between him and Lady Rayleigh. As I noted in Chapter 5, she wrote from Schwalbach in the summer after its publication, "I have begun Arthur's book & get on well with it especially when I come to such well known points as the share of

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[29] Balfour, *A Defence of Philosophic Doubt*, pp. 254-255.

[30] See Chapter 4. At any rate, Balfour afterwards participated in Rayleigh's experiments that showed a hereditary peculiarity in color vision (Chapter 6), which in turn would have further encouraged this line of argument reappearing in future statements of his philosophy; see below, this chapter.

[31] Stephen, "Philosophic Doubt," p. 166; W.R. Browne to A.J. Balfour, London, 19 November 1880, Add. Mss. 49838/81-82, BP, BL.

[32] F.M. Balfour to A.J. Balfour, San Martine de Certozza, n.d. [1879], GD433/2/504/6, BP, NAS.

the fixed stars in causation – on the resemblance of the universe to a ballot box."[33] Rayleigh watched for reviews in the press, which he sent to Evelyn. In another letter she reported having "read about half his book," and commented on the reviews: "It is satisfactory that the Pall Mall thinks Arthur's book is important enough to give it two notices – but we are not much impressed by the first. Mind you send the second when it comes."[34]

Rayleigh did not engage directly in the philosophical debates, but his views on the issues were well known. Unlike Sidgwick, who reacted against his evangelical upbringing with skepticism and, ultimately, a form of agnosticism, Rayleigh (like Balfour) retained elements of his household's evangelicalism – though with less fervor than the older generations of his family.[35] Religiously, he was an Anglican conservative (in the High Church tradition), and he felt (as he once expressed) that "true science and true religion

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[33] E. Rayleigh to J.W.S. Rayleigh, Schwalbach, 12 July [1879], Terling. The "ballot box" analogy appears as a reply to William Stanley Jevons's *The Principles of Science* (1874); Balfour, *A Defence of Philosophic Doubt*, pp. 35-42. It also attracted notice by Stephen, "Philosophic Doubt," p. 167.

[34] E. Rayleigh to J.W.S. Rayleigh, Schwalbach, 20 July 1879, Terling. [Anonymous], "*A Defence of Philosophic Doubt*," *Pall Mall Gazette* 219 (1879); [Second Notice] 220 (1879): 11-12.

[35] On Sidgwick's religious views, Sheldon Rothblatt, *The Revolution of the Dons: Cambridge and Society in Victorian England* (Cambridge: Cambridge University Press, 1968), pp. 133-141; 217-219; Frank Miller Turner, *Between Science and Religion: The Reaction to Scientific Naturalism in Late Victorian England* (New Haven: Yale University Press, 1974), pp. 38-67; Richard Noakes, "Cranks and Visionaries: Science, Spiritualism, and Transgression in Victorian Britain," Ph.D. thesis: University of Cambridge, 1998, pp. 255-274; Bart Schultz, *Henry Sidgwick: Eye of the Universe: An Intellectual Biography* (Cambridge: Cambridge University Press, 2004): 43, 82, 247-248.

neither are nor could be opposed."[36] He avoided overstating claims to scientific certainty, both within his scientific publications as well as in conversation. His son recalled Rayleigh telling him "as a very young man" (probably in the early 1880s): "When I was your age I expected to attain much greater certainty than I now think can be attained. I do not think the most religious among scientific men, say Faraday or Maxwell, would pretend to certainty."[37] Given the period in which Rayleigh purportedly expressed this view, it is likely that *A Defence of Philosophic Doubt* – or at least his conversations with the author and Lady Rayleigh – had an influence in lessening his faith in scientific certainty. Like Balfour, Rayleigh's beliefs ultimately allowed for divine intervention and a rejection of the uniformity of nature. He was known to profess, among his sayings, "I can believe that spirit made matter but not that matter made spirit," and "It is very difficult, when in a laboratory to believe in the Uniformity of Nature."[38]

His abhorrence of "materialism" and yet faith in the complementarity of science and religion encouraged his participation in various proceedings of the Society for Psychical Research. Like his Trinity friends Walter Browne and James Stuart, he became an early scientific member, but apparently only after Sidgwick secured the membership of other men of science; Sidgwick reported to Balfour in February, 1882: "John won't join

[36] Quoted in Strutt, *Life*, pp. 359-360.

[37] Strutt, *Life*, p. 360. See Peter J. Bowler, *Reconciling Science and Religion: The Debate in Early-Twentieth Century Britain* (Chicago: University of Chicago Press, 2001), Chapter 1: "The Religion of Scientists," pp. 27-58, and Bernard Lightman, "Victorian Sciences and Religion: Discordant Harmonies," *Osiris* 16 (2001): 343-366.

[38] E. Rayleigh, "Notes," p. 59, Terling; compare Strutt, *Life*, p. 431.

except under the condition that at least two eminent scientists join along with him, (besides Balfour Stewart, who has accepted)."[39] Rayleigh's occasional involvement in the Balfour circle's seances usually entailed overseeing experimental conditions meant to provide a scientific basis for investigations of spiritual phenomena. Nora Sidgwick reported to Gerald Balfour that Rayleigh's activities at sittings included attempting in vain to photograph a spirit, "Pocky," and planning "some mechanical arrangement to test table turning."[40] His interest in psychical studies attracted sufficient popular notice to illicit a press commentary:

> Lord Rayleigh not only knows everything about the material constitution of the visible world, but a great deal about the spiritual constitution of the invisible world. One of the first physicists of the day, he is also one of the most ardent believers in the Spiritualism of the day. It seems very, very improbable, yet it is quiet possible, that a Cambridge Don, having taught this class the properties of fluids, will invite is [sic] members to come and converse with their departed grandmothers, so that a knowledge of science may not turn them into Materialists.[41]

According to Frank Turner, the psychical researches of the Balfours, Sidgwick,

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[39] H. Sidgwick to A.J. Balfour, Cambridge, 10 Feb. 1882, Add. Mss. 49832/31-32, BP, BL.

[40] E.M. Balfour to G.W. Balfour, London, 15 January 1876, GD433/2/449/2/5-6, BP, NAS. On "spirit photography," Jennifer Tucker, "Photography as Witness, Detective, and Imposter: Visual Representation in Victorian Science," in *Victorian Science in Context*, ed. Bernard Lightman (Chicago: University of Chicago Press, 1997), pp. 378-408.

[41] Anonymous news clipping marked "W.M.N.," dated 19 December 1879, Terling. On the Cambridge physicists' reaction to scientific naturalism, Brian Wynne, "Natural Knowledge and Social Context: Cambridge Physicists and the Luminiferous Ether," in *Science in Context: Readings in the Sociology of Science*, ed. Barry Barnes and David Edge (Milton Keynes: Open University, 1982), pp. 212-231; Crosbie Smith, *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain* (Chicago: University of Chicago Press, 1998).

and their friends, set the group "between the forces of contemporary science and religion" – where they followed an alternative course to the skepticism of both clergymen and scientific men who dismissed psychical phenomena as the work of the devil or simply fraudulent.[42] In Sidgwick's words, the Society for Psychical Research members "believed unreservedly in the methods of modern science" but "were not prepared to bow with equal docility to the mere prejudices of scientific men." They also believed "that there was an important body of evidence – tending *prima facie* to establish the independence of the soul or spirit."[43] Clearly the Society provided the Balfours, Rayleigh and Sidgwick a way to reconcile religious beliefs, like the existence of an afterlife, with their enthusiasm for science – without "tending toward materialism."

Rayleigh received his deputation as President of the BAAS Montreal meeting in a letter from Sir William Siemens, the President in 1883. Siemens wrote, "The meeting at Montreal will be one of great importance for the future welfare of the Association as it is the commencement of a wider sphere of action!"[44] In preparing his speech, Rayleigh received advice from Balfour and Sidgwick. Of Balfour's input, he wrote, "Arthur [Balfour]'s notes have reached me and I have made what use I can of them, but most of his criticism go too deep."[45] Sidgwick recorded in his journal that he "went to tea with

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[42] Turner, *Between Science and Religion*, p. 54.

[43] Henry Sidgwick, "Presidential Address, July 16, 1888," in *Presidential Addresses to the Society for Psychical Research* (Glasgow: The Society for Psychical Research, 1912), p. 35; Turner, *Between Science and Religion*, p. 55.

[44] W. Siemens to J.W.S. Rayleigh, 2 May 1883, quoted in Strutt, *Life*, p. 139.

[45] Quoted in Strutt, *Life*, p. 139.

Rayleigh at the laboratory" to wish him farewell just prior to his voyage to Canada. Sidgwick wrote, "We talked over his presidential address.... I, who belong to the prescientific era, can understand more than half of it, and what I understand is all interesting and worthy of attention."[46] No doubt Rayleigh's brother-in-laws approved the theistic tenor of his views on the "foundations of belief."

The Rayleigh and Balfour network were thus occupied during these years of the 1880s developing a Christian-aristocratic view of scientific authority, in direct opposition to the agnostic view popularized by professionals like Huxley. Rayleigh's highly publicized overseas trip enabled him to exert the influence of "lord and professor," which he accomplished through his speech, his personal visits to the laboratories of eminent American physicists, and the press accounts noting the presence of "people of high rank in their own country" and representing "names pre-eminent in the fields of science."[47] Having carried out this crowning professional duty, he clearly felt he achieved the scientific community's expectations for him as Cavendish professor and, upon his return, resigned his position. After finishing out the 1884 Michaelmas term, he and his family returned to Terling where he resumed his preferred routine of country-house laboratory studies.

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[46] H. Sidgwick, [journal entry for 6 August 1884], quoted in A. S[idgwick] and E.M. S[idgwick], *Henry Sidgwick: A Memoir* (London: Macmillan, 1906), p. 383.

[47] [Anon.], "Lord and Professor," *Punch, or the London Charivari* 76 (1879): 273; [Anon.], "Distinguished People in Town," *The Brunswick Daily News*, 16 October 1884, appearing as a clipping in Clara Lady Rayleigh, *The British Association's Visit to Montreal, 1884* (London: privately printed, 1885), Terling. Clara (Rayleigh's mother), recorded in this journal an amusing eyewitness account of Rayleigh's tour.

Balfour and Salisbury in the 1890s: "The New Appeal to the Argument from Design"

Balfour's close relationship with Salisbury, as noted in Chapter 6, provided an important source of counsel to his political career. But, in addition to sharing conservative party views, nephew and uncle shared sympathies in the religion and science conflict. Biographer Max Egremont distinguished Salisbury's approach to the debate: "For him, as for Balfour, science and religion were not incompatible; they were different, and one should be able to exist alongside the other. Yet Salisbury would never have attempted to prove this from a philosophical standpoint."[48] Nevertheless, Lady Gwendolyn Cecil (Salisbury's daughter) recalled the philosophical tenor of his positions in debates on religion at home:

> The dogmatism of negative critics, the questions which they begged, the contradictions which appeared in their metaphysic, would be trenchantly dealt with; or disrespectful fun would be made of the systems of rationalist morality or worship of humanity by which it was proposed to replace Christianity as a social force. He showed complete confidence in the effective strength of his case.[49]

His views infused his household with "a certain note of rational disdain towards unbelief."[50] At times "the family conclave would be reinforced by Mr. Balfour," whose "lightning quickness of apprehension would rouse Lord Salisbury to a fuller exertion of

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[48] Max Egremont, *Balfour: A Life of Arthur James Balfour* [1980] (London: Phoenix Giant,1998), pp. 50-51.

[49] Lady Gwendolyn Cecil, *Life of Robert, Marquis of Salisbury*, 4 vols. (London: Hodder and Stoughton, 1921-1932), III: 21.

[50] Cecil, *Life*, III: 21.

his faculties."[51]

Despite the correctness of Egremont's judgment that Salisbury never matched Balfour's taste for explicating philosophical proofs, we should not underestimate Salisbury's popular appeal on the question of the "foundations of belief." As early as 1861 (then as Lord Cranborne), he publicly criticized the evolutionary link made between humans and gorillas, writing for the *Saturday Review*, "There are difficulties in the way of disbelieving that a real link exists, or has existed – far greater difficulties, perhaps, in believing it."[52] In a series of subsequent essays he criticized Darwinists and urged Anglican clergymen to learn about science to more effectively challenge their antagonists.[53]

The culmination of Salisbury's public stance came in 1894 when the British Association council elected him President of its annual meeting at the University of Oxford, where he long occupied the Chancellor's office. He took the opportunity in his speech, which Rayleigh read and corrected in draft form, to expound on his views on "some of the stupendous problems of natural study which still defy our investigation."[54]

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[51] Cecil, *Life*, III: 23-24.

[52] [Lord Cranborne], "Adventures in Equatorial Africa," *Saturday Review* 11 (1861): 506-508, on 506; Andrew Roberts, *Salisbury: Victorian Titan* [1999] (London: Phoenix, 2000), p. 594.

[53] Roberts, *Salisbury*, p. 594. Prior to his succession to his father's estate, and owing to his father's disapproval of his marriage, he depended in part on his pen for income. He wrote many articles for the *Saturday Review* between 1857 and 1865, and beginning in 1860, some thirty-three articles for the *Quarterly Review*; *DNB*.

