Making Connections: Microscopy and Scientific Practice in Colonial America and the Wider Trans-Atlantic World

Archana Kapoor

Submitted in accordance with the requirements for the degree of Masters of Arts by Research

The University of Leeds

School of Philosophy, Religion and the History of Science

September 2013

The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others

Acknowledgements

I would like to thank a number of people who helped and assisted me during the course of the thesis. First, the researchers at the Historical Society of Pennsylvania and the American Philosophical Society who provided me with useful sources and a lucky find! Secondly, Adrian Wilson and Patricia Fara who offered their advice on ways in which to improve the thesis.

My most important thanks, however, must go to my supervisors, Jonathan Topham and Graeme Gooday, and to my family. Thank you all for your patience when things did not go well and for the words of encouragement when I needed them, and thanks, mum, for putting up with my inconvenient work schedule.

Abstract

Recent scholarship has challenged the assumptions that neither colonial Americans nor European microscopists contributed to science during the eighteenth century. Moving away from earlier attitudes and utilising new sources of information, scholars are now establishing that Europeans used microscopes as scientific tools during the eighteenth century and that colonial Americans contributed significantly to the various branches of natural history. These as yet separate developments are brought together in the thesis, which argues that eighteenth-century microscopes and texts moved across the Atlantic Ocean from London to colonial settlements, and that they were used by colonials as part of scientific investigations of plants and insects, as well as for entertainment. The thesis thereby contributes to recent developments in scholarship, but also extends this new scholarship to consider the trans-Atlantic geography of microscopy, and of microscopy as a facet of colonial science.

The existing literature on colonial microscopy is not what we can describe as a distinct *body* of literature: after the initial studies in the 1940s, few, if any, historians have considered colonial microscopy as a distinct subject of research. This study builds extensively on the findings of earlier historians and makes the subject of colonial microscopy the explicit focus of research. It is divided into three main chapters: each chapter identifies different types of microscopy-related activities, sites of microscopy, as well as colonials who engaged with microscopy. Chapter two charts the development of microscopy in the institutional and public spheres of colonial America between 1732 and 1771. Both chapter three and chapter four examine the microscopy-related interests of two elite naturalists, James Logan of Philadelphia and Alexander Garden of Charleston.

The study shows that eighteenth-century microscopy was a trans-Atlantic science. It presents an exciting new area of research and raises new questions for the wider historiography of eighteenth-century science.

Table of Contents

Abbreviations

CJB

Correspondence of John Bartram, 1734-1777, ed. Berkeley, Edmund and Dorothy Berkeley (Gainesville: University Press of Florida, 1992).

EAN

Early American Newspapers <http://0-infoweb.newsbank.com.wam.leeds.ac.uk>

HBC

Henry Baker Correspondence, John Rylands Library, Manchester, II-VIII.

LJL

Edwin Wolf II, *The Library of James Logan of Philadelphia* (Philadelphia: The Library Company of Philadelphia, 1979).

LPCC

The Letters and Papers of Cadwallader Colden, vols. III (1919) and V (1921) (New York: New York Historical Society, 1918-1937).

List of Illustrations

Chapter 1: Introduction

This study explores the history of microscopy in colonial America and the trans-Atlantic world in the eighteenth century. The existing literature, with its widespread evidence for colonial microscopy, is an excellent starting point for research, but it is also fragmented. The history of colonial microscopy has not been considered as a distinct subject of research, evidence is scattered throughout different types of studies, and we lack detailed accounts of the ways in which colonial Americans engaged with microscopy. This thesis sets out to improve this situation. It builds on past research, utilises new source material, and complements recent studies of eighteenth-century microscopy, colonial science, and scientific communication to present detailed accounts of the microscopical activities of everyday colonials and elite naturalists in colonial America. It maps the circulation of microscopy-related materials within trans-Atlantic commercial and correspondence networks, discusses the development of microscopy in the institutional and public spheres of colonial America, and brings to light the microscopical interests of two well-known elite naturalists, the secretary James Logan of Philadelphia and the physician Alexander Garden of Charleston.

This chapter is divided into three sections. Section 1.1 discusses the emerging histories of eighteenth-century microscopy and colonial science, and explains how this study complements and extends these recent studies. Section 1.2 presents a critical assessment of the existing literature on colonial microscopy. The final section sets out the structure of the rest of the thesis and summarises the study's principal arguments.

1.1 Historiography of European microscopy, colonial science and the trans-Atlantic world in the eighteenth century

The main themes addressed in the thesis – microscopy as a scientific practice in the eighteenth century, the practice of science in colonial America, and the two-way circulation of knowledge in the trans-Atlantic

world – are newly emerging areas, and signal changes in the way historians are approaching scientific activity in the eighteenth century. Recent research has challenged earlier arguments that neither European microscopists nor colonial Americans produced or contributed valuable information, stances which reflected the technological and political ideas of the time. Moving away from earlier attitudes and utilising new sources of information, scholars are now establishing that Europeans used microscopes as scientific tools during the eighteenth century and that colonial Americans contributed significantly to the various branches of natural history. These as yet separate developments are brought together in the thesis, which argues that eighteenth-century microscopes and texts moved across the Atlantic Ocean from London to colonial settlements, and that they were used by colonials as part of scientific investigations of plants and insects, as well as for entertainment. The thesis thereby contributes to recent developments in scholarship, but also extends this new scholarship to consider the trans-Atlantic geography of microscopy, and of microscopy as a facet of colonial science. With these recent historiographical developments in mind, it is an opportune time to investigate the history of colonial microscopy, and to introduce the subject as an area of research.

The most recent development – that microscopes were used as scientific instruments during the eighteenth century – is fundamental to the thesis. Eighteenth-century microscopes were long considered unimportant for two main reasons: first, on the grounds that they were of poor quality compared to later periods and, secondly, and as supporting evidence for the first point, on the grounds that few naturalists used them to study plants, insects and other objects as in the seventeenth and nineteenth centuries. The majority of technicians and historians characterised the period in the history of microscopy as one of public activity, with fashionable microscopes that nevertheless suffered from visual distortions and which were used as dilettante toys, as evidenced by the complaints of contemporaries. Comparisons with other, more productive periods, such as the microscopical activities in the seventeenth century during which plants, animals and other natural specimens were studied in minute detail, and the nineteenth century,

when production of reliable, achromatic microscopes began, diverted scholarly attention away from the intermediate period.[1] The neglect following from the perceived incapability of eighteenth-century naturalists to practice microscopy has been unintentionally compounded by studies of botany and natural history in the trans-Atlantic world, few of which contain informative accounts of microscopical practices. The emphasis placed by the majority of scholars on the collection, classification, distribution, and physiology of plants and animals, and on observations made with the naked eye rather than with instruments, leaves the reader with little substantive information about eighteenth-century microscopical practices.

A number of historians of natural history acknowledged that microscopes were used to study plants, insects and other natural specimens in the eighteenth century, but the admissions – which can be found in specific studies of botany and natural history, as well as general introductions to the subject – are generally only made in passing.[2] The lack of research into scientific microscopical practices during the eighteenth century is reflected in the contents of two of the foremost collections on the history of eighteenth-century natural history. In the eighteenth-century volume of *The Cambridge History of Science,* Gerard L'E Turner commented on the public nature of microscopy in Europe, adding that the 'serious work [in microscopy] was done mainly in the fields of mineralogy, classification of plants and insects, and zoology'.[3] However, the comment was a passing remark: Turner's article did not consider the evidence for 'serious' microscopy at greater length.[4] Similarly, in the important collection

[1] See Maria Rooseboom, *Microscopium* (Leyden: National Museum for the History of Science, 1956), p.7.; Edward Ruestow, *The Microscope in the Dutch Republic: The Shaping of Discovery* (Cambridge: Cambridge University Press), p. 276, p. 284; Marian Fournier, *The Fabric of Life: Microscopy in the seventeenth century* (Baltimore; London: Johns Hopkins University Press, 1996), p.4, pp. 16-17; Catherine Wilson, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton, New Jersey: Princeton University Press, 1995).
[2] For example, see Kärin Nickelsen, *Draughtsmen, Botanists and Nature: The Construction of Eighteenth-Century Botanical Illustrations* (Dordrecht: Springer, 2006), p.14; Elisabeth Davis and Diane Schmidt, *Guide to Information Sources in the Botanical Sciences,* 2nd edition, (Englewood, Colorado: Libraries Unlimited, 1996), p. x.
[3] Gerard L'E Turner, 'Eighteenth-Century Scientific Instruments and Their Makers', *Cambridge History of Science*: *Eighteenth-Century Science,* volume 4 (Cambridge; New York: Cambridge University Press, 2008), p. 525.
[4] Turner, 'Eighteenth-Century Scientific Instruments and Their Makers', p. 525.

Cultures of Natural History we find only sporadic references to botanical and anatomical microscopy, although it must be noted that the use of instrumentation in general was not of primary importance to the aims of the contributors.[5] Roche, Koerner, and Schiebinger touched on botanical microscopy,[6] and Cook referred to use of microscopes as anatomical 'instruments' in the seventeenth century.[7] However, although the volume acknowledged that 'Scientific practices… depended… upon the use of instruments', it offered little explanation of the use of microscopes or other instruments in natural history.[8] Philip Sloane, in his review of *Cultures of Natural History*, pointed out the underdevelopment of the 'issue' and called for 'a clearer insight into the ways in which quantification and experimentation [entered]… into the natural history tradition', a comment which applies to instrumentation in the literature on natural history in general.[9]

The literature on the history of eighteenth-century scientific microscopy had already begun to improve around that period, and a small number of recent studies have successfully challenged the earlier assumptions that instruments were of poor quality and that they were rarely used by naturalists as scientific tools. While later microscopes were of better quality and reliability, and were used extensively as scientific tools, this can be acknowledged without having to negate the usefulness of earlier instruments. As Julius Groner and Paul Cornelius, Peter Heering, and Marc Ratcliffe have shown, a variety of microscopes – simple, compound and solar – were used by naturalists as educational and scientific tools during the eighteenth century.[10] The latter two scholars particularly questioned the earlier

---

[5] *Cultures of Natural History*, eds. Nicholas Jardine, Secord, James, and Spary, E.C (Cambridge; New York: Cambridge University Press, 1996).
[6] Daniel Roche, 'Natural history in the academies', p. 139; Lisbet Koerner, 'Carl Linnaeus in his time and place', p. 148, p. 153; Londa Schiebinger, 'Gender and natural history', p. 172.
[7] Harold J. Cook, 'Physicians and natural history', *Cultures of Natural History*, pp. 102-pp.103.
[8] Roche, 'Natural history in the academies', *Cultures of Natural History*, p. 139
[9] Philip Sloane, 'Review: Cultures of Natural History', *British Journal for the History of Science*, 30:2 (June, 1997), p. 243.
[10] Julius Groner and Paul Cornelius, *Merchant, Microscopist, Naturalist and King's Agent* (Pacific Grove, California: Boxwood Press, 1996); Peter Heering, 'The enlightened microscope: re-enactment and analysis of projections with eighteenth-century solar

historiographical consensus, based on their work with original instruments and largely unconsulted sources. In an approach similar to that taken by Brian Ford in 1991,[11] Heering recently presented photographic evidence to demonstrate the clarity of some of the microscopical images as reproduced using eighteenth-century solar microscopes – instruments which projected and enlarged images for mass viewing – and which, Heering argued, were used as educational tools.[12] One of the most important scholars to have argued for greater consideration of eighteenth-century microscopy and of the use of microscopes as scientific tools has been Marc J. Ratcliffe in *The Quest for the Invisible.*[13] Based on extensive research into a range of European microscopes, microscopists and specimens, Ratcliffe argued that 'programme[s] of microscopical research' continued into the eighteenth century and produced scientific knowledge.[14]

This thesis augments Ratcliffe's convincing demonstration of *European* activity during the eighteenth century by presenting evidence of microscopic practice across the Atlantic Ocean. By identifying the American colonies as sites of microscopic practice, the thesis reconfigures the geography of microscopy 'Atlantically'.[15] This reconfiguration follows the vein of similar studies by historians of colonial science who have demonstrated the complex exchange of scientific materials, knowledge, and practices which took place within trans-Atlantic networks during the eighteenth century. Sara Gronim in her book on the Scientific Revolution in New York, characterised the approach as 'breaking the insularity of Europe'.[16] Similarly, a discussion of public and scientific colonial microscopy breaks

---

microscopes', *British Journal for the History of Science,* 41:3 (September 2008), pp. 345-367; Ratcliffe, *The Quest for the Invisible.*

[11] Brian Ford, *The Leeuwenhoek Legacy* (Bristol: Biopress; London: Farrand, 1991).