[54] The Marquis of Salisbury, [Presidential Address], *BAAS Reports* 64 (1894): 3-15, on p. 5. J.W.S. Rayleigh to Salisbury, Terling, 16 June 1894, Hatfield; Strutt, *Life*, pp.

He focused his commentary on research in matter, the ether, and life – particularly Darwin's theory of natural selection. He praised Darwin's achievement: "Nothing can detract from the lustre shed upon it by the wealth of his knowledge and the infinite ingenuity of his resource."[55] Yet Salisbury maintained his characteristic denial of the theory, citing as irreconcilable difficulties Lord Kelvin's age of the earth calculation and Friedrich Leopold August Weismann's "gravest objection" that the process of natural selection cannot be directly observed, and therefore remains a hypothetical principle.[56] Turning to a suggestion in Weismann's writings, Salisbury observed, "It is inconceivable that there could yet be another principle [other than natural selection] capable of explaining the adaptation of organisms without assuming the help of a principle of design."[57] He concluded, "I quite accept the Professor's dictum."[58] Salisbury supported this anti-Darwinian view by quoting a former BAAS presidential address made by his family network's ally, Kelvin:

> Overpoweringly strong proofs of intelligent and benevolent design lie around us, and if ever perplexities, whether metaphysical or scientific, turn us away from them for a time, they come back upon us with irresistible force, showing us

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226-227.

[55] Salisbury, "Presidential Address," p. 11.

[56] William Thomson, "On Geological Time," [1868] *Transactions of the Geological Society* (Glasgow), 3 (1871): 1-28; August Weismann, *The Germ-Plasm: A Theory of Heredity* (London: W. Scott, 1893). On aspects to the age-of-the-earth debate, Cherry Lewis and Simon J. Knell (eds.), *The Age of the Earth: from 4004 BC to AD 2002* (London: Geological Society, 2001).

[57] Salisbury, "Presidential Address," p. 15.

[58] Salisbury, "Presidential Address," p. 15.

> through nature the influence of a free will, and teaching us that all living things depend on one everlasting Creator and Ruler.[59]

Salisbury thus weighed in on the side of Divine intervention and the doctrine of design.

The force of Salisbury's perspective may have fallen on deaf ears had he not the distinction of being former Tory Prime Minister (with leadership imminent again in 1895), at a time when a growing tide of popular writings eschewing scientific naturalism attempted to reconcile science and religion at the end of the century. The developing wave included books by the Anglican Darwin sympathist Frederick Temple (later Archbishop of Cantebury) and the millenarian Scottish Free-Churchman Henry Drummond.[60] Evidently noting readers' appetite for such works, Edward Lacy Garbett, a Christian apologist, reissued a "modernized"edition of the second Earl of Rosse's *Argument to Prove the Truth of the Christian Revelation* in 1892.[61] Arthur Balfour's

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[59] Salisbury, "Presidential Address," p. 15, from William Thomson, [President's Address], *BAAS Reports* 41 (1872): lxxiv-cv. On Kelvin's views, J. Burchfield, *Lord Kelvin and the Age of the Earth* (New York: Science History Publications, 1975); David . Wilson, "Kelvin's Scientific Realism: The Theological Context," *The Philosophical Journal* 11 (1974): 41-60; Crosbie Smith and M. Norton Wise, *Energy and Empire: A Biographical Study of Lord Kelvin* (Cambridge: Cambridge University Press, 1989).

[60] Frederick Temple, *The Relations between Science and Religion* (London: Macmillan, 1884); Henry Drummond, *Natural Law in the Spiritual World* (London: Hodder and Stoughton, 1884); John Durant, "Darwinism and Divinity: A Century of Debate," in *Darwinism and Divinity: Essays on Evolution and Religious Belief*, ed. John Durant (Oxford: Basil Blackwell, 1985), pp. 9-39; David N. Livingstone, "Situating Evangelical Responses to Evolution," in *Evangelicals and Science in Historical Perspective*, ed. David N. Livingstone, D.G. Hart, and Mark A. Noll (Oxford: Oxford University Press, 1999), pp. 193-219.

[61] The Late Earl of Rosse, *Argument to Prove the Truth of the Christian Revelation*, ed. E.L. Garbett (London: William Reeves, 1892). For an analysis of Rosse's position, N.D. Atkinson, "Sir Laurence Parsons, 2nd Earl of Rosse, 1758-1841," Ph.D. thesis: University of Dublin, 1961.

second book, *The Foundations of Belief*, published in late 1894 (but bearing the publication date of 1895), appeared at the crest of this tide. The debates in which he engaged – most notably with the aged Thomas Huxley – in Peter Bowler's analysis "made it plain that scientific naturalism was on the wane."[62] Indeed, Huxley's entre into what Lightman has called his "final battle" actually began with his reaction upon hearing Salisbury's Oxford address.

Lady Rayleigh, present among a very full audience, recorded in her diary Huxley's evident discomfort during the standing ovation Salisbury received: "Huxley, who seconded the vote of thanks, found it very hard not to become controversial over the Darwinian theory."[63] Huxley later retold the scene to Louisa Tyndall (John Tyndall's wife), calling it a "massacre": "Lord Salisbury was clever as usual; but knowing nothing about the topic, in reality, he makes an awful hash of this attempt to deal with Darwin's views."[64] Huxley and his wife joined the Rayleighs at breakfast the following morning. Robin Strutt (Rayleigh's son), "had a keen argument with him defending his Uncle's position with regard to Darwinism."[65]

Huxley's restraint at the meeting evaporated when an opportunity arose to reply in print. Within a couple of months, while attending a dinner at the Savoy to commemorate

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[62] Balfour, *The Foundations of Belief*; Bowler, *Reconciling Science and Religion*, pp. 11-12.

[63] E. Rayleigh, "Diary of Evelyn Lady Rayleigh, 1888-1905," p. 91, Terling.

[64] T.H. Huxley to [L. Tyndall?], 20 August 1894, 9.269, HP, ICA; Desmond, *Huxley*, p. 605.

[65] E. Rayleigh, "Diary," p. 92, Terling.

the twenty-fifth anniversary of *Nature*, he agreed to write a retrospective on evolution. He saw it as his "anti Salisbury manifesto," an opportunity to counter the Oxford debacle.[66] Interestingly, Huxley's rhetorical strategy in this response highlighted Salisbury's positive statement of Darwin's accomplishment without drawing attention to the criticism. But he addressed the issue of the timing of evolution: "[I]t has become clear to me that the question whether the forms of life on the globe have come about by evolution, or in some other way, is an historical problem, and must be treated as such." He repeated his stance made as early as 1878, that based on evidence from paleontology, "the evolution of many existing forms of animal life from their predecessors is no longer an hypothesis but an historical fact." Recognizing the open question as to the cause of evolution, he confidently urged, "I doubt as little, now as heretofore, that the probabilities are greatly in favour of our finding a way to the causes of evolution by pertinacious study of variation and natural selection."[67]

Salisbury's address similarly incensed the Darwinian entomologist, Edward Bagnall Poulton, who delivered a rebuttal in his presidential address to the Zoological Section of the BAAS in Liverpool in 1896. In 1895 Huxley died, and Poulton saw his speech as a way of carrying on Huxley's attack: "Professor Huxley, in seconding the vote of thanks to the President, said he could imagine that certain parts of the address might

[66] T.H. Huxley, "Past and Present," *Nature*, 51 (1894-1895): 1-3; Desmond, *Huxley*, p. 606; A.J. Meadows, *Science and Controversy: A Biography of Sir Norman Lockyer* (Cambridge, MA: MIT Press, 1972), p. 217.

[67] Huxley, "Past and Present," pp. 2-3.

raise a very good discussion in one of the Sections."[68] Poulton criticized, "It was clear that the theory of Natural Selection as held by Darwin was misconceived by the speaker, and the criticism was ill-aimed."[69] Poulton noted the work by William Bateson and Hugo De Vries that supported natural selection when applied to "large and conspicuous variations," over which Darwin himself had puzzled.[70] But Poulton devoted the balance of his address to the age-of-the-earth difficulty, as he recognized the importance of defending the professional turf of naturalists from the onslaught of geologists:

> For the duration of the three great [geological] periods we must look to the geologist; but the question as to whether the whole of organic evolution is comprised within these limits, or, if not, what proportion of it is so contained, is a question for the naturalist. The naturalist alone can tell the geologist whether his estimate is sufficient, or whether it must be multiplied by a small or by some unknown but certainly high figure, in order to account for the evolution of the earliest forms of life known in the rocks.[71]

In addressing the substance of Salisbury's two criticisms, Poulton's concern rested with the scientific matters alone. But his restraint from dealing with the question of divine intervention or design softened the overall sharpness of his rebuttal.[72]

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[68] Edward Bagnall Poulton, "A Naturalist's Contribution to the Discussion upon the Age of the Earth," in *Essays on Evolution, 1889-1907* (Oxford: Clarendon Press, 1908), p. 2.

[69] Poulton, "A Naturalist's Contribution," p. 3.

[70] Poulton, "A Naturalist's Contribution," p. 4; on Bateson and De Vries, Robert Olby, *Origins of Mendelism*, 2nd edition (Chicago: University of Chicago Press, 1985).

[71] Poulton, "A Naturalist's Contribution," p. 5.

[72] On the age of the earth question in this controversy, Brian C. Shipley, "'Had Lord Kelvin a Right? John Perry, Natural Selection, and the Age of the Earth, 1894-1895," in Lewis and Knell, *The Age of the Earth*, pp. 91-105.

Less restraint accompanied Huxley's assault on Balfour's book, which achieved a publishing sensation and thus a much wider influence than Salisbury's speech. As Lightman and Desmond have argued, "Balfour's Attack on Agnosticism" (to quote the title of Huxley's critique), roused Huxley back to his writing desk for a final defense of agnosticism against this "cleverest exhibition of philosophical ineptitude."[73] Huxley was not alone, as many others critiqued the book in reviews appearing in virtually all of Britain's popular serials. The Bristol evolutionary psychologist C. Lloyd Morgan found it to be "one of the most remarkable books of modern times."[74]

In his *Foundations of Belief* – which characteristically benefitted from his family circle's advice – Balfour launched his second major, destructive criticism of the agnostic creed, this time identifying as his target the proponents of "naturalism," which he meant to include agnostics and positivists.[75] His essay achieved a force that his earlier *Defence of Philosophic Doubt* lacked, in part because his renewed attack expounded in clearer detail a constructive philosophy. But Balfour's eminence as leader of the Conservative

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[73] Desmond, *Huxley*, pp. 608-609. The definitive account of the debate is Bernard Lightman, "'Fighting Even with Death': Balfour, Scientific Naturalism, and Thomas Henry Huxley's Final Battle," in *Thomas Henry Huxley's Place in Science and Letters: Centenary Essays*, ed. Alan P. Barr (Athens, GA: University of Georgia Press, 1997), pp. 323-350; also "Darwin, Huxley & Balfour and The Victorian Crisis of Faith," in John C. Greene, *Debating Darwin: Adventures of a Scholar* (Claremont, CA: Regina Books, 1999), pp. 47-70. Balfour's *Foundations* achieved sales of over 10,000 copies within the first year; Lightman, "Fighting," p. 333.

[74] C. Lloyd Morgan, "Naturalism," *Monist* 6 (1895-1896): 76-90. On Morgan, Bowler, *Reconciling Science and Religion*, pp. 47-48, 140-141.

[75] Balfour, *Foundations*, Preface. Lady Frances Balfour served as Balfour's amanuensis and typist – see, for example, Add. Mss. 49913 and 49921, BP, BL.

party (then in opposition) also helped. In the book he maintained his earlier argument about the fallibility of the senses as a basis for belief, offering a strong argument for the role of authority as the foundation both for theological faith and scientific premises – an aspect to his argument that incensed critics who saw it as Conservative propaganda. He emphasized that his view restored coherence to the human experience of aesthetics, scientific knowledge, and theological faith as opposed to the fracturing of these expressions of belief by naturalism. His essay essentially reconciled science and religion within a Christian world view, with a notable appeal for the role of tradition or authority in directing human belief as opposed to reason and senses.[76]

Historians disagree over the successfulness of Huxley's rebuttal, which in fairness to Huxley never appeared in full owing to the intervention of his own death.[77] In Huxleyan style, he critiqued Balfour's slippery agglomeration of labels under the term "naturalism" as applied to the agnostics, and he reasserted old arguments for a defense of his agnosticism. But he failed to respond to Balfour's most effective maneuver, disengaging science from the naturalism creed. At best Huxley only questioned Balfour's authority to speak in the name of science or of theology.[78] But Joseph Hooker assured the bed-ridden Huxley after reading the first installment of his critique, "You have probed his

[76] An excellent summary of Balfour's argument is given in Lightman, "Fighting," pp. 328-332.

[77] Compare Lightman, "Fighting," and Green, "Darwin, Balfour & Huxley."