[12] Heering, 'The enlightened microscope', pp. 345-367.

[13] Ratcliffe, *The Quest for the Invisible,* p. 2, p. 9, pp. 1-10.

[14] Ratcliffe, p. 2, p. 9. This is in opposition to Edward Ruestow who argued that studies of insects and plants declined after the classic period of microscopy, and were neglected by eighteenth-century naturalists. See Ruestow, *The Microscope in the Dutch Republic,* p. 284. See also Ratcliffe, p.2, p. 9.

[15] Susan Manning and Cogliano, Francis D., 'Introduction', *The Atlantic Enlightenment,* eds. Susan Manning and Cogliano, Francis D. (Aldershot: Ashgate Publishing Limited, 2008), p. 7.; John Muthyala, *Reworlding America: Myth, History and Narrative* (Athens, Ohio: Ohio University Press, 2006), p. 2.

[16] Sara Gronim, *Everyday Nature: Knowledge of the Natural World in Colonial New York* (New Brunswick, New Jersey; London: Rutgers University Press, 2007), p. 6.

the Euro-centric environment in which histories of eighteenth-century microscopy have usually been studied.

Gronim's study reflects the renewed interest among scholars in the history of colonial science: this historiographical development is also central to the thesis. Prior to the recent studies by Gronim and others, the history of eighteenth-century colonial science, as with the history of eighteenth-century microscopy, had been neglected by historians. The historiographical consensus was that colonial Americans – with the exception of the printer Benjamin Franklin, the iconic figure whose electrical experiments were internationally renowned – made only minor contributions to eighteenth-century science. Historians (of American nationality) considered the scientific and political Enlightenments of America to be intrinsically connected, and argued that American science developed after the War of Independence (1775-1783) when political as well as scientific independence from Britain had been achieved.[17] The mass manufacture of optical and other scientific instruments in America and the publication of discoveries in American journals were cited as examples of the modern development of science that took place after the Revolution. The 'nationalistic', teleological approach perpetuated the belief that scientific activity was restricted and minimal during the colonial period, and effectively dismissed the contributions of colonial naturalists.[18]

This has since been successfully challenged by historians as part of the collective drive to study the history of colonial science, and to point to the significance, importance and richness of colonial activity, particularly from the 1740s onward. The earlier historiographical consensus did not prevent

---

[17] Derek Struik, 'American Science between 1780 and 1830', *Science*, new series 129:3, (April,1956); Greene, *American Science in the Age of Jefferson* (Ames: Iowa State University Press, 1984) p. xviii, p.3; *The American Enlightenment: The Shaping of the American Experiment and a Free Society* , ed. Adrienne Koch (New York: George Braziller, 1965), p. 51, p. 52, p. 36; Henry S. Commager, *The Empire of Reason: How Europe Imagined and America Realized the Enlightenment* (Garden City, New York: Anchor Press/Doubleday, 1977), p.3, pp. 15-19, pp. 21-39.

[18] For the nationalistic approach see: Roy MacLeod, 'Introduction' in *Nature and Empire: Science and the Colonial Enterprise*, ed. Roy MacLeod, (Chicago: University of Chicago Press, 2000), p. 2, and Daniel W. Howe, *American History in an Atlantic Context: An Inaugural Lecture delivered before the University of Oxford 3 June 1991* (Oxford: Clarendon Press, 1993), p. 4.

research into such subjects, most notably by Raymond Stearns, Brooke Hindle, and Carl and Jessica Bridenbaugh.[19] Their studies of colonial naturalists, colonial links with the Royal Society of London, and the interconnections between colonials and Europeans, have recently been developed further by Sara Gronim, James Delbourgo, Susan Parrish and Joyce Chaplin.[20] These scholars have demonstrated dynamic and complex interactions between European and colonial naturalists, identifying the circulation of texts, instruments and letters within multiple trans-Atlantic networks. Knowledge, texts and instruments are recognised as having circulated in various directions within the 'Atlantic Circuits',[21] with complex interchanges and distribution of information between various groups of people. The focus has largely moved away from the "heroic" figures – such as the small circle of elite colonials which were studied by earlier historians – towards ordinary 'informal' individuals, women and indigenous tribes.[22] However, Joyce Chaplin and Keith Thomson have also demonstrated that opportunities for research into elite naturalists have not yet been exhausted.[23] These recent studies offer insights into the cultures of

[19]Raymond P. Stearns, *Science in the British Colonies of America* (Urbana: University of Illinois Press, 1970); Brooke Hindle, *The Pursuit of Science in Revolutionary America 1735-1789* (Chapel Hill: The University of North Carolina Press, 1956), pp. 5-6; Frederick E. Brasch, 'The Royal Society of London and Its Influence Upon Scientific Thought in the American Colonies', *Scientific Monthly*, 33:4 (October, 1931) and 33:5 (November, 1931); Carl Bridenbaugh and Jessica Bridenbaugh, *Rebels and Gentlemen: Philadelphia in the Age of Franklin*, 2nd ed. (Westport, Connecticut: Greenwood Press, Publishers, 1970), pp. 307-358.

[20] Gronim, *Everyday Nature: Knowledge of the Natural World in Colonial New York*; James Delbourgo, *A Most Amazing Scene of Wonders: Electricity and Enlightenment in Early America* (Cambridge, Massachusetts; London: Harvard University Press, 2006); Parrish, Susan, *Cultures of Natural History in the Colonial British Atlantic World: American Curiosity* (Chapel Hill: University of North Carolina Press, 2006); Joyce Chaplin, *Subject Matter: Technology, the Body, and Science on the Anglo-American Frontier, 1500-1676* (Cambridge, Massachusetts: Harvard University Press, 2001).

[21] Delbourgo, *A Most Amazing Scene of Wonder,* p.14.

[22] For examples of the approach away from "heroes" toward ordinary colonials see footnote 11. See also *Science and Empire in the Atlantic World*, eds. Delbourgo and Dew, Nicholas (New York; London: Routledge, 2008), pp. 5-6.

[23] Chaplin, 'Benjamin Franklin and Science, Continuing Opportunities for Study', *Perspectives on Science*, 14:2 (Summer, 2006), pp. 232-251; Keith Thomson, *Jefferson's Shadow: The Story of His Science* (New Haven; London: Yale University Press, 2012). See also Gordon E. Kershaw, *James Bowdoin II: Patriot and Man of the Enlightenment* (Lanham; New York: University Press of America, 1991) and Alfred R. Hoermann, *Cadwallader Colden: A Figure of the American Enlightenment* (Westport, Connecticut; London: Greenwood Press, 2002).

natural history, civic science, and the relationship between religion and science, and have important repercussions for literature and gender studies.

The recent efforts of historians of colonial science to explore the communication of scientific knowledge within trans-Atlantic circuits reflect a wider historiographical issue concerning the circulation of scientific knowledge within multiple spaces and geographies. In recent decades, historians of historical geography and science have demonstrated that scientific activity, rather than being confined to any one particular site, occurred simultaneously on local, regional, national and international scales.[24] Scholars including Ian K. Steele, Charles Withers, James Secord, Susan Manning, Francis Cogliano and Simon Schaffer, have argued for the complex geographies in, and between which, science has been practiced and communicated.[25] These and other historians have increasingly focused on the circulation and communication of knowledge, the transmission of its material culture – in the form of texts, letters, people, specimens, and instruments – between such geographical sites and boundaries, and the impact on the production of knowledge.

Tracing the circulation of the material culture of microscopy – microscopes, texts, letters, and specimens – across the Atlantic, draws on James Secord's general recommendation for historians to investigate 'practices of circulation on a wide variety of scales'.[26] Secord's advice – to see 'how every local situation has within it connections with and possibilities for interaction with other settings'[27] – can be applied to the

[24] Withers, *Placing the Enlightenment*, p. 7.
[25] Ian K. Steele, *The English Atlantic 1675-1740: An Exploration of Communication and Community* (New York; Oxford: Oxford University Press, 1986), pp. viii-ix; *Geography and Enlightenment,* eds. David N. Livingstone and Withers (Chicago; London: University of Chicago Press, 1999), pp.3-4, pp. 10-13,p. 17;Charles Withers, *Placing the Enlightenment: Thinking Geographically about the Age of Reason* (Chicago; London: The University of Chicago Press, 2007); James Secord, 'Knowledge in Transit', *Isis,* vol. 95:4 (December 2004), pp. 654-672; W. Meinig, *The Shaping of America: A Geographical Perspective on 500 Years of History*, vol. 1, Atlantic America, 1492-1800 (New Haven; London: Yale University Press, 1986), , pp. xv-xvii, pp. 258-9, pp. 266-67; *The Brokered World: Go-Betweens and Global Intelligence, 1770-1820,* eds. Simon Schaffer et al. (Sagamore Beach: Science History Publications, U.S.A, 2009).
[26] Secord, 'Knowledge in Transit', *Isis,* 95:4 (December 2004), p. 666.
[27] Secord, p. 664.

history of microscopy, and to Ratcliffe's recent work.[28] If we approach London (and Europe more generally) as 'local' settings in which microscopes and microscopy-related texts were first produced, we can then identify what Miles Ogborn and Charles Withers have described as 'the patterns of dispersal' of such materials beyond Europe to colonial settings, and of the observations which were sent back.[29]

The literature on colonial and trans-Atlantic science in the eighteenth century is currently dominated by studies into the circulation of materials, practices, and knowledge pertaining to electricity, medicine, botany, and natural history. This study demonstrates that microscopy was also a trans-Atlantic science and, more generally, that microscopy-related activities, whether scientific or more public-orientated, took place on both sides of the Atlantic. Presenting microscopy as a colonial, trans-Atlantic science introduces different types of scientific instruments, scientific practices and, more widely, a type of instrument group, into current scholarship. Optical instruments – most notably microscopes and telescopes – and their associated practices in colonial America have not been investigated in much detail by historians, unlike mathematical and electrical apparatus. Studies of colonial astronomy have been made: these consider the place of astronomy in the culture of colonial America, and the inter-colonial and trans-Atlantic connections to a far greater extent than the existing literature on colonial microscopy (discussed in section 1.2).[30] However, much of the work on

[28] Ratcliffe, *The Quest for the Invisible*.
[29] *Geographies of the Book,* eds. Miles Ogborn and Withers, Charles (Farnham: Ashgate, 2010), p. 10.
[30] The literature covers astronomy in the seventeenth and eighteenth centuries, of astronomy in institutions and observatories. Transits and comets are also mentioned in some studies. See Raymond Stearns, *Science in the British Colonies of America* (Urbana: University of Illinois Press, 1970), p. 120, p. 131, pp. 152-153, pp. 374-375, p. 431, p. 454, pp. 520-523, p. 642, pp. 651-665. See also David Yeomans, 'The Origin of North American Astronomy – Seventeenth Century', *Isis*, 68:3 (September, 1977), pp. 414-15, p. 425.; Brooke Hindle, *The Pursuit of Science in Revolutionary America,* p.99, pp.153-155 and *David Rittenhouse* (Princeton, New Jersey: Princeton University Press, 1964), pp. 41-78; Samuel E. Morison, 'The Harvard School of Astronomy in the Seventeenth Century' in *New England Quarterly* 7:1 (March, 1934), pp.3-24.; Silvio Bedini, '"That Awfull Stage" (The Search for the State House Yard Observatory)' in *Science and Society in Early America*, pp. 155-200; Sara S. Genuth, 'From Heaven's Alarm to Public Appeal: Comets and the Rise of Astronomy at Harvard', *Science at Harvard University: Historical Perspectives,* Clark A. Elliott and Rossiter, Margaret W (London; Toronto: Associated University Presses; Bethlehem: Lehigh University Press, 1992), pp. 28-54.; Sara Gronim, *Everyday Nature*, pp. 146-147, pp. 152-154, pp. 160-163.

astronomy, though useful, has been limited to either a particular event – notably the Venus transits of 1761 and 1769 – or to particular individuals such as John Winthrop and David Rittenhouse. Drawing attention to the use of microscopes in colonial America may prompt not only further investigations into microscopical practices, but also the use of other optical and less-well known instruments, such as telescopes. The study of 'material objects' such as instruments, and the investigation of their 'transatlantic career[s]' as suggested by James Delbourgo, and as studied by James Raven and Sara Schechner, can significantly advance our understanding of colonial and trans-Atlantic knowledge cultures.[31] Microscopes and other optical instruments, though not as immediately 'Obscure' as the late eighteenth-century tractors studied by Delbourgo, can also 'hold object lessons for both the history of enlightenment in North America and the cultural geography of the British Atlantic world'.[32]

Wider still, studies of the history of colonial microscopy may contribute to other historiographical developments concerning first, the relationship between religion and science and of religious responses to science, secondly, the participation of colonial women in natural history and, thirdly, literature studies. For reasons of space, the study only briefly considers evidence for such activities, and does not discuss the religious, gender, and literature-related aspects of microscopy in detail. Much has been written on the ways in which Quaker beliefs in the eighteenth century influenced the types of natural historical subjects which the Friends studied, of the strength of Quaker networks in natural history, and of the religious responses of Quakers to scientific knowledge. Geoffrey Cantor's *Quakers, Jews, and science: religious responses to modernity and the sciences in Britain, 1650-1900* and Jean O'Neill and Elizabeth McLean's *Peter Collinson and the*

[31] James Delbourgo, 'Common Sense, Useful Knowledge, and Matters of Fact in the Late Enlightenment: The Transatlantic Career of Perkins's Tractors', *William and Mary Quarterly,* 61:4, (October, 2004), p. 648, p. 649.; James Raven, *London Booksellers and American Customers: Transatlantic Literary Community and the Charleston Library Society, 1748-1811* (Columbia: University of South Carolina, 2002); Sara Schechner, 'John Prince and Early American Scientific Instrument Making' , *Sibley's Heir: A volume in memory of Clifford K. Shipton,* eds. Frederick S. Allis Jr and Smith, Philip C.F., (Boston: The Colonial Society of Massachusetts, 1982), pp. 431-504.

[32] Delbourgo, 'Common Sense, Useful Knowledge, and Matters of Fact in the Late Enlightenment', p. 649.

Eighteenth-Century Natural History Exchange are excellent examples of this, with O'Neill and McLean, Raistrick, Tolles, and Earnest having also commented on the Quaker beliefs of the elite naturalists discussed in this thesis.[33] Furthermore, Susan Parrish briefly touched on the exposure of colonial women to microscopy-related literature in her article 'Women's Nature'.[34] However, the elite colonials discussed in the thesis – the Quaker James Logan, the lapsed Quaker John Bartram, and the Presbyterian Alexander Garden – do not appear to have explicitly stated that their microscopical observations revealed and demonstrated the creative power of God. Logan's and Bartram's general interest in botany can be attributed to their Quaker beliefs,[35] and the correspondents to whom they communicated their findings were also Quakers, but the religious framework for their microscopy is unclear. Furthermore, with a few notable exceptions, the thesis concentrates on male naturalists. An assessment of the reaction of Quakers, Presbyterians, Puritans, and women to microscopical discoveries will require further investigation.

The historiographical developments discussed above – scientific microscopy in Europe, science in colonial America, and the trans-Atlantic context – are brought together in this thesis and extended. The position of the thesis in relation to the studies which have been made of colonial microscopy is discussed in the following section.

---

[33] Geoffrey N. Cantor, *Quakers, Jews, and science: religious responses to modernity and the sciences in Britain, 1650-1900* (Oxford: Oxford University Press, 2005); Jean O'Neill and Elizabeth P. McLean, *Peter Collinson and the Eighteenth-Century Natural History Exchange* (Philadelphia: American Philosophical Society, 2008); Arthur Raistrick, *Quakers in Science & Industry* (York: Sessions Book Trust, 1993), pp. 242-247; Frederic B. Tolles, *James Logan and the Culture of Provincial America,* 2nd edition, (Westport, Connecticut: Greenwood Press, 1978), p. 198; Ernest Earnest, *John and William Bartram, Botanists and Explorers, 1699-1777, 1739-1823* (Philadelphia: University of Pennsylvania Press, 1940), pp. 63-65; John Brooke and Geoffrey Cantor, *Reconstructing Nature: The Engagement of Science and Religion* (Edinburgh: T & T Clark, 1998), pp. 302-304, p. 305. See also Joseph Kastner, *A Species of Eternity* (New York: E.P. Dutton, 1977).

[34] Susan S. Parrish, 'Women's Nature: Curiosity, Pastoral, and the New Science in British America', *Early American Literature,* 37:2 (2002), pp. 202-204.

[35] Cantor, *Quakers, Jews, and science,* pp. 233-241.

1.2 Critical Assessment of the Secondary Literature on Colonial Microscopy

The literature on colonial microscopy is not what we can describe as a distinct *body* of literature: after the initial studies in the 1940s, few, if any, historians have considered colonial microscopy as a distinct subject of research.[36] The absence of a systematic research programme has produced a disjointed and unconnected collection of studies, few of which contain in-depth accounts of colonial activity. There is little cross-citation within the fragmented literature, with the evidence scattered throughout studies of colonial naturalists, colonial botany, colonial institutions, colonial science, as well as studies of European naturalists and science in the eighteenth century. Despite the publication of numerous studies of institutional, public, and private microscopy-related activities in colonial America – many of which are investigated further in this study – and the recent historiographical developments in histories of microscopy and colonial science (as discussed in 1.1), we are no closer to understanding the significance of such activities for histories of science in colonial America and the wider trans-Atlantic world.

The earliest studies – entitled 'The Advent of Microscopes' (1943), 'The Advent of the Microscope at Yale College'(1943), and 'Microscopy in America (1830-1945)' (1945 and published posthumously in 1964)[37] – are the most informative, largely because they presented colonial microscopy as a distinct subject of research. They also considered evidence of activity across different geographies and time periods, thereby providing basic overviews of microscopy in colonial America. For instance, Frederic T. Lewis concluded his article with the claim that by the mid-eighteenth century microscopes had become 'common' in colonial America.[38] These

[36] Frederic T. Lewis, 'The Advent of Microscopes in America, with notes their earlier history', *Scientific Monthly,* 57:3 (September, 1943), pp. 249-259; Lorande L. Woodruff, 'The Advent of the Microscope at Yale College', *American Scientist,* Summer number, 31:3 (1943), pp. 241-245; Simon H. Gage, 'Microscopy in America (1830-1945), ed. Oscar Richards, *Transactions American Microscopical Society*, LXXXIII, no.4 (October 1964), pp.1-125.
[37] See the preceding footnote.
[38] Lewis, 'The Advent of Microscopes in America', p. 259.

now outdated studies also appear to have been made as part of a collective drive towards studying the history of American microscopy, coinciding with the centenaries of mass microscope manufacturing companies in nineteenth-century America.[39] However, the impetus for this focused research soon declined, and the call for further studies into the subject in order to 'supply' what Frederic T. Lewis described as 'a forgotten page in American history', failed to stimulate sustained research.[40]

Although not in direct response to Lewis's call, subsequent scholars continued to publish of the early history of microscopy in colonial America. Their findings and their use of different types of sources as evidence serve as useful foundations for investigating institutional, public, and private activity in colonial America: historians published evidence of colonial microscopy in institutions,[41] in the public sphere,[42] and the practice and engagement of individuals[43] based on written correspondence, printed

[39] For example, see O.W. Richards, *Three American Microscope Builders* (Buffalo: American Optical Company, 1945); *The Evolution of the Microscope: Important Names and Contributions Aiding Its Progressive Development* (Buffalo, New York: Spencer Lens Company, 1947).

[40] Lewis, 'The Advent of Microscopes in America', p. 259.

[41] The most useful is I.B Cohen's study of microscopes at Harvard College, which provided the intellectual settings for the instruments: *Some Early Tools of American Science: The Account of the Early Scientific Instruments and Mineralogical and Biological Collection in Harvard University* (Cambridge, Massachusetts; Harvard University Press, 1950) . pp.110-116. For microscopes in other institutions see Leonard Tucker, 'President Thomas Clap of Yale College: Another "Founding Father" of American Science' in *Isis*, 52:1 (March, 1961) p. 63n33, p. 68.; 'Papers Relating to the College', *William and Mary Quarterly*, 16:3 (January, 1908), pp. 166-167; Silvio Bedini, 'Of 'science and liberty': The scientific instruments of King's college and eighteenth-century Columbia colleges in New York', *Annals of Science*, 50:3 (1993) p. 201.; Clifford K. Shipton, *New England Life in the Eighteenth Century : Representative Biographies*, 2nd edition (Cambridge: Harvard University Press, 1995) p. 314.; Francis L. Broderick, 'Pulpit, Physics, and Politics: The Curriculum of the College of New Jersey, 1746-1794', *William and Mary Quarterly*, Third series, 6:1 (January, 1949), pp. 42-68, p.57.

[42] For notices and printed adverts for the sale of microscopes see Silvio Bedini's *Early American Scientific Instruments and their Makers* (Washington: Smithsonian Institution, 1964), p. 26, p. 31, p. 46 and *Thinkers and Tinkers: Early American Men of Science* (New York: Charles Scribner & Sons, 1975), p. 177, p.203. For public demonstrations by David Lockwood see I.B. Cohen, *Benjamin Franklin's Science* (Cambridge, Mass.: Harvard University Press, 1990), p. 59.