[78] Lightman, "Fighting," pp. 340-345.

weak places with effect."[79] Despite being prodded by editors, Balfour found no need to reply to any of his critics, least of all a dying Huxley.[80]

Explicitly taking on both Salisbury and Balfour in a single breath, another outspoken voice of the biological community, the biometrician Karl Pearson, dealt squarely with Balfour's theistic claims to "foundations of belief." A socialist and agnostic, the contemporaneous emergence of Salisbury's address, Balfour's publications, and the reclamation of Conservative leadership did not escape his notice. Pearson, justifiably so, interpreted both Salisbury's and Balfour's commentaries as instances of Tory, High-Church propaganda: "Mr. Balfour's demonstration that naturalism affords no basis for ethics, and Lord Salisbury's attack on science – his new appeal to the argument from design – will go far, in the absence of any prominent theologically-minded Liberal politician, to bring the new bigotry into line with the Tory party." Pearson also offered a lengthy criticism singularly devoted to Balfour's text.[81] A like-minded critic dubbed Balfour's philosophy "The Tory Religion."[82]

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[79] J. Hooker to T.H. Huxley, 27 March 1895, 3.425, HP, ICA; Desmond, *Huxley*, p. 609.

[80] Lightman, "Fighting," p. 347.

[81] Karl Pearson, "Politics and Science," in *Chances of Death and Other Studies in Evolution*, 2 vols. (London: Edward Arnold, 1897), I: 148-149; Pearson, "Reaction! A Criticism of Mr. Balfour's Attack on Rationalism," in *The Chances of Death*, I: 173-225. On the politics of the Balfour-Pearson debate, L.S. Jacyna, "Science and Social Order in the Thought of A.J. Balfour," *Isis* 71 (1980): 11-34." On Pearson as a middle-class apologist, Donald A. MacKenzie, "Karl Pearson and the Professional Middle Class," *Annals of Science* 36 (1979): 125-143.

[82] John M. Robertson, "The Tory Religion;" *The Free Review* (February 1895): 458-470. For the wider reception of *Foundations of Belief*, [Anonymous], "Some Replies

The book's strong religious message – which, in view of Balfour's political office, was inseparable from his politics – garnered both praise and vehement opposition. Recalling Balfour's Cambridge days, his friend, Reginald Baliol Brett, second Viscount Esher, wrote: "Arthur's opinions have not varied. He was then a 'Christian' of a queer undefined sort, and in that faith he has abided. He has done more – for he has justified philosophically his faith – an operation not common as you know."[83] Lady Rayleigh, who witnessed the sensation produced by her husband's discovery of argon, wrote, "Society has been monstrous to us this year owing to 'Argon' and the 'Foundations of Belief.'"[84] Rather than respond to critics in the serials, Balfour chose instead to found a society – in some ways a reincarnation of the short-lived Metaphysical Society to which he, Sidgwick, and Huxley belonged in the late 1870s – "to discuss the Foundations of Belief with a view to construction." The membership was expressly restricted to those willing to

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to Mr. Balfour," *The Review of Reviews* 9 (1895): 238-239; [Anon.], "The Book of the Month: "The Foundations of Belief," by Mr. Arthur James Balfour, and other Founders," *The Review of Reviews* 9 (1895): 273-286; [Anon.], "Mr. Balfour's 'Foundations'," *The Review of Reviews* 9 (1895): 330-331; [Anon.], "More About Mr. Balfour's Book," *The Review of Reviews* 9 (1895): 427. The best modern analyses of its reception are John David Root, "The Philosophical and Religious Thought of Arthur James Balfour (1848-1930)," *Journal of British Studies* 19 (1980): 120-141; Jacyna, "Science and Social Order"; and Lightman, "Fighting."

[83] Reginald Baliol Brett (second Viscount Esher), *Journals and Letters of Reginald, Viscount Esher*, ed. Maurice V.B. Brett and Oliver S.B. Brett (third Viscount Esher), 4 vols. (London: I. Nicholson and Watson, 1934-1938), I: 183; Kenneth Young, *Arthur James Balfour: The Happy Life of the Politician, Prime Minister, Statesman and Philosopher, 1848-1930* (London: G. Bell and Sons, 1963), pp. 158-159.

[84] E. Rayleigh, "Diary of Evelyn Lady Rayleigh," ed. E.M. Sidgwick, unpublished typescript, 2 vols. I: 104, Terling. In the same year that *The Foundations of Belief* appeared, Lord Rayleigh and William Ramsay jointly announced their discovery of argon; Strutt, *Life*, pp. 187-225.

contribute to a "working philosophy of religious belief." The inaugural meeting was held on 25 March 1896, and Arthur Balfour, Gerald Balfour, Lord Rayleigh, and Frederic Myers counted among the founding members; Henry Sigwick, Alfred Lyttelton and Hugh Cecil (a cousin) were also afterwards elected. The Balfour brothers, Rayleigh, and Sidgwick served as chairmen.[85]

Conclusion

In 1904 the BAAS elected Balfour president of its meeting in Cambridge, marking a third decade in which the Association brought a conservative-aristocratic perspective to the public platform.[86] By then Balfour succeeded his recently-departed uncle as Tory Prime Minister, and his book had reached its eighth edition (with several more printings to come).[87] The address applied his theism to recent unified theories of matter emphasizing the electrical nature of atoms and the ether (quoting Joseph Larmor as one authority on this subject). He showed admiration for the theory, explaining, "All will, I think, admit that so bold an attempt to unify physical nature excites feelings of the most acute intellectual gratification."[88] He repeated his usual skepticism of the empirical basis

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[85] Arthur James Balfour (ed.), *Papers Read Before the Synthetic Society, 1896-1908* (London: Spottiswoode, 1909), pp. v-viii; Maisie Ward, *The Wilfrid Wards and the Transition*, 2 vols. (London: Sheed and Ward, 1934-1937), I: 354-379; 417-520; Alan Willard Brown, *The Metaphysical Society: Victorian Minds in Crisis, 1869-1880* (New York: Columbia University Press, 1947), pp. 252-260.

[86] A.J. Balfour, "Reflections Suggested by the New Theory of Matter," *BAAS Reports* 74 (1904), pp. 1-14.

[87] Arthur James Balfour, *The Foundations of Belief, Being Notes Introductory to the Study of Theology*, 8th rev. ed. (London: Longmans, Green and Co., 1901).

[88] Balfour, "Reflections," pp. 8-9.

of scientific reasoning, noting, "the blind forces of Natural Selection which so admirably simulate design when they are providing for a present need, possess no power of prevision," and "it is hard to see why evolution, which has lamentably failed to produce trustworthy instruments for obtaining the raw materials of experience, should be credited with a larger measure of success in its provision of the physiological conditions which condition reason."[89] Characteristically, he created an opening for other sources of belief: "Considerations like these, unless I have compressed them beyond the limits of intelligibility, do undoubtedly suggest a certain inevitable incoherence in any general scheme of thought which is built out of materials provided by natural science alone."[90] He concluded, "As Natural Science grows it leans more, not less, upon a teleological interpretation of the universe."[91]

Clearly, within the space of two decades, Rayleigh, Balfour, and their familial network established a strong position in the religion and science debates that marked their challenge to the professional authority asserted by "anti-religious controversialists." They appealed to the instincts of popular audiences that the "deeper mysteries of the universe" required tools other than faith in the naturalism creed. Buttressing their views was the ongoing and supportive counsel they provided each other when preparing their speeches, articles and book chapters. At the *fin de siecle*, excepting the lives claimed from Sidgwick and Argyll in 1900 and Salisbury in 1903, the Balfourian network gained supporters

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[89] Balfour, "Reflections," pp. 12-13.

[90] Balfour, "Reflections," p. 13.

[91] Balfour, "Reflections," p. 14.

through their promotion of elite societies, like the Society for Psychical Research and newly-constituted Synthetic Society. Closely allied with the reigning government – particularly with Balfour and Salisbury in the highest offices of the Conservative party – they represented a powerful coalition of aristocratic men and women deeply troubled by yet committed to the promotion of professional authority in the sciences. As Huxley and Pearson made clear by their reactions, Balfour's alliance proved to be a serious threat to the agnostic creed. The debates underlined opposing philosophies and contests for authority, but whether they represented a true class-based division is a question I shall address in the concluding chapters of this dissertation.

Chapter 8

A Country-House Model for Professional Genetics: The Arthur James Balfour Professorship

> I would...venture to say that probably there is more difference of opinion at this moment among many scientific men with regard to certain fundamental principles lying at the root of heredity than there was, for example, in the seventies or eighties of the last century after the great Darwin's doctrines were generally accepted – as indeed they are, in their outline, part of the universal heritage of the race – but before all the more minute scientific investigations had taken place with regard to the actual method by which inherited qualities are handed on from generation to generation.[1]

One of Frank Balfour's last proteges was William Bateson, whose father was a prosperous Liverpool merchant and Master of St. John's College, Cambridge. Matriculating at St. John's in 1879, the younger Bateson followed a course of study for the Natural Sciences Tripos examination and took a first in 1882. His success won him election to a college Scholarship, and in 1883 he took another first in Part II of the Natural Sciences Tripos, Zoology. He quickly rose to prominence in connection with his rediscovery of Mendel's Law. He held successive positions at Cambridge as fellow, Reader in Zoology, and Professor of Biology, but his professional growth was accompanied by the precariousness of the university's support of his research. Ultimately he left Cambridge to assume the directorship of the newly-founded John Innes Horticultural Institute at Merton, Surrey.[2]

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[1] Arthur James Balfour, *Arthur James Balfour as Philosopher and Thinker*, ed. Wilfred M. Short (London: Longmans, Green and Co., 1912), p. 215, from Balfour's speech at the International Congress on Eugenics, London, 24 July 1912.

[2] Beatrice Bateson, *William Bateson, F.R.S., Naturalist: His Essays & Addresses* (Cambridge: Cambridge University Press, 1928), pp. 10-11.

An important but understudied aspect to the Bateson story is the leading part played by Arthur Balfour in lobbying for additional institutional support of Bateson's position. Robert Olby has established Balfour's role in campaigning for a permanent chair of genetics on Bateson's behalf, hypothesizing that Balfour was the anonymous donor who funded the temporary chair of biology that Bateson held from 1908 to 1910. Moreover, in collaboration with Reginald Baliol Brett, second Viscount Esher (a lifelong friend), in 1912 Balfour founded a permanent Cambridge chair of genetics, anonymously funded by a certain "Mr. William Watson" and offered to Bateson.[3] Despite the success of Balfour's campaign, he failed to draw Bateson away from the John Innes Institute. These facts are known (though not widely acknowledged in the historiography); they appear prominently in the Cambridge Genetics Department's history.[4] But they remain unexplained. Why would Balfour, in particular, lead such a campaign to retain Bateson at Cambridge? How does Balfour's philanthropy and lobby, in this instance, illustrate the more general patterns of his country-house network's relationship to professional science?

To answer these questions, we must examine Balfour's growing interest in the new field of genetics and the myriad of factors underlying his support of Bateson's research program. My central thesis here is that Bateson's approach to the study of

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[3] Robert Olby, "Scientists and Bureaucrats in the Establishment of the John Innes Horticultural Institution under William Bateson," *Annals of Science* 46 (1989): 497-510, on 499.

[4] [Anon.], "Genetics, University of Cambridge: A Brief History of the Department," http://www.gen.cam.ac.uk/dept/dept_history.html, retrieved 22 February 2001.

variation and inheritance appealed to Balfour in its metaphysical orientation, utilitarian value, and distinctive methodological approach to the problem of evolution. As in the spirit of the other professional lobbies waged by Balfour's aristocratic network, Balfour recognized the scientific promise and competitive edge that Bateson's program represented for Cambridge. For Balfour, it showed characteristics of the right kind of science endorsed by his aristocratic circle and simultaneously represented a powerful antidote to scientific naturalism and the promise of practical good. Reflecting his loyalty to his late brother Frank, Arthur Balfour recognized in Bateson's work its debt to the Cambridge morphological tradition as opposed to the rivaling methods of Karl Pearson's biometric program. To begin, I will describe Bateson's gradual shift away from the morphological method and toward a systematic study of variations in individuals based on descriptive and statistical investigation. I will then examine the background to Arthur Balfour's interest in genetics and follow his campaign to found Britain's first professorship for genetics at Cambridge, meant for Bateson but ultimately held by his student, Reginal Crundall Punnett.

Bateson's Departure from Balfourian Morphology

In Bateson's undergraduate studies, the embryonic development of the little-studied *Balanoglossus* captivated his interest, and, in Balfourian fashion, he attempted to demonstrate evolutionary affinities between the worm-like species and the vertebrates. His other interests included languages and psychical studies. He later recollected "mathematics were my difficulty," but in addition to his skill as a naturalist, he was a good linguist.[5] In 1882 he joined the Society for Psychical Research as one of its founding members.

Because the *Balanoglossus* was abundant in the Chesapeake Bay, rather than follow the usual pattern for Cambridge graduates and study at the Stazione Zoologica in Naples, Bateson received permission to work with the Johns Hopkins embryologist William Keith Brooks at his laboratory in Hampton, Virginia. Brooks's approach to embryology was "rather more inclined to hypothetical ancestors than Balfour," and was thus "more in the spirit of his age."[6] A protagonist of natural selection, Brooks concerned himself less with how Darwin's theory explained animal development and morphology, and more with the problem of finding the unknown cause of variation. He thus influenced Bateson's progression from an interest in morphological problems to the pursuit of theoretical questions relating to variation.

The publication of Bateson's research won him a fellowship at St. John's College in 1885.[7] He presented evidence for his theory that vertebrates are descended from

[5] William Bateson, [Letter on compulsory Greek], *Nature* 71 (1905): 390, quoted in Bateson, *William Bateson*, p. 10.

[6] G. Evelyn Hutchinson and Stan Rachootin, "Historical Introduction," in William Bateson, *Problems of Genetics* [1913] (New Haven: Yale University Press, 1979), p. viii; Keith R. Benson, "American Morphology in the late 19th Century: The Biology Department at Johns Hopkins University," *Journal of the History of Biology* 18 (1985): 163-205.

[7] William Bateson, "The Early Stages in the Development of Balanoglossus," *Quarterly Journal of Microscopical Science* 24 (1884): 208-236; Bateson, "The Later Stages in the Development of Balanoglossus Kowalevskii, with a Suggestion as to the Affinities of the Enteropneusta," *Quarterly Journal of Microscopical Science* 25 (1885) (Suppl.): 81-122; 26 (1886): 511-533; and Bateson, "The Ancestry of the Chordata," *Quarterly Journal of Microscopical Science* 26 (1886): 535-571; collected in Bateson,

unsegmented forms by homologizing the notochord of embryos with the proboscis of *Balanoglossus*. This departed from Anton Dohrn's view that homologies must be due to inheritance from a common ancestor. Bateson posed a question foreshadowing his break from the morphological approach. Noting that characters followed a property of repetition in all living things, he wrote,

> The meaning of cases of complex repetition will not be found in the search for an ancestral form, which presenting this same character, may be twisted into a representation of its supposed descendant.... From whence was their repetition derived? The answer to this question can only come in a fuller understanding of the laws of growth and variation, which are as yet merely terms.[8]

Edwin Lankester, Jr., endorsed Bateson's views, which advocated for comparison of the characteristics of closely-related species as opposed to the homologies of embryonic forms. Lankester believed Bateson's speculations on the *Balanoglossus* "gives the most hopeful hypothetical solution of the pedigree of Vertebrates."[9]

Bateson's early *Balanoglossus* work fell within the paradigm of Cambridge's morphological school, which after Balfour's death was headed by Adam Sedgwick, who had been elected to a Readership in Animal Morphology in 1882.[10] But Bateson's next

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Scientific Papers of William Bateson, 2 vols., ed. R.C. Punnett (Cambridge: Cambridge University Press, 1928).

[8] Bateson, "The Ancestry of the Chordata," pp. 548-549.

[9] Edwin Lankester, Jr., "Vertebrata," *Encyclopaedia Britannica* 24 (1889): 178-188, on 187; Peter J. Bowler, *The Mendelian Revolution: The Emergence of Hereditarian Concepts in Modern Science and Society* (London: The Athlone Press, 1989), p. 287.

[10] On the structure of Cambridge morphology, Helen Blackman, "The Natural Sciences Tripos and the Structure of Animal Morphology in Late-Victorian Cambridge," *Journal of the History of Biology* (under review).

research topic involved a search for environmentally-induced variations among the fauna of the Steppe District of Russia, now Kazakhstan. Before departing, he applied for the Balfour Studentship, but he received news of his rejection while in the Steppe. He believed that the selection committee's decision reflected the discord growing between his new research interests and the Cambridge morphological tradition: "My work is of a kind with which the Cambridge people have little sympathy, and by next October, while the *kudos* got from *Balanoglossus* will be spent, any to be derived from my present occupation will still be in the future, and this is the kind of thing that the Committee, being humans, will be guided by."[11] Despite Bateson's perception of having been slighted, other reasons likely guided the committee's decision. William Hay Caldwell, who held the first studentship, received an extension in lieu of Bateson's election in October 1886.[12] His research on reproduction in the platypus was, at the time, of greater interest. Moreover, the managers of the Balfour Fund (chaired by Alfred Newton) privileged students in financial need.[13] Bateson, whose travels were funded by grants

[11] W. Bateson to [A. Bateson?], Kazalinsk, 22 November 1886, quoted in Bateson, *William Bateson*, p. 20. It should also be noted that Bateson characteristically showed sensitivity to slights of his work; I owe this point to Helen Blackman, pers. comm., 11 August 2004.

[12] Balfour Memorial Notebook, ZOO 10/1,2, University Archives, CUL.

[13] Helen Blackman, "A Spiritual Leader? Cambridge Zoology, Mountaineering and the Death of F.M. Balfour," *Studies in the History and Philosophy of Biological and Biomedical Sciences* 35 (2004): 93-117, on 102-103. Caldwell's researches on the platypus resulted in a discovery that confirmed their oviparous nature and required their reclassification with birds and reptiles; Roy MacLeod, "Embryology and Empire: the Balfour Students and the Quest for Intermediate Forms in the Laboratory of the Pacific," in *Darwin's Laboratory: Evolutionary Theory and Natural History in the Pacific*, ed. Roy MacLeod and Philip.F. Rehbock (Honolulu: University of Hawaii Press, 1994), pp.

from the Royal Society and the Worts Fund, seemed to recognize as much: "Looked at from an outsider's standpoint, I expect it is a good thing I haven't [gotten elected]. I have been much too successful pecuniarily and so on, lately, and I have really been getting more than I worked for, which is a bad thing."[14] After the expiration of Caldwell's extension in October 1887, the managers elected Bateson to the studentship on 8 November 1887. He held the position until October 1890.[15]

In the years following his Steppe studies, Bateson devoted himself to the collection of specimens (a venture lacking "since Darwin's time") for a comprehensive study and classification of variations. Ironically, while he began to doubt the efficacy of natural selection to account for variations, he found his inspiration in Darwin, "who was above all men a field-naturalist."[16] He denied Frank Balfour's reigning assumption, that "in the development of animals stages are passed through in which they resemble other forms: from this resemblance it is inferred that they are descended from those forms."[17] Moreover, it became increasingly clear in Bateson's variation studies that natural selection failed to account for "discontinuous" variations. As he later summarized, natural

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140-164, on 151; Brian K. Hall, "The Paradoxical Platypus," *BioScience* 49 (1999): 211-218.

[14] Letter by W. Bateson to [A. Bateson?], Kazalinsk, 22 November 1886, quoted in Bateson, *William Bateson*, p. 19; William Bateson, *Letters from the Steppe written in the Years 1886-1887*, ed. Beatrice Bateson (London: Methuen, 1928), p. v.

[15] Balfour Memorial Notebook, ZOO 10/1,2, University Archives, CUL.

[16] W. Bateson to the Electors of the Linacre Professorship, Cambridge, June 1890, quoted in Bateson, *William Bateson*, pp. 35-36.

[17] Quoted in Bateson, *William Bateson*, p. 32.

selection held that "specific diversity of form is consequent upon diversity of environment," but "diverse environments often shade into each other insensibly and form a continuous series, whereas Specific Forms of life which are subject to them on the whole form a Discontinuous Series."[18] By 1888 he wrote to his sister Anna (a Newnham student), "My brain boils with Evolution. It is becoming a perfect nightmare to me."[19]

Bateson's method departed from the narrowly-focused microscopical studies characteristic of Cambridge's Morphological Laboratory, and he turned whole-heartedly to carefully recording the characters of wild and domesticated animals – an approach typical of field natural history. According to Beatrice Bateson, "These researches brought him in contact with the 'practical man' in all his guises; his passionate interest communicated itself to breeder and collector, amateur and professional." Moreover, "He ransacked museums, libraries, and private collections; he attended every sort of 'Show,' mixing freely with gardeners, shepherds and drovers, learning all they had to teach him."[20] He thus showed a particular affinity toward amateur naturalists, and promoted their work alongside laboratory studies:

> Above all, I should strive to stimulate those whom I could influence to study animals *as they are*, in the field and on the sea, looked on as living things and not as diagrams and types. Nothing has been more unfortunate for Zoology than the

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[18] William Bateson, *Materials for the Study of Variation: Treated with Especial Regard to Discontinuity* (London: Macmillan, 1894), 5.

[19] W. Bateson to A. Bateson, 2 September 1888, quoted in Bateson, *William Bateson*, p. 38. On Anna Bateson and other Newnham College geneticists, Marsha L. Richmond, "Women in the Early History of Genetics: William Bateson and the Newnham College Mendelians, 1900-1910," *Isis* 92 (2001): 55-90.

[20] Bateson, *William Bateson*, pp. 27-28.

> separation between what is called its scientific side and the pursuit of Natural History; for this separation has gone far to destroy much that was beautiful in the study of life.[21]

During this period, the zoological community ill-received Bateson's ideas and his call for such a panoramic field-work enterprise as would be required for variation studies of the scope he proposed. Even Bateson admitted, "The only way in which we may hope to get at the truth is by the organisation of systematic experiments in breeding, a class of research that calls perhaps for more patience and more resources than any other form of biological inquiry."[22] But for Bateson any valid theory of evolution required the empirical support of facts that were obtainable only by such an endeavor. His break from traditional morphology was repeated by other Balfour students, including Walter Heape and Adam Sedgwick.[23]

Other important facets to Bateson's intellectual orientation – which, as I will further elaborate, bore a strong affinity with the Balfour family network's outlook –

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[21] W. Bateson to the Electors of the Linacre Professorship, Cambridge, June 1890, quoted in Bateson, *William Bateson*, p. 34; compare Bateson, *Materials*, pp. 574-575. On the specialization of biology alongside natural history in the late-nineteenth century, Lynn K. Nyhart, "Natural History and the 'New' Biology," in *Cultures of Natural History*, ed. N. Jardine, J.A. Secord, and E.C. Spary (Cambridge: Cambridge University Press, 1996); David E. Allen, "On Parallel Lines: Natural History and Biology from the Late Victorian Period," *Archives of Natural History* 25 (1998): 361-371; Robert E. Kohler, *Landscapes & Labscapes: Exploring the Lab-Field Border in Biology* (Chicago: University of Chicago Press, 2002).

[22] Bateson, *Materials*, 574.

[23] Helen Judith Blackman, "Women, savages and other animals: the comparative physiology of reproduction, 1850-1914," Ph.D. thesis, University of Manchester, 2001; MacLeod, "Embryology and Empire"; Gerald L. Geison, *Michael Foster and the Cambridge School of Physiology: The Scientific Enterprise in Late-Victorian Society* (Princeton: Princeton University Press, 1978), pp. 124-130.

included his support of the higher education of women at Cambridge, where his sisters and future wife were residents of Newnham College. He showed interest in that area "between science and religion" by becoming a member of the Society for Psychical Research. This and his doubts about the theory of natural selection showed a consistent attitude against scientific naturalism.[24] According to Beatrice Bateson, "He dreaded the pedantry and increasing narrowness of each branch of biological research." He possessed a religious side, though he showed no outward profession of faith as did the members of the Balfour network. His wife noted, "Every morning for many years he read to [the children] at breakfast, generally from the Old Testament." He once wrote, "Faith in great work is the nearest to religion that I have ever got, and it supplies what religious people get from superstition."[25] Bateson's social outlook was "the ideology of a class which regarded automatic provision of living and education for its members as one of their natural rights." Beatrice dubbed him "intellectually an aristocrat."[26]

As he prepared his first monograph, *Materials for the Study of Variation* (1894), for publication, Bateson sought financial support for his breeding experiments and a more permanent, lucrative academic position. His trials and tribulations in lobbying for

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[24] "[His] complex of ideas and intuitions set Bateson firmly against utilitarian rationalism and it near neighbor, materialism. In natural selection and chromosome theory he saw both at work, and would have none of them"; William Coleman, "Bateson, William," *DSB*, I: 506; Coleman, "Bateson and Chromosomes: Conservative Thought in Science," *Centaurus* 15 (1970): 228-314.

[25] Bateson, *William Bateson*, pp. 28, 69, 29.

[26] J.G. Crowther, *British Scientists of the Twentieth Century* (London: Routledge & K. Paul, 1952), p. 289; Bateson, *William Bateson*, p. 50; also Olby, "Scientists and Bureaucrats," p. 499.

Cambridge's support of his variation experiments are well-documented, as are his rediscovery of Mendel's laws in 1900 and naming of the new field "genetics" in 1906.[27] Curiously, until Marsha Richmond's recent work, scholars have generally overlooked the "familial network" that he independently garnered in order to continue his extensive breeding experiments in the absence of sufficient institutional support, a recurring theme among Cambridge biologists who improvised during the gradual institutional reform that eventually resulted in better endowments for biological research.[28] Richmond's important studies illuminate yet another case of late-nineteenth and early-twentieth-century home-based science, resonating with many of the themes of my dissertation. Balfour's lobby on Bateson's behalf demonstrates a strong instance of the Balfour network's more general pattern of professionalization.