[43] For Cotton Mather, the first colonial believed to have received a microscope, see Richard Shryock and Otto Beale,*Cotton Mather: First Significant Figure in American Medicine* (Baltimore: Johns Hopkins Press, 1954). See especially James Logan in Frederic B. Tolles, *James Logan and the Culture of Provincial America*, 2nd edition (Westport, Connecticut: Greenwood Press, 1978), p. 201 and Edwin Wolf II, *The Library of James Logan of Philadelphia* (Philadelphia: The Library Company of Philadelphia, 1974), p. xix, p. 69, p. 196, p.279, p. 306, p. 334, p. 525. See also Alexander Garden in Edmund Berkeley and Dorothy Berkeley, *Dr. Alexander Garden of Charles Town* (Chapel Hill: University of

publications, printed media in the form of newspapers and broadsheets, and collegial records. The evidence was generally subsidiary to the work's primary intention, however, and therefore usually summarised, paraphrased, and presented as interesting adjuncts to the main body of the text without further discussion. This can be seen in studies of individual colonial naturalists such as James Logan and Alexander Garden, who are discussed in this thesis.[44] Highly visible evidence – for instance, colonial publications or advertisements in which the content was based almost entirely on microscopical observations, and which historians published in full in their studies – also went unstudied.[45] The publication by historians of more evidence of colonial activity by historians did not necessarily produce better quality research, in-depth analysis, or useful overviews.

Although a large amount of evidence for colonial microscopy had been published by the mid-1970s and mid-1980s, the difficulty in locating the evidence within the literature, and the absence of focused research into the subject, appears to have had a detrimental impact on the way in which scholars of nineteenth-century American microscopy regarded colonial activity. In their separate studies into trade, commercial and public microscopy in nineteenth-century America, both the lawyer Donald Padgitt and historian of science John H. Warner described colonial activity as

---

North Carolina Press, 1969). For James Logan and John Bartram see Nathaniel Burt, *The Perennial Philadelphians: The Anatomy of an American Aristocracy*, 2nd edition (Philadelphia: University of Pennsylvania Press, 1999), p. 503; Tolles, p.201; Raymond Stearns, *Science in the British Colonies of America* (Urbana: University of Illinois Press, 1970), p. 578.; *Chain of Friendship: Selected Letters of Dr. John Fothergill of London, 1735-1780,* eds. Betsy C. Corner and Booth, Christopher (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 1971), p.50; A.V. Precup, 'John Bartram: 1699-1777), *Bioscience*, 26:5 (May, 1976), p. 359.

[44] Tolles, *James Logan and the Culture of Provincial America*, 2nd edition (1978) and Berkeley and Berkeley, *Dr. Alexander Garden of Charles Town* (1969).

[45] Two notable examples are first, Alexander Garden's account of cochineal beetles which was based entirely on microscopical observations and was published in the *Philosophical Transactions* and, secondly, David Lockwood's printed broadsheet which advertised public demonstrations for colonial Americans. To historians, the microscopical content appeared secondary to other considerations. However, Lockwood's advertisement has been referred to more recently by Michael Guenther in particular reference to microscopy, a promising indication of future research, in his doctoral thesis, 'Enlightened Pursuits: Science and Civic Culture in Anglo-America, 1730-1760', PhD thesis (Northwestern University, December 2008), p. 106, pp. 108-109, p. 108n21.

having been minimal and 'scattered'.[46] Warner's evidence for 'microscopical interest' in colonial America appears to have been based solely on Lewis's article on 'The *Advent* of Microscopes in America'.[47] Although Warner's assessment of colonial activity supported his primary argument that microscopy became a popular science in early nineteenth-century America, it is of interest that he drew on Lewis's outdated but easy-to-locate article rather than on the evidence for colonial microscopy which had been published elsewhere in studies of naturalists, colonial botany and colonial science. Both Padgitt's and Warner's articles reflected the disjointed state of the literature on colonial microscopy and the lack of systematic research into the subject. Furthermore, they reflected the historiographical consensus concerning the scientific activities of British colonials and European microscopists: Padgitt's emphasis on the trade in *American-manufactured* microscopes obscured the activity of colonial retailers who traded *European-made* instruments, whereas Warner's article commented on the absence of scientific microscopy during the eighteenth century.[48] Both of these conceptions have since been challenged by scholars, as discussed in the previous section.

However, although a small handful of scholars have recently argued for the practice of scientific microscopy in eighteenth-century Europe (see 1.1), we still lack a systematic account of microscopy – whether scientific, public, or institutional – in colonial America. Recent studies into colonial science and trans-Atlantic scientific networks have produced evidence for such activities, notably those by Michael Guenther and James Raven who referred to the circulation of microscopes in the trans-Atlantic world and situated the evidence for colonial activity within the cultural and intellectual contexts of public and institutional science.[49] Guenther, in particular,

---

[46] Donald L. Padgitt, *A Short History of the Early American Microscopes,* (Chicago; London: Microscope Publications Ltd, 1975), p.2; John H. Warner, 'Exploring the Inner Labyrinths of Creation: Popular Microscopy in Nineteenth Century America' in *Journal of the History of Medicine and Applied Sciences,* 37:1, (1982), pp. 8-9.
[47] Warner, 'Exploring the Inner Labyrinths of Creation', p.9, p.9n5.
[48] Padgitt, *A Short History of the Early American Microscopes,* p.2 and Warner, 'Exploring the Inner Labyrinths of Creation', pp.8-9.
[49] Michael B. Guenther, 'Enlightened Pursuits: Science and Civic Culture in Anglo-America, 1730-1760' PhD thesis (Northwestern University, December 2008), p. 106, pp. 108-109, p. 108n21; James Raven, *London Booksellers and American Customers:*

connected an early colonial advertisement for public demonstrations to other 'public… as well as private showings' in colonial America.[50] Whereas John H. Warner had referred to the 'scorn' of a Scottish traveller to illustrate the absence of microscopical 'enthusiasm' in colonial America, Guenther drew on the same individual to instead illustrate examples of colonial exposure to solar microscopes.[51] Furthermore, Guenther and Susan S. Parrish raised wider issues concerning the religious nature of microscopy, the social nature of microscopy, and the participation of women in microscopical activities.[52] Nevertheless, research remains sporadic.

Sustained research in the vein of Guenther's study – which returned to previously consulted sources, while countering earlier dismissals of colonial activity and considering colonial activity within the Atlantic context – will significantly enrich our currently limited understanding of the nature and extent of colonial microscopy. However, whereas recent scholars have continued to refer to colonial microscopy in passing, this study makes the subject the focus of research, enabling a much more thorough discussion of colonial microscopy in the scientific culture of the colonial and trans-Atlantic world than previously attempted.

To sum up, the history of colonial microscopy has not been the focus of a sustained research programme unlike, for instance, studies into the distribution and use of electrical machines, plants, and animals in the trans-Atlantic world. This study builds extensively on the findings of earlier historians and makes the subject of colonial microscopy the explicit focus of research, thereby enhancing the current literature on the subject, as well as contributing to more recent developments in scholarship.

Transatlantic Literary Community and the Charleston Library Society, 1748-1811 (Columbia: University of South Carolina, 2002), p. 15, p. 176, pp. 245-246, pp. 176-177. See also Joyce E. Chaplin, *The First Scientific American: Benjamin Franklin and the Pursuit of Genius* (New York: Basic Books, 2006), pp. 59-60; Susan S. Parrish, 'Women's Nature: Curiosity, Pastoral, and the New Science in British America', pp. 202-204.

[50] Guenther, 'Enlightened Pursuits', p. 108.

[51] Warner, 'Exploring the Inner Labyrinths of Creation', p.9; Guenther, 'Enlightened Pursuits', p. 108, p. 108n20.

[52] Guenther, 'Enlightened Pursuits', p. 106, pp. 108-109, p. 108n21; Parrish, 'Women's Nature', pp. 202-204.

1.3 The Structure of the Thesis.

The thesis examines the ways in which different types of colonials – professors, students, lecturers, wholesale merchants, auctioneers, and elite naturalists – engaged with microscopy. It is both chronologically and geographically widespread, and covers the development of microscopy in eight different colonies between 1732 and 1771. Particular attention is placed on the settlements of Philadelphia, Charleston, Boston and New York during the 1730s and 1760s. The thesis is divided into three main chapters. Chapter two discusses the development of microscopy in institutional and public spheres across eight colonies, and considers the activities of everyday colonials. Chapter three and chapter four focus on two elite naturalists who engaged with microscopy in Philadelphia and Charleston.

As mentioned in the previous section, the existing literature is an excellent starting point for research, but the thesis also draws on new source materials including letters and printed media. I had no direct access to colonial media and relied on *Early American Newspapers* – an online and searchable database – for access to colonial newspapers, magazines and gazettes.[53] For obvious reasons, the online database provides users with a snapshot of printed newspapers, and my search results were therefore restricted to certain publications, settlements, and time periods. Unfortunately, and notwithstanding the substantial evidence of microscopy-related activities in Boston and New York, this study presents little evidence for public microscopy in Philadelphia and Charleston.

Chapter two charts the development of microscopy in colonial America between 1732 and 1771, and is divided into two sections. The first section discusses institutional microscopy in nine colleges and societies. It identifies patterns in the types of microscopes such institutions owned and the use of microscopes in colonial institutions. The second section discusses public

[53] A free month's trial to the database – Early American Newspapers, <http://0-infoweb.newsbank.com.wam.leeds.ac.uk/> – was provided by the University of Leeds in 2013.

microscopy in Boston, New York and, to a lesser extent, Philadelphia. Based on the extensive use of printed adverts, this section considers public and commercial activities including demonstrations of microscopy, and the availability of microscopes at colonial stores and auctions.

Chapter three examines the microscopy of the elite naturalist James Logan (1674-1751), the Irish Quaker, secretary, and renowned botanist in Philadelphia, Pennsylvania. Between 1710 and 1747, Logan practised microscopy, published his findings, and communicated with colonial and European naturalists on the subject. The chapter is divided into four sections which discuss Logan's earliest known exposure to microscopy in the 1710s, microscopical observations of pollen during the experiments into the generation of plants, and relationship with the farmer John Bartram whom Logan introduced to microscopy. The chapter concludes with the final phase of Logan's microscopy in the mid-late 1740s, during which Logan expressed interest in bestselling books and instruments. Logan's microscopy demonstrates that microscopes, microscopy-related literature, and observations circulated within the trans-Atlantic correspondence networks between London and Philadelphia in the first half of the eighteenth century.

Chapter four also demonstrates the trans-Atlantic circulation of such materials, but between London and Charleston, South Carolina, where the elite naturalist Alexander Garden (1730-1791) practised microscopy. The Scottish physician, who migrated to South Carolina after Logan's death, also published his microscopical observations and communicated with other elite naturalists on the subject of microscopy between 1755 and 1761. The chapter is divided into three sections which discuss Garden's earliest known engagement with microscopy, active responses to microscopical discoveries, and microscopical observations of indigenous insects.

Each chapter identifies different types of microscopy-related activities, sites of microscopy, as well as colonials who engaged with microscopy. Such variety demonstrates both the multifaceted and widespread nature of microscopy in eighteenth-century colonial America.

Chapter 2: The Development of Microscopy in Colonial America, 1732–1771

This chapter reconstructs the development of microscopy in colonial American culture between the 1730s and 1770s. It attempts to capture the widespread and multifaceted nature of institutional and public microscopy by identifying some of the patterns which existed between the microscope collections of colleges, societies, wholesale stores, and auction houses in a number of colonial settlements. In addition to identifying the precise activities of professors, lecturers, retailers and other individuals who engaged with microscopy, the chapter also presents a general survey of the ways in which colonial Americans accessed microscopes and microscopical knowledge. Variety is the cornerstone of this chapter, particularly as few studies of this size and scope exist in the literature. The chapter develops the existing literature in three main ways. It builds on the work of previous scholars who identified but did not assess instances of institutional and public microscopy, and counters the claims of historians of nineteenth-century American microscopy who considered colonial activity to have been minimal.[54] It also complements recent studies of civic and colonial science, particularly by Raven and Guenther who studied microscopical activities within the context of colonial scientific culture.[55] Building on the work of previous scholars, this chapter introduces microscopy into the intellectual and scientific cultures of eighteenth-century colonial America.

The chapter is divided into two sections. These discuss first, microscopy in the institutional sphere between the 1730s and 1770s and, secondly, microscopy in the public sphere between the 1740s and 1760s. The institutional and public spheres are not fixed divisions: they act as guides for understanding the different environments in which microscopy-related

[54] For the absence of significant colonial activity see Donald Padgitt, *A Short History of the Early American Microscopes*, p.2 and John Warner, 'Exploring the Inner Labyrinths of Creation', pp. 8-9.
[55] James Raven, *London Booksellers and American Customers*, p. 15, p. 176, pp. 245-246, pp. 176-177.; Michael Guenther, 'Enlightened Pursuits: Science and Civic Culture in Anglo-America, 1730-1760' PhD thesis (Northwestern University, December 2008), p. 106, pp. 108-109, p. 108n21.

activities took place and, as will be seen in each of the sections, often overlapped. Section 2.1 begins with a comparative survey of microscope collections in nine colonial institutions – six colleges and three societies – across eight colonies between 1732 and 1771. Examples of institutional microscopy dominate the existing literature. By drawing these records together and supplementing them with evidence taken from printed media, section 2.1 provides an intellectual survey of institutional microscopy that identifies the different types of microscopes which were held by colleges and societies and, in some instances, the use of microscopes as educational tools in institutions. Section 2.2 explores the place of microscopy in the public sphere of colonial America between the mid-1740s and mid-1760s, and utilises new source material in the form of printed newspapers and magazines. It concentrates on public demonstrations of microscopy by itinerant lecturers and colonials, and on the provision of microscopes by wholesale retailers and auctioneers in three settlements. Both the geographical and chronological ranges of section 2.2 are smaller in scale than the survey of institutional microscopy. Nevertheless, the snapshot of public activity points to the diverse ways in which colonials gained access to microscopes and microscopical knowledge, and complements recent studies into civic and colonial science.

2.1 Microscopes in Colonial Institutions in the Eighteenth Century

Between 1732 and 1771, nine colonial institutions across eight colonies owned and, in some instances, used at least one of the following types of instruments: simple (see Appendix 1.1), compound and solar (see Appendix 1.2) microscopes. The colonies include Massachusetts and Connecticut – where the colleges of Harvard and Yale received the earliest microscopes in the early 1730s – as well as New Jersey, Rhode Island, Pennsylvania, Virginia, and South Carolina. The microscopes were usually of the latest design and reflected the fashions of the instrument trade in London. It must be noted that details such as the types and makes of the instruments were not always provided, and just under half of the microscopes discussed in this

section cannot be identified. Nevertheless, we can begin to suggest some of the general patterns that existed between institutional collections. The comparative approach builds on Simon Gage's now outdated survey of microscope collections in American institutions during the eighteenth and nineteenth centuries, and the intellectual context for institutional microscopy builds on the studies of I.B. Cohen and, more recently, James Raven.[56]

Instrument collections symbolised the institution's capacity to teach and to encourage natural history and the experimental sciences.[57] The growth in institutional instrument collections in America reflected first, the change in emphasis from theoretical to experimental sciences and, secondly, an increase in the number of societies and colleges during the 1740s and 1750s.[58] From the 1730s onward, optical, mathematical and philosophical instruments formed the collections of colleges and societies across colonial America. As a general rule, colleges requested at least two types of microscopes alongside other scientific instruments, whereas societies received single instruments as gifts from local patrons. However, microscopes were also donated to institutions – for instance, Harvard College in Massachusetts received three microscopes from European and colonial patrons of science[59] – and the Charleston Library Society in South Carolina commissioned a total of three microscopes (one of which replaced a damaged instrument).[60] The majority of colleges owned compound and solar instruments, both of which were known for their easier handling and usefulness as educational tools. For instance, solar microscopes projected enlarged images of specimens onto a darkened wall or sheet for multiple viewers to observe, thereby allowing a lecturer to educate a group of individuals about the microscopical features of the specimens which were displayed.

---

[56] Gage, 'Microscopy in America (1830-1945)' , pp.1-125.; Cohen, *Some Early Tools of American Science*, p. 109, pp. 113-114, p.138, p. 144; Raven, *London Booksellers and American Customers*, p. 15, p. 176, pp. 245-246, pp. 176-177.
[57] Silvio Bedini, 'Of 'science and liberty', *Annals of Science*, 50:3 (1993) p. 201.
[58] For a useful introduction to science in colonial institutions see Simon Raatz, 'Science: Colonial Era', *The Oxford Companion to United States History*, eds Paul S. Boyer and Dubofsky, Melvyn (New York; Oxford: Oxford University Press, 2001), p. 86.
[59] Cohen, *Some Early Tools of American Science*, p. 113, p. 114.
[60] James Raven, *London Booksellers*, pp. 175-177.

The size of the microscope collections varied according to whether the institution received instruments from patrons, or commissioned the instruments. The available evidence suggests that the majority of colonial institutions were in possession of at least two instruments by the 1770s. Perhaps unsurprisingly, Harvard College (1636) – which owned the largest instrument collection in colonial America – also owned the largest collection of microscopes. Harvard replaced its initial collection of four microscopes, three of which were donated by European and colonial patrons, with an equal number of instruments following a fire in 1764.[61] Yale College (1701) held the second largest collection – at least three instruments by 1747 [62] – with William and Mary College (1693),[63] the College of Rhode Island (1764),[64] and the Charleston Library Society (1748) each owning at least two.[65] The Library Company of Philadelphia (1731),[66] the library in Providence in New Jersey,[67] and the College of New Jersey (1746)[68] appear to have owned one instrument.

From the 1730s onward, colonial institutions and their patrons caught up with developments in the London instrument trade. Single and compound instruments – both of which were designed in the early seventeenth and eighteenth centuries – were well established in Europe by the time Harvard and Yale received the instruments in the 1730s. The compound microscope continued to form the staple of colonial collections into the 1760s. However, there appears to have been a slight interval between the invention of the solar microscope in the early 1740s – this was used in public demonstrations in Boston and Philadelphia in 1744 (see section 2.2) – and the instrument's importation into colonial institutions during the 1760s. Records point to a

[61] Cohen, *Some Early Tools of American Science,* p.109, pp. 113-114, p.138, p. 144.
[62] Woodruff, 'The Advent of the Microscope at Yale College', p. 244; Leonard Tucker, 'President Thomas Clap of Yale College', p. 63n33, p. 68.
[63] 'Papers Relating to the College', pp. 166-167.
[64] Silvio A. Bedini, 'Of 'science and liberty', p. 205.
[65] Raven, *London Booksellers,* pp. 175-177.
[66] Nathaniel Burt, *The Perennial Philadelphians: The Anatomy of an American Aristocracy,* 2nd edition (Philadelphia: University of Pennsylvania Press, 1999), pp. 240-241. According to Burt, the microscope and also telescope were 'much in demand'.
[67] *The Providence Gazette*, 5 September 1767, EAN.
[68] Broderick, 'Pulpit, Physics, and Politics', p. 57.

small influx of solar microscopes at Harvard College in 1763,[69] the Charleston Library Society by 1767,[70] and the College of William and Mary in 1767.[71] Although the majority of colleges and societies in colonial America were founded in the 1750s after the invention of the solar microscope, this does not explain the delayed introduction of the fashionable instrument at Harvard and other early institutions, particularly as few microscopes before 1758 remain unidentified.

At least four institutions received fashionable microscopes from leading instrument makers in London. The individuals were identified when the college or society commissioned the microscopes, usually as part of a larger purchase of scientific and philosophical instruments. In the 1730s, Harvard College received a Wilson-type simple microscope that the London optician James Wilson had popularised in 1702, and Yale College received a compound microscope by either Edmund Culpeper or Matthew Loft.[72] In 1764, Harvard replaced its collection of microscopes – two solar microscopes, a single and compound microscope all of which were destroyed in 1764 – with the instruments of the lecturer and instrument maker Benjamin Martin. These included an optical set of 'a Solar Microscope, Megalascope, & single Microscope in a Shagreen case', and an unidentified 'Martin's microscope' which may have been a compound instrument.[73] The Charleston Library Society ordered a Universal microscope from George Adams after reading Adams's bestselling *Micrographia Illustrata* (1745).[74] When seeking a replacement for the damaged instrument, the society applied to the instrument maker Peter Dolland (which, James Raven noted, the society misspelt as Dollard).[75] Finally, William and Mary College commissioned compound and solar

[69] Cohen, *Some Early Tools of American Science,* p. 114.
[70] Whitfield Bell, *Patriot-Improvers: Biographical Sketches of the American Philosophical Society,* vol. 1, 1743-1768 (Philadelphia: American Philosophical Society, 1947), p. 363.
[71] 'Papers Relating to the College', pp. 166-167.
[72] James Wilson, 'The Description and Manner of Using a Set of Small Pocket Microscopes, Made by James Wilson. . .', *Philosophical Transactions* (1702), 23, pp.1241-1247.; Cohen, *Some Early Tools of American Science,* p. 111; Woodruff, 'The Advent of the Microscope at Yale College', p. 244.
[73] Cohen, *Some Early Tools of American Science,* p.114.
[74] Raven, *London Booksellers,* pp.245-246.
[75] Ibid, p. 176.

microscopes, alongside other scientific instruments, from either Dolland or Edward Nairne.[76]

Furthermore, five of the eight institutions advertised their receipt of a microscope, intention to use a microscope, or general possession of a microscope in printed media. The remainder of this section discusses the use of microscopes as educational tools in colonial institutions. Printed notices reflected the institution's capacity to teach, or to encourage the new experimental sciences and thus to portray the institution as a reputable centre of learning. The College of New Jersey's broadsheet, which was reprinted in the *New American Magazine* (March, 1760), is an excellent example of this.[77] The notice targeted a specific group of people – potential students and their families – and publicised the college's move away from the theoretical curricula towards the experimental sciences. The transition was symbolised by an illustration in which five optical and mathematical instruments – a compound microscope, telescope, globe, sextant, and a pair of dividers – were illuminated by a ray of light in one of the college's halls. The visual and highly symbolic message signalled to potential students and their families that the college was equipped with suitable instruments with, we can quite safely assume, the intention that they would be used by professors at the college. There are further examples of the intention to use microscopes as educational tools in institutions. For instance, in 1732, Thomas Hollis, a generous English patron of science at Harvard, donated a 'Small Shagreen Case with a Double [compound] Microscope &…Utensils' which he 'hoped Mr[.] Professor Greenwood would make good use of'.[78] In 1767, the treasurer of New Jersey, Esquire Joseph Clarke, also 'presented' the library in Providence with 'An elegant Microscope…for the Encouragement of Learning, and for the Use of the Gentlemen Proprietors'.[79] The library publicised its receipt of the microscope in the local gazette.[80] The third example is particularly interesting. The collection of 'two Microscopes' at Rhode Island College (1764) were two of just five

[76] 'Papers Relating to the College', p.167.
[77] Broderick, 'Pulpit, Physics, and Politics', p. 57.
[78] Cohen, *Some Early Tools of American Science*, p. 109, p. 113.
[79] *The Providence Gazette*, 5 September 1767, EAN.
[80] Ibid.

instruments that the College owned by 1772, the first of which – an 'Electrical Machine' – had been requested by the students.[81] The college owned three types of instruments – 'a pair of Globes, two Microscopes, and an Electrical Machine'[82] – thereby attesting to the educational value which the college attached to electrical and optical demonstrations. However, the precise nature of this educational value is not known. For instance, medical students would almost certainly have used the microscope in order to observe the circulation of blood in animals, whereas students of botany and natural history would have used the instrument to study the minute features of plants, animals, and other specimens.