The Appeal of Bateson's Science for Balfour

Bateson adopted an explicitly skeptical stance toward the theory of natural selection, a skepticism that Balfour also promoted on philosophical grounds. Rather than blindly following "those theoretical conclusions which the laboratories from time to time ask [naturalists] to accept," Bateson became (as he later recollected) "agnostic as to the

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[27] Olby, "Scientists and Bureaucrats"; Robert C. Olby, "William Bateson's Introduction of Mendelism in England," *British Journal for the History of Science* 20 (1987): 399-420;

[28] Marsha L. Richmond, "The 'Domestication' of Heredity: The Familial Organization of Geneticists at Cambridge University, 1895-1910," *Journal of the History of Biology* 37 (2004): 1-41.

actual mode and processes of evolution."[29] On the question of evolution, he consistently emphasized the contradictions between the evidence of variation and the principle of natural selection, always concluding that the limits of contemporary scientific knowledge on the cause of variations required further experimental study for advancement. At the same BAAS meeting opened by Arthur Balfour's presidential address, Bateson told the zoological section:

> To prove the reality of Selection as a factor in Evolution is, as I have said, a work of supererogation. With more profit may experiments be employed in defining the *limits* of what Selection can accomplish. For whenever we can advance no further by Selection, we strike that hard outline fixed by the natural properties of organisms. We come upon these limits in various unexpected places, and to the naturalist ignorant of breeding nothing can be more surprising or instructive.[30]

This "agnosticism" toward natural selection fit well within Balfour's own skepticism of evolution, promulgated both in his philosophical books and BAAS presidential address, as discussed in Chapter 7.

But, secondly, Balfour increasingly recognized the value of breeding experiments for utilitarian ends. For both personal and political reasons he saw the promise they held for the advancement of British arable and pastoral agriculture, which for decades suffered from low profits owing to the availability of cheaper imports.[31] While Balfour's own

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[29] Bateson, *Materials*, p. 575; Bateson, "Evolutionary Faith and Modern Doubts" (Address to American Association for the Advancement of Science, Toronto, 1922), *Science* 55 (1922); reprinted in Bateson, *William Bateson*, p. 397.

[30] William Bateson, "Presidential Address to the Zoological Section," *BAAS Reports* 74 (1904); reprinted in Bateson, *William Bateson*, pp. 240-241.

[31] For an overview, David Cannadine, *The Decline and Fall of the British Aristocracy* [1992], rpt. of rev. ed. (New York: Vintage, 1999), pp. 88-138.

estates, as noted in Chapter 6, were drawn into the economic hardships caused by the depression, the pastoral part of his holdings, which overall were relatively minor, offset the seriousness of the blow generally felt by the larger arable estates of the noble landowners.[32] Yet, as a political leader Balfour could not ignore one of the most dire questions of the nation, and his primary response lay in his political work, where he unsuccessfully strove to find a middle ground between British protectionism and free trade.[33] Moreover, as Sir E. John Russell discussed, while farmers called for protectionism, the government, trapped within the paradigm of *laissez faire*, "regarded technical education as the remedy for the current agricultural distress and sought means for providing it."[34] Many farmers responded by "intensifying their efforts and increasing their output," but soil fertility posed major limitations.[35] A few individual landowners recognized the importance of experimental research into various aspects of agriculture, including the nutritive value of different grasses (for feeding livestock), soil nutrients and

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[32] Kenneth Young, *Arthur James Balfour: The Happy Life of the Politician, Prime Minister, Statesman and Philosopher, 1848-1930* (London: G. Bell and Sons, 1963), p. 287; Cannadine, *The Decline and Fall*, p. 92. An early indicator of income shortfall appears in notes he made in 1880; Arthur J. Balfour, "Notes, etc.," Add Mc. 49962, BP, BL. Apparently, Balfour's failed investments in wet carbonizing and various mining, industrial, and railway interests proved more damaging to his finances; Paul Harris, *Life in a Scottish Country House: The Story of AJ Balfour and Whittingehame House* (Haddington: Whittingehame House Publishing, 1989), pp. 95-101.

[33] Young, *Arthur James Balfour*, pp. 209-222; Jason Tomes, *Balfour and Foreign Policy: The International Thought of a Conservative Statesman* (Cambridge: Cambridge University Press, 1997), pp. 90-97.

[34] Sir E. John Russell, *A History of Agricultural Science in Great Britain, 1620-1954* (London: George Allen & Unwin, 1966), p. 180.

[35] Russell, *A History of Agricultural Science*, p. 177.

fertilizers, and relative productivity whether breeding varieties of crops or livestock.[36] Balfour, as a landowner and member of the East Lothian Agricultural Society, was aware of the importance of such research, though he did not go so far as to make his estate available for the purpose as did other large landowners, like the Duke of Bedford.[37] Emphasizing its practical importance, Balfour promoted Bateson's work at Cambridge:

> [N]o more important group of scientific problems await solution than those connected with Heredity. These problems touch closely on every great question connected with life – scientific, philosophical, sociological, and political; on every practical art connected with the cultivation of crops or the raising of stock; – nay on every sport connected with the breeding of animals.[38]

The third important synergy between Balfour's interest and Bateson's program was its methodology. From the start, Bateson emphasized the importance of studying variations as they appeared in nature as well as in domestic breeding arrangements. Not unlike Darwin, his style of research privileged observation of individuals over statistical analysis, which was the method championed by Bateson's chief opponent, Karl Pearson.[39]

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[36] Russell, *A History of Agricultural Science*, pp. 180-197, 198-231, 232-267; Harold R. Fletcher, *The Story of the Royal Horticultural Society, 1804-1968* (Oxford: Oxford University Press, 1969), pp. 311-312.

[37] E. John Russell and J.A. Voelcher, *Fifty Years of Field Experiments at the Woburn Experimental Station* (London: George Allen and Unwin, 1936).

[38] Arthur James Balfour, "Endowment in the Study of Genetics in the University of Cambridge," Typescript dated June 1910, ESHR 19/2, CCA.

[39] Soraya de Chadarevian, "Laboratory Science versus Country-House Experiments: The Controversy between Julius Sachs and Charles Darwin," *British Journal for the History of Science* 29 (1996): 17-41; Donald MacKenzie and Barry Barnes, "Scientific Judgment: The Biometry-Mendelism Controversy," in *Natural Order: Historical Studies of Scientific Culture*, ed. Barry Barnes and Steven Shapin (Beverly Hills: Sage, 1979), pp. 191-210; Theodore M. Porter, *Karl Pearson: The Scientific Life in a Statistical Age* (Princeton: Princeton University Press, 2004).

The primary site for Bateson's experimental enterprise was his country cottage, Merton House, in Grantchester.[40] Here he practiced a country-house style of science familiar to Balfour. According to Beatrice Bateson,

> We had now ground; we had poultry-pens well stocked; we had row upon row of peas, poppies, lychnis; the garden was full of big and little experiments – some, tentative trials of subjects; some, serious undertakings. Our "gardener," Blogg, was a captial man and a delightful person.... Besides him we had our own hands. When lecturing and College work were done, the rest of the day was spent in hard manual labour; from the merest menial drudgery to high flights of scientific speculation, hand and brain were hard at work. There was all the sorting, sowing and gathering of seed to be done personally; the fertilising and recording; most of the digging, hoeing, weeding, staking and watering; the five incubators, each with 100 egg power, and as many rearers (all run with oil lamps); the tiny chicks; and at times hundreds of larvae to be attended to. All writing (not reckoning the ordinary post, which was often very heavy) was done at night.[41]

In addition to the mutual antipathy that Bateson and Balfour shared toward Pearson, they shared an affinity for the kind of amateur science that professionals like Pearson increasingly disparaged.[42] For Balfour, Bateson's genetics bore the hallmark of a science infused with the right combination of metaphysics, utilitarianism, and methodology.

Balfour and James Cossar Ewart

Balfour held an intrinsic interest in questions of variation and inheritance. As early as 1891, he followed the post-Darwinian debates to which August Weismann's work added fuel (see Chapter 7); Balfour noted in his inaugural address as Lord Rector of

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[40] Bateson, *William Bateson*, pp. 62-69; Richmond, "The 'Domestication' of Heredity."

[41] Bateson, *William Bateson*, p. 62; compare R.C. Punnett, "Early Days of Genetics," *Heredity* 4 (1) (1950): 1-10, esp. 5-7.

[42] Donald A. MacKenzie, "Karl Pearson and the Professional Middle Class," *Annals of Science* 36 (1979): 125-143.

the University of Glasgow,

> Weismann's conclusions are largely based on the extreme difficulty of conceiving any possible theory of heredity by which the transmission of acquired characteristics could be accounted for; on the relative simplicity and plausibility of his own theory of heredity, according to which the transmission would be impossible; and on the absence of any conclusive proof that the transmission has ever taken place.[43]

In the late 1890s, Balfour also counted among the supporters of James Cossar Ewart's breeding experiments at his farm in Penicuik, near Edinburgh. Ewart held the chair in natural history at the University of Edinburgh, which Frank Balfour had previously declined. By this time, Arthur Balfour was elected Chancellor of the university.[44] Paralleling Bateson's efforts at Cambridge, Ewart desired to experimentally establish evolutionary patterns and account for variations, and he similarly showed a neutral stance toward natural selection. He also demolished the theory of telegony. According to this popularly-held belief, a sire had the capacity to "infect" a mare during their mating in a manner that would leave vestiges of his characteristics on her subsequent offspring by other sires. To test this theory, on his farm Ewart crossed a purebred pony from the Isle of Rum, on loan from Lord Arthur Cecil (Balfour's uncle), with a Burchell's zebra stallion acquired from Africa. Ewart's experiments, summarized in a monograph published in 1899, showed negative results.[45] He extended his

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[43] Arthur J. Balfour, "A Fragment on Progress," in Balfour, *Essays and Addresses* (Edinburgh: David Douglas, 1893), pp. 241-314, on 248-249.

[44] See Chapter 6 above; Young, *Arthur James Balfour*, p. 415.

[45] J.C. Ewart, *The Penycuik Experiments* (London: Adam and Charles Black, 1899); J.H.A[shworth]. and F.H.A.M[arshall], "Obituary Notice: James Cossar Ewart, M.D., LL.D., F.R.S.," *Proceedings of the Royal Society of Edinburgh*, 54 (3) (1935): 200-

investigations to other domesticated and wild animals, including dogs and fowl. Although he received immediate accolades for this work, he had to rely on his personal finances and private donations to manage his enterprise.[46]

The private donors included Arthur and Alice Balfour, who visited the farm in the late-1890s.[47] In 1898, Alice sent a contribution, explaining her motivation:

> Would you think me very impertinent if, for the interest of the subject, & for the interest that my brother Frank would have taken in your work had he still been here to see it, I am to ask whether I might send a cheque for £25 to help, even tho' feebly, in the great expense of your experiments? Please forgive me if I am wrong in asking this. And if you allow me to help in the only way of which I am capable, however little it amounts to, may I ask you not to let my name appear?[48]

In the following year, Arthur, also requesting anonymity, sent a more generous £500, "having regard to the great expense of your scientific researches."[49] By 1903, both siblings attempted further lobbies in support of Ewart's work. Alice explored the idea of using Whittingehame property, but noted its disadvantages:

> I am afraid I do not at present know of any suitable place where you could take your beasts. Whittingehame is at the east end of East Lothian, & is an hour by rail from Edinburgh, which I suppose would be too far for you. Moreover, the land is

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203; Richard W. Burkhardt, Jr., "Closing the Door on Lord Morton's Mare: The Rise and Fall of Telegony," *Studies in the History of Biology* 3 (1979):1-21.

[46] He received, for example, the Neill Medal and Prize of the Royal Society of Edinburgh; J.H. Ashworth and F. Fraser Darling, *A Bibliography of the Works of James Cossar Ewart*, Supplement to *Animal Breeding Abstracts*, 1 (1934), "Biographical Note."

[47] J.C. Ewart, untitled visitor's book, Penicuik, EP, UEL. Among the visitors' names listed are Arthur and Alice Balfour, William Bateson, and the Duke of Bedford.

[48] A.B. Balfour to J.C. Ewart, Whittingehame, 30 May 1898, Gen. 137/3, EP, UEL.

[49] F.S. Parry to J.C. Ewart, London, 29 June 1899, Gen.137/4/114, EP, UEL.

> a bad grass land, & almost the whole of that end of the County is let out in large farms, which cannot be divided up.[50]

Also that year, Arthur, as Prime Minister, wrote a letter in support of Ewart's application to the Carnegie Trust for research funds, but the attempt proved unsuccessful.[51] Ultimately, by 1911, Edinburgh rewarded Ewart's professionally-acclaimed work by creating a Lectureship in Evolution and Heredity. In 1913, the university put at Ewart's disposal the farm, Fairslacks, for breeding experiments on sheep, in the interests of improving wool quality.[52]

The Arthur James Balfour Professorship

In his support of Ewart's work, Balfour had demonstrated his interest in studies of variation. He later recalled, "It had become clear to all thinking men that no more important group of scientific problems await solution than those connected with Heredity."[53] According to Esher, "It is a subject in which he has always taken a deep interest and to which he has given a great deal of thought and attention."[54] Within a few

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[50] A.B. Balfour to J.C. Ewart, London, 24 March 1903, Gen. 138/8, EP, UEL.