There is, however, evidence that individuals used single, compound and solar microscopes in a small number of colleges and societies. Between 1734 and 1765, three professors at Harvard College and King's College, New York, and two itinerant lecturers at the library societies of Philadelphia and Charleston all used microscopes to educate colonials. Little is known of the use of single and compound microscopes at Harvard by the earliest Hollis professors of mathematics and natural history – Isaac Greenwood and John Winthrop. Greenwood, to whom a patron of the college had presented a compound microscope in 1732 in the hope that it would be made 'good use of', displayed the instrument within two years of its receipt.[83] We know this from the actions of Peter Oliver, a student at Harvard who was inspired to order a 'Large' microscope in 1734.[84] In 1746, Winthrop – who succeeded the Hollis professorship in 1738 – discussed the differences between the lenses of single and compound microscopes during a lecture which, according to the historian I.B. Cohen, was 'devoted to microscopes'.[85] Winthrop's lecture notes suggest that he recommended the compound microscope to his students. Although the 'lens' in 'single microscopes…such as those of [James] Wilson's' was 'exceedingly small' and enabled greater magnification, Winthrop described the lenses in

[81] Bedini, 'Of science and liberty', p.204.
[82] Ibid.
[83] Cohen, *Some Early Tools of American Science*, p. 109, p. 113.
[84] Clifford K. Shipton, *New England Life in the Eighteenth Century: Representative Biographies*, 2nd edition (Cambridge: Harvard University Press, 1995) p. 314.
[85] Cohen, *Some Early Tools of American Science*, p. 110

'Double microscopes' as 'better', possibly because the latter were easier to use.[86] It is not clear whether the lecture focused on the technical construction of microscope lenses, or was supplemented with visual demonstrations, although it is highly likely that Winthrop displayed Harvard's simple and compound microscopes to illustrate the lecture. According to Frederic T. Lewis in his now outdated article, Winthrop made little use of Harvard's microscopes.[87] Lewis pointed to the greater interest of Winthrop's student, the inventor Edward Bromfield who performed microscopical demonstrations to colonials using a solar microscope, as discussed in section 2.2.[88] Bromfield graduated in 1742, therefore dating Winthrop's lectures on microscopes to before 1746.

Significantly more is known of Dr. Clossy's use of compound and solar microscopes at King's College (1754), New York.[89] In 1770 and 1771, Clossy used the local gazette to inform potential students that, towards the end of his anatomical and pharmaceutical courses, he would display the circulation of blood – the movement of blood globules – in both small and 'larger creatures'.[90] Clossy did not specify the types of 'creatures' he would use, although eighteenth-century guides to microscopy usually recommended 'the Tails or Fins of Fishes;… the fine Membrane between a Frog's Toes', and 'the Tail of a Water-Newt'.[91] Clossy demonstrated 'proofs of the blood's motion' to students on an individual basis with the compound microscope, and projected the phenomenon to the entire class with the solar microscope.[92] The circulation of blood was one of the most commonly cited microscopical discoveries in the eighteenth century and, after the invention of the solar microscope in the 1740s, was regularly displayed at public demonstrations in England and colonial America.

---

[86] Ibid, p. 110.
[87] Lewis, 'The Advent of Microscopes in America', p. 258.
[88] Ibid.
[89] It is not known whether the microscopes belonged to King's College, or if they were the private property of Clossy who used the instruments in his classes.
[90] *New York Gazette*, 3 September 1770 and 3 June 1771, EAN.
[91] John Cuff, *The description of a pocket microscope* (1744), p. 7.
[92] *New York Gazette*, 3 September 1770 and 3 June 1771, EAN.

This section concludes with a brief discussion of two such displays – both of which were advertised in local gazettes – by itinerant lecturers at the Library Company of Philadelphia and the Library Society of Charleston. These demonstrations identify institutions as sites of *public* microscopy and provide further evidence of the overlapping nature of institutional and public activities. In 1744, William Black recorded that the Scottish lecturer Dr. Alexander Spence(r) – who also performed in the northern settlement of Boston (see section 2.2) – displayed 'Several Curious Objects Shown by the Solar Microscope, together with the Circulation of the Blood'[93] in the Library Company of Philadelphia's 'Library-Room'.[94] In 1767, the Irish lecturer William Johnson – whose demonstration appears to have specifically targeted 'the ladies' – used 'the [solar] microscope belonging to the [Library] Society' of Charleston in 'the Library Society's rooms'.[95] Johnson may have performed similar demonstrations during his earlier visits to Charleston in 1765 and 1766, although it is not known when the society purchased the solar microscope.[96] The following section discusses the public culture of microscopy, including demonstrations, in more detail.

Despite being based on limited evidence and a small number of institutions, this survey of microscopes in colonial colleges and societies has provided useful insights into the nature of institutional microscopy. Institutions owned similar types of microscopes, advertised their instruments, and were also sites of microscopy. Building on the comparative and intellectual approaches of previous scholars, this section develops our understanding of the place of microscopy and the practice of microscopy in colonial institutions.

[93] Quoted from the eyewitness account of William Black's diary entry 5 June 1744 in Cohen, *Benjamin Franklin's Science,* p. 44.
[94] *Pennsylvania Gazette*, 3 May 1744 in Cohen, *Benjamin Franklin's Science,* p. 43.
[95] *South Carolina Gazette,* 16 February 1767 quoted in Shipton, *New England Life in the Eighteenth Century*, pp. 362-363.
[96] Shipton, *New England Life in the Eighteenth Century*, p. 362.

2.2. Microscopy in the public sphere: demonstrations, stores, and auctions

This section examines the ways in which colonials were exposed to microscopy, or engaged with microscopy in the public spheres of Philadelphia, Boston and New York between the 1740s and 1760s. The section focuses on two main types of public and commercial activities: first, it continues the earlier discussion of public demonstrations and, secondly, discusses the trade in microscopes or, more precisely, the *availability* of microscopes in colonial stores and auctions. Printed notices in colonial newspapers and magazines demonstrate the extent to which microscopes and microscopy became familiar components of colonial scientific culture. Lewis made a similar but unsubstantiated claim in 1943, and the lack of subsequent research into the subject almost certainly influenced the opinions of the lawyer Padgitt and the historian Warner, both of whom described public microscopy in the colonial period as minimal and 'scattered' (see section 1.2).[97] However, this section successfully demonstrates the vibrancy of public and commercial microscopy in colonial America, and develops Guenther's recent study of public microscopical demonstrations.[98] Based on the extensive use of printed advertisements as evidence for public activity, the section presents a detailed account of the place of microscopy in colonial scientific culture.

The broadsheet of David Lockwood – an English itinerant lecturer who performed microscopical demonstrations and displayed a musical clock in Boston and Philadelphia in 1744 – is a useful starting point for discussing colonial demonstrations. Lockwood – whose notice is published in Cohen's *Benjamin Franklin's Science* – offered to display numerous specimens with the newly invented solar microscope.[99] These included: 'incredibly magnified' microscopical 'Animalcules, 'small insects', 'living and dead Objects, too tedious to mention', 'the Circulation of the Blood in a Frog's

[97] Lewis, 'The Advent of Microscopes', p. 259;Padgitt, *A Short History of the Early American Microscopes,* p.2; Warner, 'Exploring the Inner Labyrinths of Creation', p.9.
[98] Guenther, 'Enlightened Pursuits: Science and Civic Culture in Anglo-America', p. 106, pp. 108-109, p. 108n21.
[99] Cohen, *Benjamin Franklin's Science,* p. 59.

Foot, a Fish's Tail…a Flea, and Louse', and the movement of the 'Bowels' of insects.[100] Lockwood performed the demonstrations in Boston between January and May,[101] and Philadelphia between July and August.[102] The broadsheet and other adverts reveal useful details such as the price of admission and the sites in which the demonstrations were held. As the solar microscope required sunlight to operate and projected images onto a sizable surface, Lockwood performed the demonstrations in the 'large [and] commodious' rooms of individuals between 'Ten in the Morning to Two in the Afternoon' during the spring, and between 'Ten in the Morning to Four in the Afternoon' during the summer. The price of admission fluctuated both within and between the two settlements. Colonials in Boston paid five shillings in January and three shillings from March onward, whereas in Philadelphia – where there was a tiered arrangement of seats for 'six or more' individuals[103] – the fee increased to between six and eighteen shillings. The price of each tier increased incrementally from six shillings in the 'third' row, twelve shillings in the 'Second' row, and eighteen shillings for the prestigious 'Foreseats' in the front row, thereby targeting a range of paying customers.[104] During the last week of the demonstrations, the 'lowest' price fell to 'One Shilling each'.[105] Unfortunately, there are no eyewitness accounts for Lockwood's demonstrations in the existing literature.

The extent of Lockwood's success is difficult to determine, however, the frequency of the advertisements, the length of Lockwood's stay in Boston, and the content of the adverts suggest that the demonstrations were successful. As the historian Cohen wrote, regular advertisements in Philadelphia between July and August 'attested to' the 'popularity' of Lockwood's general 'attraction' among colonials.[106] In Boston, where

---

[100] Ibid.
[101] *Boston Gazette,* 10 and 17 January 1744; *Boston Evening Post*, 5 and 12 March 1744, 30 April 1744, 7 and 14 May 1744, EAN.
[102] Cohen, *Benjamin Franklin's Science,* p. 58; *Pennsylvania Gazette,* 2, 9, 16 and 23 August 1744, EAN.
[103] *Pennsylvania Gazette,* 2, 9, 16 August 1744, EAN.
[104] Ibid.
[105] *Pennsylvania Gazette,* 23 August 1744, EAN.
[106] Cohen, *Benjamin Franklin's Science,* p. 60.