[51] A.B. Balfour to J.C. Ewart, London 6 July 1903, Gen. 138/8, EP, UEL; A.B. Balfour to J.C. Ewart, 23 July 1903, Gen. 138/8, EP, UEL; "Extract from Minutes of Senatus Academicus of Date 28th March 1903," in "The Carnegie Trust," Appendix F (1903), pp. 246-47, torn typescript, containing a Report of the Research Committee, Convener J.C. Ewart, Gen. 132/5/2, EP, UEL.

[52] Ronald M. Birse, *Science at the University of Edinburgh, 1583-1993* (Edinburgh: University of Edinburgh, 1994), pp. 79, 99.

[53] Arthur James Balfour, "Endowment in the Study of Genetics in the University of Cambridge," Typescript dated June 1910, ESHR 19/2, CCA.

[54] Esher, typescript, 22 November 1911, ESHR 19/2, CCA.

years Balfour initiated a similar lobby for Bateson. This began with his raising the funds for Bateson's temporary chair of biology and culminated in his mobilization of his aristocratic network to endow the creation of a more permanent chair. The creation of a temporary chair of biology in 1908 coincided precisely with the planning of Cambridge's commemoration of the centenary of Charles Darwin's birth, in which Rayleigh as Chancellor and Balfour as former Prime Minister played significant roles. The Darwinian buzz associated with the celebrations created a receptive climate for biology. As Bateson noted during the event, "From the Mendelian standpoint the gathering was rather tantalising."[55] Although the biology professorship was expressly devoted to genetics research, its non-endowed and temporary status left Bateson in a tenuous position. When he received the invitation to stand for the John Innes directorship and negotiated the parameters of the position to his approval, he resigned the Cambridge chair. According to Beatrice Bateson,

> [T]hat the University would be enabled to make the Professorship permanent could not be taken for granted; – his position had more of dignity than security. Our boys were growing into school-years. Therefore when the invitation came to assume the Directorship of the newly-founded John Innes Horticultural Institute at Merton, with its promise of unlimited facilities for experiment in plant-breeding, Will decided to resign the Chair of Biology which he has occupied a bare two years, and to accept the post offered to him by the John Innes Council.[56]

Despite Bateson's removal to Merton, Balfour held hope for attracting him back to Cambridge, or at the very worst, enabling the continuation of work along the lines he

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[55] W. Bateson to C.C. Hurst, 25 June 1909, Bateson Papers, CUL; see Marsha L. Richmond, "The 1909 Darwin Celebration: Re-examining Evolution in Light of Mendel, Mutation, and Meiosis" (under preparation).

[56] Bateson, *William Bateson*, pp. 121-122; Olby, "Scientists and Bureaucrats."

established. In a private circular, Balfour petitioned for the endowment of a permanent chair. He wrote (referring specifically to Bateson's rediscovery of Mendel's Law):

> It was at Cambridge (at least so far as this country is concerned), that this branch of investigations was initiated afresh at the beginning of the present century: it is at Cambridge that it has been most actively and successfully pursued. But unhappily the necessary funds are approaching exhaustion; and, unless help be forthcoming, it will have to be abandoned.
>
> This would, in my opinion, be lamentable from every point of view. It would be injurious to science; it would not be very creditable to the liberality of the public; it would be a grave misfortune to the University.
>
> Let it be remembered that the funds required to endow the Professorship and the Experimental Station are to be used in no doubtful or uncertain enterprise. The results already attained afford a sure prospect of future success; the workers are competent and willing; all that is required are sure endowments as may be necessary to enable them to continue what they have so admirably begun.
>
> The endowment necessary for a chair in the University is £20,000. The breeding station would require land, some garden ground, a small building and a fund to defray current expenses of working. For the establishment of a station £400-500 a year is needed.[57]

After a year of no remarkable developments toward this end, Balfour called a private meeting held at 4 Carlton Gardens (his London home) on 21 November, inviting "a few representative members of the University of Cambridge and others interested in this subject."[58] The attendees proposed the "Arthur Balfour Chair of Genetics" as a "testimonial to him as a man and Minister.[59] Esher, convinced that further support of genetics at Cambridge would produce "far reaching results to the nation and incalculable

[57] Arthur James Balfour, "Endowment in the Study of Genetics in the University of Cambridge," Typescript dated June 1910, ESHR 19/2, CCA.

[58] Esher, typescript, 22 November 1911, ESHR 19/2, CCA.

[59] Esher, typescript, 22 November 1911, ESHR 19/2, CCA.

benefits to science," sent Balfour's circular to Sir Francis Trippel, an army major in Esher's national defense circle. Esher requested Trippel to "approach some members of the great City Guilds and others who might feel disposed to do honour to Mr Balfour, and to further a great work in which he is so deeply interested."[60]

But ironically the Liberal party leadership, Prime Minister Herbert Henry Asquith, proved to be the linchpin in securing success for the conservative network's lobby. Esher excitedly wrote to Balfour in February, 1912, "I think I have the money for our Chair of Genetics. Asquith has been very good and has helped me! The name of the benefactor is not to be indulged to anyone."[61] The donor was later identified to be William George Watson, founder and chairman of the board of directors of the highly successful Maypole Dairy. Watson's public-spirited philanthropy included establishing profit-sharing among employees (a solution to "labour unrest") as well as founding the Danish Bacon Agency in London, which promoted free trade with Danish farmers. He later turned the agency over to Danish farmers "free of any charge for goodwill."[62] He communicated his pledge to Cambridge genetics on 9 February 1912: "Confirming our conversation this morning I am willing to give £50.000/-/- to be divided as agreed and used to prove an endowment of the Study of Genetics in the University of Cambridge & for the benefit of the enlarged

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[60] Esher, typescript, 22 November 1911, ESHR 19/2, CCA; Esher to Sir Francis Trippel, London, 22 Nov., 1911, ESHR 19/2, CCA.

[61] Esher to A.J. Balfour, London, 15 February 1912, reprinted in *Journals and Letters of Reginald, Viscount Esher*, ed. by Oliver, Viscount Esher, 4 vols. (London: Ivor Nicholson & Watson, 1938), III: 80.

[62] "William George Watson," Typescript MS, n.d., ESHR 19/2, CCA.

British School [of Art] at Rome."[63] Prime Minister Asquith wrote to Esher, "Regard is had to the public-spirited employment of wealth!"[64] Watson's endowment underlined the reality that in this period *novo riche* among businessmen superceded the traditional aristocracy's capacity to finance public endeavours.[65]

In late winter, 1912, the Cambridge Committee of the House of Lords met to receive news of the endowment and to make further plans for the proposed professorship. Rayleigh, as Chancellor of Cambridge, chaired the meeting.[66] Despite Esher's preference to name the chair the "Arthur Balfour Professorship," the committee recommended simply "Balfour Professorship," perhaps to associate it indiscriminately with the Balfour family name. This recommendation satisfied neither Esher nor John Stanley Gardiner, professor of zoology.[67] Gardiner wrote,

A slight difficulty has arisen in which I think should be put before you. We have

[63] W.G. Watson to Esher, Reading, 9 February 1912, ESHR 19/2, CCA. I have been unable to trace the origin of the benefaction earmarked for the British School of Art in Rome. As mere speculation, it may be no coincidence that Eustace Balfour, the acknowledged artist and architect of the family, died in 1911, and the benefaction may have been a contribution to a memorial in his name.

[64] H.H. Asquith to Esher, London, 14 February 1912, ESHR 19/2, CCA.

[65] Further on this theme, Cannadine, *The Decline and Fall of the British Aristocracy*, 90-92, 308-310, 357-359, also Olby, "Scientists and Bureaucrats."

[66] Esher to W.G. Watson, London, 7 March 1912 (copy), ESHR 19/2, CCA.

[67] The Vice-Chancellor, Ernest Stewart Roberts, upon the Senate Council's recommendation, converted the Readership of Animal Morphology (previously the Professorship of Animal Morphology, Frank Balfour's chair) to the Professorship of Zoology after Adam Sedgwick's resignation in 1907; "Report of the General Board of Studies on the Readership in Animal Morphology," 9 November 1907, Min.V.6, University Archives, CUL; also Chapter 6 above.

> in Cambridge the "Balfour Studentship"; the "Balfour fund" and the "Balfour Library." It would be possible to call these the 'F M Balfour' or the 'Francis Maitland Balfour' but there is bound to be confusion in the future.
>
> F M Balfour next to Darwin was in the opinion of many the most brilliant zoologist of the last century. He was a younger brother of A J, & he died in 1882.
>
> The whole question of the name is really of little importance on account of the relationship, but some of the friends of Prof. F.M. Balfour have written to me as I am his successor. They claim to use the name "Balfour" and suggest the benefactor if he knew the facts would consent to use a Christian name before "Balfour." They further point out that the subject, Genetics, is very far apart from Prof. Balfour's side.[68]

Amid the proprieties imposed by the anonymity requirement, Balfour and Watson managed a private meeting in Cannes.[69] A press announcement of the anonymous benefaction appeared in *The Times* on 13 March 1912 in the form of a letter to the editor.[70] In early April Esher made the formal proposal to the Vice-Chancellor of the University, Stuart A. Donaldson, regarding the chair: "It would meet the wishes of our benefactor, and probably those of most Cambridge people, and I think would be generally appreciated, if the new Chair could be called the *Arthur Balfour* Professorship of Genetics in the University of Cambridge."[71]

Also by this time, Balfour and Esher began negotiations for establishing a

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[68] J.S. Gardiner to Esher, Cambridge, 30 March 1912, ESHR 19/2, CCA; Esher to A.J. Balfour, London, 7 March 1912 (copy), ESHR 19/2, CCA.

[69] Esher to W.G. Watson, London, 12 February 1912, ESHR 19/2, CCA; W.G. Watson to Esher, Reading, 3 March 1912, ESHR 19/2, CCA.

[70] Esher, "Balfour Professorship of Genetics: Munificent Gift to Cambridge" *The Times*, London, 13 March 1912.

[71] Esher to Vice-Chancellor, Callander, 3 April 1912 (copy), ESHR 19/2, CCA.

research station to be connected with the chair. They received advice from the Cambridge scientists, who differed in their views. The physicist Joseph Larmor recommended closely allying the chair and its experimental space with the current biology department:

> [A] Professor of Genetics at Cambridge would be more effective it were in close touch with the existing biological department as now, than if it were isolated in a separate department and *permanent* building of its own. I think there is a tendency to be guarded against for each department to establish itself complete and self-contained, which means some duplicating as well as isolation of effort, whereas the notion of *University* should mean combined activity.[72]

The biologists most directly concerned with genetics, however, opposed this view and advised in favor of experimental conditions not unlike Bateson's former arrangement at Merton House. Based on the opinions of Thomas Barlow Wood (professor of agriculture), Reginald Crundall Punnett (professor of biology, formerly Bateson's student and research assistant), and Rowland Henry Biffen (professor of agriculture), the Cambridge University Association, presided by Rayleigh, communicated its recommendations to Esher:

> You will see that they [the biologists] don't take Larmor's view that the professor should be tied to the laboratories. How could he do his real work there? The point about centralising is very important. At present, time is apt to be wasted by, say, going to attend to the proper cross-fertilisation of a plant in the Botanic Gardens, and then rushing off to kill a chicken on the University Farm, beyond Girton!
>
> The efficient pursuit of Genetic research entails close and constant supervision of the experiments, whether plant or animal. The investigator ought, as far as possible, to live with his material. For this reason a *house* has been added to the capital estimate. The suggested *laboratory* would consist of a large and several smaller rooms for the breeding of small animals and insects, as well as a general room with conveniences for the use of investigators working in the garden. As

[72] J. Larmor to Esher, London, 8 March 1912, ESHR 19/2, CCA.

there must be one man (gardener) living on the spot, a cottage has been estimated for.[73]

The recommendation clearly privileged a domestic arrangement for experimental genetics, in which the lobbyists deemed an out-of-doors agricultural station, supplemented with an indoor laboratory, to be more the appropriate choice than annexation to the biological laboratories housed more centrally on the crowded New Museums Site, off of Downing Street.[74] Professionalization of genetics, in this case, meant the adoption of a domestic model for science of the country-house variety, clearly reflecting the influence of the donors' predilections. Esher wrote to Balfour, "I came to the conclusion that the right thing to do is to put the Professor of Genetics into the closest possible touch physically with his work. We selected one acre of ground close to the University Farm as a site."[75] A contract of purchase was signed on 9 April 1912, placing nearly two acres of land on Storey's Way into Esher's and Balfour's hands.[76]

Design for the house commenced even before the official purchase. Esher contracted the architectural firm, Dunnage & Hartmann, to draw up a design. From the start, he felt that the house "ought to be of course commodious enough to hold a married man," though Punnett later complained that he felt the living space being constructed was

[73] H.A. Roberts to Esher, Cambridge, 9 March 1913, with enclosure, "Estimate for a Small Institute for the Study of Genetics," ESHR 19/2, CCA.