Lockwood stayed for twice as long, colonials were encouraged to see the solar microscope in a number of ways. For instance, following the initial microscopical demonstrations at Mr. Browne's house, Lockwood promoted the microscope by describing the positive reactions of other colonials who had 'ever yet seen it'.[107] The 'Entertaining…Microscope' had, colonials were led to believe, 'given entire Satisfaction to all Gentlemen and Ladies' who had attended previous demonstrations at Mr. Browne's house in January and Mr. Clear's house in March.[108] These experiences encouraged colonials to attend the demonstrations and, moreover, created a reputation for Lockwood's microscopical demonstrations within the public sphere. Lockwood also facilitated the exposure of colonials to microscopical displays and to microscopical knowledge by performing at different sites 'for the Convenience of the Curious' who lived at different 'End[s]' of the town.[109] Colonials were invited to attend demonstrations in the 'large [and] commodious rooms' of Mr. Browne in 'Kingstreet' between January and early March, 'the House of William Clear…at the South End of Boston' between March and April, and 'the House of Mr. James Viscount…at the North End' of the settlement between April and mid-late May.[110] Further research may ascertain the extent to which Browne, Clear and Viscount engaged with microscopy. By mid-July, Lockwood had relocated to Philadelphia.[111] Little is known of Lockwood's activities in Philadelphia, although the evidence reveals he was based at Mr. Videll's school on Second-Street throughout August.[112]

There are no eyewitness accounts for Lockwood's microscopical demonstrations, but colonials did record their reactions to performances by the Scottish itinerant lecturer Dr. Alexander Spence(r), a colonial gardener, and a colonial student. These eyewitness accounts reveal the identity of

---

[107] *Boston Evening Post*, 5 and 12 March, EAN.
[108] Ibid,; *Boston Evening Post,* 30 April, 7 and 14 May 1744, EAN.
[109] *Boston Evening Post*, 5 March 1744, EAN.
[110] *Boston Gazette*, 17 January 1744, EAN; *Boston Evening Post*, 5-12 March 1744, EAN*; Boston Evening Post*, 30 April, 7 and 14 May 1744, EAN.
[111] Cohen, *Benjamin Franklin's Science,* p. 58.
[112] *Pennsylvania Gazette*, 2, 9, 16 and 23 August 1744, EAN. For information about Videll see Wendy Bellion, *Citizen Spectator: Art, Illusion, and Visual Perception in Early National America* (Chapel Hill: University of North Carolina Press, 2011), p. 44n23.

other audience members and sites of public microscopy. For instance, William Black recorded in his diary that 'Doctor Spencer' had displayed the 'Circulation of Blood' at the 'State House' in Philadelphia to, he added, the 'Satisfaction' and entertainment of himself as well as 'Colonel Beverley and the Gentleman of the Levee'.[113] The gardener James Alexander, who worked in a botanical garden near Philadelphia, also performed microscopical demonstrations to visitors. John Smith's description of the unidentified specimen at the garden, which had been 'magnified 1/10th of an Inch to 4 feet' by the solar microscope, was almost certainly a botanical specimen.[114]

The most interesting eyewitness account is a poem in which the writer – a young woman in Boston – described the impact that a 'well-spent Hour' viewing 'A Thousand untho't Glories' had had on her 'Soul'.[115] The poem, which was published in the *Boston Newsletter* (1746), was written in response to a demonstration by Edward Bromfield, mentioned earlier as a student at Harvard (see section 1.1) in the attic of his house on Beacon Hill. The 'Act of Praise', she wrote, had displayed 'The Wonders of my God' through the 'inchanting [sic] Ray' and 'Glass' of the solar microscope.[116] The account points to the explicit engagement of a female with microscopy and provides evidence for Parrish's passing reference to the general exposure of colonial women to microscopical knowledge.[117] The poem is particularly interesting for its direct references to the religious nature of microscopy. An 'enthusiastic minister' who read 'a treatise upon microscopes' and displayed a solar microscope for a 'small fee' to passengers on a ship to Albany, also enlarged on the 'hidden wonders' of God's creation.[118] A study into the religious responses of colonials to microscopical knowledge in the vein of Cantor's studies of the religious

---

[113] Cohen, *Benjamin Franklin's Science,* p. 58.
[114] Quoted in Bell, *Patriot-Improvers,* pp. 477-478. The botanical garden was owned by Thomas Penn.
[115] *Boston Newsletter,* 21 August 1746. The poem is published in full in Shipton, *New England Life in the Eighteenth Century,* p. 485.
[116] Ibid.
[117] Parrish, 'Women's Nature: Curiosity, Pastoral, and the New Science in British America', pp. 202-204.
[118] The information is based on the eyewitness account of the Scottish traveller Alexander Hamilton, discussed in Michael B. Guenther, *Enlightened Pursuits,* p. 108.

responses of English Quakers to astronomy, and Delbourgo's assessment of the religious responses of colonial Americans to electricity would contribute to the literature on religion and science.[119] The reactions of the female poet and the minister are the only religious reactions to microscopy that I could find.[120]

In addition to witnessing the use of microscopes in demonstrations, colonials were also invited to purchase solar and other types of microscopes at retail outlets for their own private use. The remainder of this section discusses the commercial culture of microscopy, and the availability of newly imported and used microscopes in colonial stores and auctions. Printed adverts suggest that there was a significant market for microscopes in the mid-eighteenth century, therefore dating the trade in microscopes to before Padgitt's date of 1796.[121] Padgitt's emphasis on the trade in American-manufactured microscopes during the early nineteenth century obscured the activity of colonial retailers who, as this section shows, also advertised microscopes. Although the elite colonial naturalists James Logan and Alexander Garden purchased their microscopes from London (see sections 3.1, 3.4 and 4.1), colonials were not always 'in the inconvenient position of having to purchase their instrument abroad'.[122] This section concentrates on the retailers and auctioneers who advertised their microscopes in Boston and New York during the 1750s and 1760s. Unfortunately, I found little evidence for trade in Philadelphia and Charleston where, as will be seen in the following chapters, Logan and Garden practised microscopy. The retail culture of microscopes in Philadelphia and Charleston requires further research by historians who have direct access to newspaper archives.

---

[119] Cantor, *Quakers, Jews, and science: religious responses to modernity and the sciences in Britain, 1650-1900* and Delbourgo, *An Amazing Scene of Wonders.*

[120] Unfortunately, there is little evidence that the elite naturalists who are discussed in the following two chapters – the Quaker James Logan, the lapsed Quaker John Bartram, and the Scottish Presbyterian Alexander Garden – explicitly referred to the hidden wonders of their own microscopical observations.

[121] Padgitt, *A Short History of the Early American Microscopes*, p.2.

[122] Ibid.

Advertisements for microscopes appear to have been a mixture of long-term and short-term notices. Some retailers and auctioneers consistently advertised microscopes and other scientific instruments on a weekly basis over a number of years. There were also, however, a number of short-term notices by retailers who did not regularly stock microscopes, or who advertised the instrument on behalf of the instrument's owner. For instance, in Boston in 1738, a microscope was advertised alongside corks and pickled pork.[123] In 1754, 'Messr'rs Gilbert and Lewis Debloir' in Boston advertised the scientific instruments of a colonial who was leaving for Europe, which included a 'Universal single and double microscope, with a Solar Apparatus'.[124] Furthermore, the microscope and telescope of a bankrupt colonial, also in Boston, were both advertised for sale in 1765.[125] These sporadic notices suggest that microscopes also become available in colonial stores as a result of the individual circumstances of colonials, and not just as the result of the retailer's deliberate efforts to import and to supply scientific instruments.

Before I discuss these leading retailers, I would like to focus on one of the most interesting advertisements that I came across during the course of my research. The notice, which was published in New York in 1753, raises interesting questions concerning the role of women in microscopical activities in colonial America, the market for microscopes in New York, and the place of microscopy in the scientific culture of the settlement. The notice advertised the business of Balthaser Sommer's unnamed widow who traded in optical instruments, spectacles, and ground 'Microscope Glasses' and other 'sorts of Optical Glasses' which she offered to sell 'at the most reasonable rates'.[126] Sommer, a respectable instrument maker from Amsterdam, migrated to New York in 1749 following the death of her husband in 1733. According to Zuidervaart, the couple's workshop – in which Sommer's wife had performed 'the lens-grinding role' – had been 'One of the most important optical firms' in the early eighteenth century,

[123] *New England*, 14 April 1741, EAN.
[124] *Boston Post-Boy*, 27 May 1754, EAN.
[125] *Boston Post-Boy*, 16 December 1765, EAN.
[126] *New York Gazette, or the Weekly Post-boy*, 21 May 1753.

and was continued by Sommer's widow after his death.[127] Her lenses had 'been highly recommended' in the Dutch edition of Henry Baker's bestselling guide to microscopy, *The Microscope Made Easy* (1744), and her advertisement in New York, as noted by Zuidervaart, appears to be 'one of the oldest known activities of an optician' in colonial America.[128]

Further research may locate additional advertisements for Sommer's business. At present, however, we know only that Sommer offered to produce 'Microscope Glasses' for colonials in New York in mid-1753 who had most likely lost or damaged their lenses, with little idea of the success or longevity of the business.[129] Did Sommer have prior knowledge of the instrument market in New York and establish the business in order to meet an existing demand for microscopes and optical instruments? Did she continue to trade after 1753, or relocate to another colonial settlement? Notwithstanding these uncertainties, Sommer's reputation, her provision of 'Microscope Glasses', and the apparent growth of a 'scientific community' in New York during the 1750s suggest that interest in microscopy may have coincided with the beginnings of a nascent scientific culture in New York.[130]

The remainder of this section discusses the systematic supply of microscopes by leading retailers and the sale of microscopes at auctions. The long-term advertisements of the retailers who regularly imported and stocked microscopes first, reveal specific details such as the makes and prices of instruments and, secondly, indicate the general types of microscopes which were considered to be in demand by colonial customers. Retailers who provided such details usually owned sizable collections of microscopes and other scientific instruments, such as telescopes and globes, and often supplied books on natural history alongside household goods.

---

[127] Huib J. Zuidervaart, 'The 'Invisible' Made Visible: Telescope Making in the Seventeenth and Early Eighteenth-century Dutch Republic', *From Earth-Bound to Satellite: Telescope, Skills and Networks,* ed. Alison Morrison-Low et al. (Leiden; Boston: Brill, 2012), p. 96n139, p. 95, pp. 95-96.
[128] Ibid, p. 96.
[129] *New York Gazette, or the Weekly Post-boy,* 21 May 1753.
[130] Michael Kamen, *Colonial New York: A History,* 2nd edition (Oxford: Oxford University Press, 1996), p. 243.

Two such retailers were the Condys in Boston – a family-run business owned successively by Jeremy, Sarah, and James-Foster in Union Street between 1762 and 1773 – and Garrat Noel in New York who advertised microscopes between 1763 and 1768.[131] Both the Condys and Noel regularly stocked single, compound, solar, parlour and pocket microscopes. The supply of solar, parlour and pocket microscopes is particularly interesting, and offers insights into the social nature of microscopy as well as the sites in which microscopy may have been practiced. For instance, solar and parlour microscopes were suited to social occasions and required a darkened room, whereas pocket microscopes were designed to be used outdoors in gardens and fields. Both the Condys and Noel stocked Wilson-type screw-barrel microscopes which had been popularised by the London optician James Wilson. Between October and December 1764, the Condys advertised Benjamin 'Martin's microscope'[132] who, as mentioned in section 2.1, supplied a set of microscopes to Harvard College in 1764. The absence of the microscope after this date suggests either that the instrument was sold, or that the Condys continued to stock the instrument but ceased to specify its maker.