[74] Blackman, "The Natural Sciences Tripos."

[75] Esher to A.J. Balfour, London, 14 March 1912, ESHR 19/2, CCA.

[76] "Contract of Purchase," 9 April 1912, ESHR 19/2, CCA.

inadequate and needed expansion.[77] Regarding a laboratory space, Wood recommended early on that one be built in such a way that it could be later reconverted as domestic space: "Would it be possible to build the laboratory and animal house as a sort of annexe to the dwelling-house? It would look like a billiard room, and might possibly be used for that purpose if it ever became necessary for the Balfour Professor to move to another site."[78] Again spatial dimensions created some debate. Punnett shared the views held by the biology cohort:

> I think he [Herbert Hartmann] has designed an excellent house, but I and several of my colleagues are afraid that the study and laboratory have been so much reduced in size that they will hardly serve the purpose for which they are intended. We feel however that we cannot ask the anonymous benefactor to increase the very generous sum he is already expending....
>
> We are very anxious that the building should meet the wants of the Professor and one of my colleagues is prepared to provide the £150 necessary to pay for an extension of 10 feet. This would make an addition of 5 feet to the length of each of the two rooms.[79]

While Esher adopted the laboratory recommendations, in the case of the living quarters he followed the original design.

As building on the site progressed, the Vice Chancellor Donaldson officially established the Arthur Balfour Professorship of Genetics on 3 June 1912.[80] With this confirmed, Balfour wrote Bateson to gauge the possibility of luring him back to

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[77] Esher to T.B. Wood, 14 March 1912, ESHR 19/2, CCA; R.C. Punnett to Esher, Cambridge, 17 February 1913, ESHR 19/2, CCA.

[78] T.B. Wood to Esher, Cambridge, 23 March 1912, ESHR 19/2, CCA.

[79] R.C. Punnett to Esher, Cambridge, 7 August 1912, ESHR 19/2.

[80] "Balfour Professorship of Genetics," C.U.R.39.47, University Archives, CUL.

Cambridge. Under the conditions of the post, Balfour and Asquith held ultimate authority in making the appointment. He explained why Bateson's assumption of the chair should be appealing:

> To you, more than to anybody else, is owed the impulse which started the Mendelian School at Cambridge, and, through that school, the foundation of the new Chair. Would you be prepared to resume your investigations as its occupant? If you would, I think it would be a great gain, both to Cambridge and to science; and I think it very probable that the Prime Minister would take the same view, though on this, of course, I cannot speak with any assurance.
> There is, so far as I know, nothing in the Trust Deed founding the Professorship which *would* confine it, or indeed *ought* to confine it, to Genetic investigations on Mendelian lines; but there is certainly a great deal to be said, on *every* ground, for making the first Professor one who would carry on with originality and power the line of investigation which has already proved so fruitful.[81]

Bateson replied promptly, declining the offer and recommending Punnett for the position. He explained,

> I value very greatly the suggestion conveyed in your letter, and the appreciative expressions you have used in reference to my work, but I feel that I must abide by the decision then made.
>
> The opportunities here [at John Innes] are already great and they will increase. Though we cannot have a constant succession of students yet the influence which this Institution will ultimately exert on biological science must be very considerable.
>
> If there were difficulty in finding a man thoroughly qualified, the case would be different; but I am sure that Mr Punnett, who worked with me for several years and succeeded me in the Professorship of Biology is in every way worthy to be appointed to the new post. If he is thus chosen, as I trust he may be, I should have perfect confidence that the school of Genetics in Cambridge will develop rapidly and on right lines. If more information as to Punnett's qualifications were desired I would, of course, gladly supply it.[82]

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[81] A.J. Balfour to W. Bateson, London, 25 June 1912, Add. 8634/G.6.1/12, CUL.

[82] W. Bateson to A.J. Balfour, Merton, 26 June 1912 (copy of draft), Add. 8634/G.6.1/14, CUL.

Punnett was elected the first Arthur Balfour Professor of Genetics on 22 November 1912.[83]

By late 1913, the building approached completion, stalled only by an unfortunate act of vandalism by suffragettes.[84] In the summer Punnett proposed "Gravel Hill Lodge" as a name for the house, given its proximity to the university's farm, Gravel Hill. But Esher and Balfour had another idea in mind and settled on the name "Whittingehame Lodge," after Balfour's own country seat, Whittingehame House. Punnett gave his approval: "Many thanks for your note with the name of the house on Storey's Way. It sounds very happy and is certainly much prettier than the only suggestion we felt able to make."[85] In rationale, design, and now name, Cambridge's site for genetics research reproduced on a more modest scale a country-house style of laboratory. Punnett moved into the house on 20 October 1913, and Balfour and Esher transferred the properties to the university on 19 January 1914.[86] It continued in use as a genetics laboratory until 1962 when the genetics department sold it to Churchill College, although by the 1930s its design came to be viewed as a real hindrance to the progress of genetics research.[87]

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[83] "Balfour Professorship of Genetics," C.U.R.39.47, University Archives, CUL.

[84] G.E. Dunnage to Esher, London, 17 May 1913 (telegraph), ESHR 19/2.

[85] R.C. Punnett to Esher, Cambridge, n.d., ESHR 19/2; R.C. Punnett to Esher, Cambridge, 21 Aug. 1913, ESHR 19/2.

[86] G.E. Dunnage to Esher, London, 28 October 1913, ESHR 19/2; "Report of the Council of the Senate on an Offer Relating to the Arthur Balfour Professorship of Genetics," 19 January 1914, C.U.R.39.47, CUL.

[87] Plaque erected on Whittingehame Lodge, 17 February 1990 (still extant); Luigi Luca Cavalli-Sforza, "Recollections of Whittingehame Lodge," *Theoretical Population Biology* 38 (1990): 301-305. On the increasingly disparaging views of the laboratory,

Conclusion

When Alice and Arthur Balfour lobbied for Ewart's genetics work in the 1890s, momentum was building within the larger scientific community's lobby for governmental support of research, which lobbyists increasingly viewed to be critical for the nation's industrial growth.[88] Alice perceptively noted the dearth of state subsidies for science, offering a complaint resounding those of scientific public spokesmen: "It is most depressing that so little money can be got in this country for scientific research. Our rich merchants all want to become landowners, & the moment that is done, so many calls come upon them as such."[89] But despite the image of the government as a "reluctant patron" (to quote Peter Alter), aristocrats integrally involved in governmental affairs defied this perceived situation. Balfour's lobby for Bateson's chair, emphasizing as it did its importance to the nation's agricultural industry, worked closely with representatives of both the Committee of Imperial Defence, headed by Esher, and the Premiership held by Asquith. While the genetics chair at Cambridge ultimately depended upon private funds, in reality the endowment suggests a back-door route to explicit governmental sponsorship through an aristocratic, state, and industrial alliance forged between the likes of Balfour, Esher, Asquith, and the Maypole Dairies.

Joan Fisher Box, *R. A. Fisher: The Life of a Scientist*. (New York: John Wiley & Sons, 1978), p. 398 (I thank Marsha Richmond for this reference). More generally on Cambridge genetics in this later period, Jennifer Marie, "The Importance of Place: A History of Genetics in 1930s Britain," Ph.D. thesis: University College London, 2004.

[88] Peter Alter, *The Reluctant Patron: Science and the State in Britain, 1850-1920* [1982], rev. ed., trans. Angela Davies (Oxford: Berg, 1987).

[89] A.B. Balfour to J.C. Ewart, Whittingehame, 17 Jan. 1903, Gen.138/8, EP, UEL.

It must be emphasized that this pattern to science sponsorship fell beneath the public's radar. Caught between a record of official government apathy and the publicized complaints waged by professional pundits, historians have missed the significance of critical continuities between the early-nineteenth century tradition of gentlemanly philanthropy and the subsequent rise of government-sponsored industrial research.[90] When yoked with the cases I analyzed in Chapter 6, Balfour's lobby for a genetics chair at Cambridge again illustrates the more general pattern to his aristocratic network's involvement in the advancement of science during this period when developing institutional arrangements responded to the needs of rapidly developing disciplines.[91]

[90] As Michael Sanderson noted, a similar oversight had plagued the history of scientific research within business firms, again resulting in an underestimate of the importance of the private sector's initiative: Sanderson, "Research and the Firm in British Industry, 1919-39," *Science Studies* 2 (1972): 107-151, esp. 107-112.

[91] The Balfour network also led the successful establishment of the National Physical Laboratory. As First Lord of the Treasury, Balfour gave strategic, though cautionary, governmental support, while Rayleigh chaired the Executive Committee appointed by the Royal Society. Glazebrook, Rayleigh's former demonstrator at the Cavendish, was appointed director. Sir Charles Parson was a donor, and Lord Esher helped with negotiations. The nominal chairperson was the president of the Royal Society, who served ex-officio. See Robert John Strutt, Fourth Baron Rayleigh, *Life of John William Strutt, Third Baron Rayleigh* [1924], aug. ed. by John N. Howard (Madison: University of Wisconsin Press, 1968), p. 279; Lord Rayleigh, *Lord Balfour in His Relation to Science* (Cambridge: Cambridge University Press, 1930), p. 33; Russell Moseley, "The Origins and Early Years of the National Physical Laboratory: A Chapter in the Pre-History of British Science Policy," *Minerva* 16 (1978): 222-250.

Chapter 9

Conclusion

> The concept of the gentleman was invented by the aristocracy to keep the middle classes in order.[1]

By the second decade of the twentieth century, the structure of British science looked very different from its former, Victorian guise. Purpose-built laboratories now populated the colleges and universities, state-sponsored research rapidly gained momentum, as did private industrial research within business firms.[2] Traditions of research within private homes continued to thrive alongside these developments, at times as makeshift solutions to lacking institutional resources, at times as legacies of earlier cases, and yet often as deliberate arrangements. Notable examples are home laboratories of women scientists who, for a combination of personal and institutional factors, fashioned experimental spaces within their homes to carry on serious programs of research. Hertha Ayrton, for example, maintained an attic laboratory in her London house; after her husband's death, she moved her experiments to a more central location on the first floor. Her case illustrates one pattern of women's scientific work and professional engagement during a period generally viewed as hostile to women's

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[1] Bertrand Russell, quoted in Martin J. Wiener, *English Culture and the Decline of the Industrial Spirit, 1850-1980* [1984], 2nd ed. (Cambridge: Cambridge University Press, 2004), p. 13.

[2] Roy MacLeod and Kay MacLeod, "The Social Relations of Science and Technology, 1914-1939," in *The Twentieth Century, Part 1*, ed. Carlo M. Cipolla, *The Fontana Economic History of Europe* (New York: Harper & Row, 1977), pp. 301-363, and Michael Sanderson, "Research and the Firm in British Industry, 1919-39," *Science Studies* 2 (1972): 107-151.

participation.[3]

Among the aristocratic network consisting of the Balfour, Campbell, Gascoyne-Cecil, Parsons, Sidgwick, and Strutt families, country-house science met a varied fate by the 1920s. The famous Leviathan telescope of Birr Castle was dismantled, its mirror sent to the Science Museum of London in 1914. With the development of powerful refracting telescopes and improved technology for crafting reflectors' specula, the clumsy Leviathan became obsolete (superseded by Mount Wilson's 100-foot reflector in 1917). Science at Birr shifted toward horticulture, and succeeding generations of the Parsons family acquired national repute for the castle gardens and arboretum.[4] Serious scientific study at Inveraray Castle and Hatfield House ended with the proprietor's deaths in 1900 and 1903, respectively. Whittingehame remained until the mid-1930s an active center for archaeological research and local natural history, largely owing to the efforts of Alice Balfour.[5] After Rayleigh's death in 1919, his son Robert rebuilt the laboratory at Terling

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[3] This theme is elaborated in Donald L. Opitz, "Male Mentoring, Women's Work, and Gender Ideology in Victorian Physics: The Careers of Agnes Pockels, Eleanor Sidgwick, and Hertha Ayrton," Paper presented at the Women and Gender in Science, Medicine, and Technology Conference, St. Louis University, 12-15 October 2000. On Ayrton, Evelyn Sharp, *Hertha Ayrton, 1854-1923: A Memoir* (London: Edward Arnold and Co., 1926).

[4] F.G. Ogilvie to Earl of Rosse, London, 8 July 1914, reproduction exhibited in Birr Museum, Birr. On the progress of telescopic technology, Albert van Helden, "Telescope building, 1850-1900," in *Astrophysics and Twentieth-Century Astronomy to 1950, Part A*, ed. Owen Gingerich, vol. 4 of *The General History of Astronomy*, ser. ed. Michael Hoskin (Cambridge: Cambridge University Press, 1984), pp. 52-58. On Birr horticulture, Lanning Roper, "The Gardens of Birr Castle," *Country Life* 136 (1964): 1024-1026, 1154-1157.

[5] Donald L. Opitz, "'Behind folding shutters in Whittingehame House': Alice Blanche Balfour (1850-1936) and Amateur Natural History," *Archives of Natural History*

Place to suit his own research purposes. After Robert died in 1947, the laboratory remained, and continues to remain, an undisturbed relic of a scientific past but within a private home.[6]

Other sites nevertheless continued to thrive. Major agricultural research stations existed at Rothamsted and Woburn Abbey.[7] Tring Park near Aylesbury boasted a world-renown butterfly collection and zoological museum assembled by Lionel Walter Rothschild, second Baron Rothschild of Tring. His niece, Miriam, a respected entomologist, further developed the butterfly collection.[8] In addition to Rayleigh's son, a select set of physicists maintained home laboratories well into the mid-twentieth century.[9] In other ways, country-house science left its mark on modern science. Even when no longer serving as family seats, several mansions physically housed scientific centers. The National Physical Laboratory opened at Bushy House, formerly a royal palace, in Teddington, in 1902, and the John Innes Horticultural Institute opened in the Manor

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31 (2004): 330-348.

[6] Sir William Gavin, *Ninety Years of Family Farming: The Story of Lord Rayleigh's and Strutt & Parker Farms* (London: Hutchinson, 1967), pp. 60-70.

[7] Sir E. John Russell, *A History of Agricultural Science in Great Britain, 1620-1954* (London: George Allen & Unwin, 1966), pp. 169-175, 289-332.

[8] Miriam Rothschild, *Dear Lord Rothschild: Birds, Butterflies, and History* (London: Hutchinson, 1983).

[9] Simon Schaffer, "Physics Laboratories and the Victorian Country House," in *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, ed. Crosbie Smith and Jon Agar (Basingstoke: Macmillan, 1998): 149-180.

House of Merton Park, near London, in 1909.[10] During World War II, Bletchley Park, in Milton Keynes, served as a center for scientific intelligence and later a museum.[11] Charles Darwin's Down House, entrusted to the British Association for the Advancement of Science in 1929, also became a famous science museum. Even as late as the 1960s, Peter Mitchell established an important site for biochemical research at Glynn House, in Cornwall.[12]

Even outside of the homes, science as a vocation continued to flourish among younger generations of the families, especially the women. Rachel Parsons, a granddaughter of the third Earl of Rosse, became an engineer and for a time assumed the directorship of the family's engineering firm.[13] Arthur Balfour's niece, Lady Eve Balfour, obtained a degree in agricultural science from Reading University in 1917 and established in 1939 the nation's first research station investigating the comparative productivity of

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[10] The selection of Bushy House as the site followed Arthur Balfour's suggestion; Lord Rayleigh, *Lord Balfour in Relation to His Science* (Cambridge: Cambridge University Press, 1930), p. 33; Russell Mosely, "The Origins and Early Years of the National Physical Laboratory: A Chapter in the Pre-History of British Science Policy," *Minerva* 16 (1978): 222-250; Robert Olby, "Scientists and Bureaucrats in the Establishment of the John Innes Horticultural Institution under William Bateson," *Annals of Science* 46 (1989): 497-510.

[11] Harry Hinsley, *Code Breakers: The Inside Story of Bletchley Park* (Oxford: Oxford University Press, 1993).

[12] Louise Wilson (ed.), *Down House: The Home of Charles Darwin* (Westerham: English Heritage, 2000); John Prebble and Bruce Weber, *Wandering in the Gardens of the Mind: Peter Mitchell and the Making of Glynn* (Oxford: Oxford University Press, 2003).

[13] W. Garrett Scaife, *From Galaxies to Turbines: Science, Technology and the Parsons Family* (Bristol: Institute of Physics, 2000), p. 450.

organic and conventional farming. Family and aristocratic networking remained important to the funding of the younger generations' endeavors. Gerald Balfour and Eleanor Sidgwick, for example, served as trustees and financiers for Lady Eve's research station, Haughley, in Suffolk.[14]

The aristocratic network's pattern of privately politicking for science, as illustrated by the cases at Cambridge explored in Chapters 6 and 8, continued beyond the Edwardian period. Arthur Balfour's successes in mobilizing government-sponsored research, for example, gained momentum during the inter-war period and can be traced in his relationships to the Medical Research Council (founded in 1913) and the Department of Scientific and Industrial Research (founded in 1915). As Lord President of the Privy Council (1919-1922, 1925-1929), Balfour oversaw both departments, which acquired unprecedented governmental support owing to the urgency of World War I needs. In 1916, the National Physical Laboratory was transferred to the Department of Scientific and Industrial Research, and consequently came under Balfour's responsibility as Lord of the Council.[15] In 1925 he established the Committee on Civil Research, comprised of leading scientists.[16] These twentieth-century patterns take us beyond the scope of my dissertation but suggest a rich area for further analysis.

In the late-Victorian and Edwardian periods, however, my dissertation has shown

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[14] Michael Brander, *Eve: The Founder of the Soil Association & the Voice of the Organic Movement* (Haddington: Gleneil Press, 2003), pp. 36, 69-73, 128-129.

[15] Rayleigh, *Lord Balfour*, pp. 32-33; Rayleigh, *Life*, p. 284.

[16] Rayleigh, *Lord Balfour*, pp. 41-45.

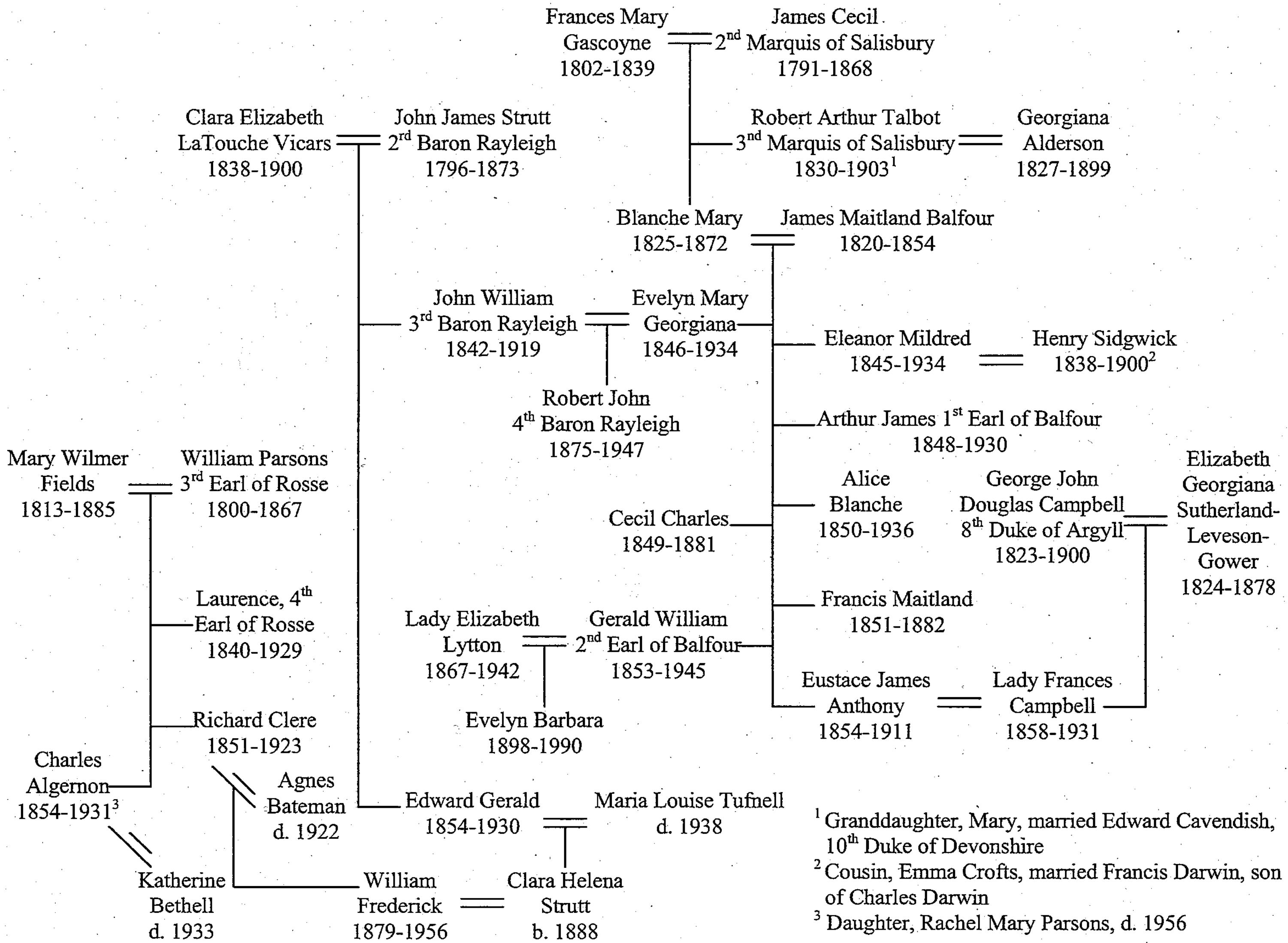
that aristocratic activities in science were broad and important to the development of the disciplines. Members of the aristocracy contributed intellectually and materially to the sciences in ways that affirmed the respectability of amateur practice while also promoting professional developments within a moral world view that embraced progress in science and industry without compromising the role of God's providence in nature. Their activities and interests defy the conclusion of one historian that "cultural absorption of the middle classes into a quasi-aristocratic elite" resulted in an "industrial behavior suspicious of change, reluctant to innovate, energetic only in maintaining the status quo."[17] As we have seen, Rayleigh and Francis Balfour shaped the direction of scientific reform at Cambridge and beyond, through their academic positions, research programs, philanthropy, and ability to negotiate university politics. In his lobby for establishing a Cambridge chair of genetics, Arthur Balfour promoted a distinct line of research by informally rallying support within his aristocratic social network and by forging alliances with the *novo riche*. All three endeavors pushed Cambridge in the direction of scientific research deemed central to the advancement of Britain's industrial and agricultural strength – in a sense, professionalizing a scholastic institution while advocating for a non-secular ideology. Although promoting "professional" interests, these individuals continued to embrace "amateur" values and to pride their work in the spaces of their country houses. Whether as practitioners of science, philanthropists, or spokespersons, they promulgated a world view that reconciled science and religion, offering a vision for the future of science embedded in aristocratic and Christian values. Arthur Balfour's

[17] Wiener, *English Culture*, p. 154.

philosophy is the best illustration, but other members of his family, as we saw in Chapter 7, shared his views. Their intellectual orientations explain, in part, their choices for research, philanthropy, and allies in a venture they viewed to be valuable for individual atonement as well as the good of society.

The endeavors and accomplishments of their network represent a remarkable continuity of aristocratic initiative and values within a period marked by rapid changes within British science and society. At the same time, the involvement of the network's members in professionalizing initiatives reveal their remarkable ability to adapt in order to meet new social and economic challenges, build strategic alliances across class divisions, and, through promotion of their intellectual interests, shape professionalizing outcomes. Their roles demonstrate how "professionalization" during this period remained fluid, contested, and wedded to specific interests shaped by the class, political, and religious positions of the spokespersons. In the end, well into the Edwardian period the country house continued to serve as the foundation upon which they based their visions for and actions within science.

Appendix: Family tree showing selected children and marriages.



[1] Granddaughter, Mary, married Edward Cavendish, 10th Duke of Devonshire

[2] Cousin, Emma Crofts, married Francis Darwin, son of Charles Darwin

[3] Daughter, Rachel Mary Parsons, d. 1956

Bibliography

Archival Collections and Abbreviations

ASZN	Archives of the Stazione Zoologica, Naples
Birr	Parsons Muniments, Birr Castle
BNL	Balfour and Newton Library, Department of Zoology, Cambridge
BP, BL	Balfour Papers, British Library
BP, NAS	Balfour Papers, National Archives of Scotland
CCA	Churchill College Archives, Cambridge
CUL	Manuscripts Department, Cambridge University Library
EP, UEL	Ewart Papers, University of Edinburgh Library
Hatfield	Hatfield House Library
HP, ICA	Huxley Papers, Imperial College Archives, London
PL	Physiology Library, Cambridge
ERO	Essex Record Office
RA, AFRL	Rayleigh Archives, Air Force Research Library, Hanscom Field, Bedford, Massachusetts
SP, Wren	Henry Sidgwick Papers, Wren Library, Trinity College
Terling	Strutt Muniments, Terling Place
Whipple	Whipple Library, Department of History and Philosophy of Science, Cambridge

Newspapers, Periodicals, and Dictionaries

Alumni Cantabrigienses, comp. John and J.A. Venn (abbreviated as *Alum. Camb.*)
Astronomical Register
Dictionary of National Biography, founded by George Smith (abbreviated as *DNB*)
Dictionary of Scientific Biography, ed. Charles Coulston Gillispie (abbreviated as *DSB*)
The Essex Chronicle
The Family Friend
The Fortnightly Review
The Free Review
The Haddingtonshire Courier [Haddington]
Nature
The Monthly Review [London]
Proceedings of the Royal Society of London
Punch, or the London Charivari
Quarterly Review
Report of the ... Meeting of the British Association for the Advancement of Science (abbreviated as *BAAS Reports*)
The Review of Reviews
The Saturday Review
The Times [London]
Transactions of the East Lothian Antiquarian and Field Naturalists' Society

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