The Condys also advertised the price of the microscopes. The store offered 'Microscopes of various sorts, from 3 piastereens [sic] to 30 Dollars'[133] in 1767 and, in 1769, 'large Microscopes' and 'Pocket' microscopes from between '2 Pistareens to 13s4d.L.M.Price'.[134] Although James-Foster Condy retracted his claim that his scientific instruments were 'as cheap as at any Store in Boston or America (without exception)',[135] he did stress that his prices were 'as low… as at any Store in town',[136] and that

[131] Adverts by the Condys were published in *Boston Evening Post*, 8 and 15 February 1762, 1 and 15 March 1762, 12 April 1762: see the footnotes below for additional adverts. Adverts by Garrat Noel – who also stocked Henry Baker's bestselling guide to microscopy, *The Microscope Made Easy* – were published in *New York Gazette*, 20 June 1763, 9 and June 1766, 9 March 1767, 30 May 1768*; New York Mercury*, 7 July 1766; *New York Journal*, 27 November and 4 December 1766, and 3, 10 and 17 November 1768, EAN.
[132] *Boston Evening Post*, 29 October and 12 November 1764, EAN; *Boston Gazette*, 29 October and 19 November 1764, EAN; *Boston Post-Boy*, 5, 19 and 26 November 1764, EAN.
[133] *Boston Evening Post*, 2 and 9 February 1767, EAN.
[134] *Boston Evening Post*, 13 February 1769, EAN.
[135] *Boston Gazette*, 23 November 1772, EAN
[136] *Boston Evening Post*, 19 August 1771, EAN;

the instruments were 'Sold upon the lowest Terms'.[137] Condy's emphasis on the affordability of his microscopes and scientific instruments suggests that there was both a considerable demand and a competitive market for such instruments.

The final part of this section discusses the availability of microscopes at auctions, or 'Public Vendue[s]', which were held in Boston between the mid-1750s and mid-1760s. Auctions were held at the house of the previous owner or at auction rooms. There were at least fifteen separate notices for microscopes in Boston between 1756 and 1765. With the exception of Arthur Savage's 'three pillar'd reflecting microscope', which Savage advertised in 1757, the types of microscopes were not specified.[138] Elias Dupee held nine of the fifteen auctions at his auction room. Each notice advertised a 'neat' or 'curious' microscope between June 1765 and March 1768 alongside household goods, clothes, furniture, watches, books, and other items on a weekly basis.[139] The microscopes were the only scientific instruments in Dupee's stock. However, the regularity with which Dupee offered the instruments in June 1766 and July 1767 – the auctions were held three times a week and were advertised on a weekly basis – raises the possibility that the microscopes might have been the same instrument, or a small number of instruments which failed to sell. The source of Dupee's instrument(s) is not known. However, the used microscopes of five deceased and bankrupt colonials in Boston were offered at auctions between 1756 and 1761. In these instances, auctions transferred privately-owned microscopes into the public sphere: furthermore, if the sale was successful the publicly advertised instrument moved back into the private sphere. Four of the five individuals were named in the adverts, no doubt to persuade readers that the microscopes and other possessions were as respectable as their wealthy and elite owners. These included 'John Franklin, Gentleman,

[137] *Boston Evening Post*, 5 and 14 June 1773, EAN; *Massachusetts Spy*, 17 June 1773, EAN.
[138] *Boston Gazette*, 10 October 1757, EAN.
[139] Elias Dupee: *Boston Post-Boy*, 24 June and 5 August and 8 July 1765, 14 July and 21 July 1766, 15 June and 22 June and 29 June 1767, 7 March 1768; *Boston Gazette*, 8 July 1765 and 7 March 1768; *Supplement to the Boston Evening Post*, July 14 and 21 1766; *Boston Evening Post*, July 21 1766, EAN.

deceased',[140] Esquire Edmund Quincy,[141] 'the Honorable Paul Mascarene'[142], and 'Mr. Owen Harris, deceased'.[143] Franklin and Quincy owned few scientific instruments other than the microscope, whereas Mascarene and Harris owned 'Sundry Mathematical [and philosophical] Instruments'.[144] Further investigation into the scientific interests of these individuals, particularly Mascarene and Harris, might uncover evidence of their practice or general engagement with microscopy. This type of study would also be useful for determining the presence of microscopes in private instrument collections, thereby complementing the earlier survey of microscopes in institutional collections in section 2.1.

This section on public microscopy has shown that colonials were presented with opportunities to attend microscopical demonstrations at the houses of individual colonials and others sites, and to purchase new and used microscopes from wholesale retailers and auctioneers. Printed adverts are excellent sources for exploring public microscopy in colonial America. Based on the extensive use of such adverts, this section has presented convincing evidence that public activities in colonial America were both vibrant and diverse.

Conclusion

This chapter has discussed the development of microscopy in colonial America and has demonstrated the multifaceted natures of institutional and public microscopy-related activities. By the mid-eighteenth century, new and used microscopes appear to have become familiar and highly publicised instruments which moved between the institutional, public and private spheres of colonial America. Microscopes were made available to professors, students, paying customers, and the general public in a number of educational, private and commercial spaces. Further research into

[140] *Boston Gazette,* 9 August 1756, EAN.
[141] Ibid, 24 April 1758, EAN.
[142] Ibid, 9 June 1760, EAN.
[143] *Boston Evening Post,* 20 and 30 July 1761, EAN.
[144] *Boston Gazette,* 24 April 1758 and *Boston Evening Post,* 20 July 1761, EAN.

institutional and public activities – particularly of activities in Philadelphia and Charleston for which I found little evidence – will enrich our understanding of the extent to which microscopes were used as educational tools and advertised for sale in the American colonies. Notwithstanding the fragmentary evidence, the chapter has shown the vibrancy of institutional and public microscopical activities in the scientific cultures of colonial America.

The remainder of this study examines the microscopical activities of two elite naturalists. Chapter three discusses the botanical microscopy of the secretary James Logan in Philadelphia, Pennsylvania, during the first half of the eighteenth century. The final chapter discusses the animal microscopy of the Scottish physician Alexander Garden in Charleston, South Carolina, in the second half of the eighteenth century. Logan and Garden are not known to have engaged with institutional and public activities in Philadelphia and Charleston. Instead, Logan's and Garden's activities – their engagement with microscopical theories and discoveries, utilisation of microscopes and texts, and communication with European and colonial naturalists – demonstrate the circulation of microscopy-related materials and knowledge within the correspondence networks of *elite naturalists* in the eighteenth century.

Chapter 3. Philadelphia as a Site of Microscopy: The Observations of James Logan, 1710–47

This chapter examines the microscopy of James Logan (1674-1751), the Irish Quaker who migrated to Philadelphia at the age of twenty-five and became a prominent member of the political, judicial, and scientific communities. Between 1710 and 1747, Logan studied the microscopical features of plants and pollen, introduced microscopy to a colonial botanist, discussed his findings with a small number of colonial and European naturalists, and published a handful of observations in his botanical treatise. The chapter builds on the work of earlier scholars who published evidence of Logan's microscopy. It supplements their evidence with new source material to present a detailed account of Logan's engagement with microscopical theories, instruments and texts over the thirty year period. By exposing the place of microscopy in some of Logan's most familiar achievements and relationships, the study improves our understanding of one of the foremost botanists and founders of science in colonial Philadelphia, and enriches our understanding of Logan's roles as botanist, tutor, and bibliophile.

The chapter is divided into four sections. The first section provides a general background to Logan as a colonial naturalist, and discusses Logan's earliest known exposure to microscopy between 1710 and 1716. The following two sections discuss the place of microscopy in two of Logan's most widely cited activities. First, Logan's experiments into the sexual generation of maize and other plants between 1728 and 1747 (section 3.2) and, secondly, Logan's relationship and tutelage of the farmer and plant collector John Bartram between 1736 and 1737 (section 3.3). The final section concludes with a short account of Logan's knowledge of developments in the book and instrument trades in London, practice of microscopy, and interaction with the printer Benjamin Franklin during the mid-1740s.

3.1 James Logan as a Naturalist in Philadelphia

This section provides the necessary background to Logan's natural history and discusses Logan's earliest known microscopical activities. It must be noted that microscopy does not appear to have been Logan's primary scientific interest: Logan expressed interest in a number of natural historical, natural philosophical and medical subjects as reflected in the contents of his library collection.[145] Although the precise date of Logan's exposure to microscopy is not known, we can date Logan's earliest known engagement with the subject to 1710. The section concludes with an analysis of Logan's microscopical activities in London in 1710 and Philadelphia in 1716.

Logan became interested in botany before his migration to Philadelphia in 1699 and continued to engage with the subject in the colonial settlement. Logan almost certainly associated with the Quaker grocer and botanist Thomas Goldney in Bristol, and maintained correspondence with the Quaker botanist Thomas Story, who visited Philadelphia between 1698 and 1714.[146] Logan also communicated with a number of early botanists in Philadelphia, five of whom formed collections of plants before 1730.[147] As Raistrick and Cantor have shown, Quakers were drawn to botany because of the early Quaker tradition to contemplate natural productions as evidence of God's creation: 'love of nature was part of… love of God'.[148] However, although Logan's interest in botany reflected this wider tradition, he is not known to have expressed religious responses to his microscopical observations.

---

[145] For a useful introduction to Logan's scientific interests, see Lokken, 'The Scientific Papers of James Logan'.
[146] Raistrick, *Quakers in Science & Industry*, p. 250.
[147] Ernest Earnest, *John and William Bartram, Botanists and Explorers, 1699-1726, 1739-1823* (Philadelphia: University of Pennsylvania Press, 1940), pp. 17-18, p. 19; Joseph Ewan, 'Calendar of Events' in *A Short History of Botany in the United States*, ed. Ewan, Joseph (New York; London: Hafner Publishing Company, 1969), p. 2.
[148] Raistrick, *Quakers in Science & Industry*, pp. 243-247, p. 246; Cantor, 'Quakers and Science' in *The Oxford Handbook of Quaker Studies*, ed. Stephen Angell and Dandelion, Pink (Oxford; New York: Oxford University Press, 2013), pp. 523- 526. See also Cantor, *Quakers, Jews, and Science.*

Despite the uncertainties surrounding the date, location and nature of Logan's initial exposure to microscopy, we know first, that Logan expressed interest in the subject during a visit to London in 1710 and, secondly, that he owned and used a microscope in Philadelphia in 1716. The evidence is based on Logan's recollection of the events over thirty years after they occurred and were communicated in letters to the Quaker wool-merchant Peter Collinson in London. While in London, Logan microscopically examined human spermatozoon with a Wilson single screw-barrel microscope, a bestselling instrument that was popularised by the London optician James Wilson in 1702.[149] Logan also purchased two collections which contained the microscopical observations of the Dutch microscopist Antoni van Leeuwenhoek, for eighteen shillings.[150] Leeuwenhoek's volumes were two of a small number of texts Logan purchased in the city, suggesting a priority for microscopical knowledge over other subjects. However, Logan left little evidence of his reactions to Leeuwenhoek's observations: the bibliographer Edwin Wolf found no other mention of the texts in Logan's correspondence, and the texts themselves were not, unlike other publications in Logan's library, annotated. Logan's actions in London could be interpreted as having been spontaneous – excited responses to a subject that Logan had been unaware of until his visit to the 'intellectual waters' of London – or, alternatively, they may have reflected the continuation of an earlier interest in microscopy which Logan then supplemented with additional information while in the city.[151]

The motivation for Logan's actions and the extenuating circumstances for his use of the Wilson microscope in London remain unclear. Logan did not specify how or where he gained access to the Wilson microscope. The sighting of the 'Animalcula in Semine Masculum' – which Logan described as 'little very active Creatures' whose shape was 'exactly given' in John Harris's *Lexicon Technicum* (1710)[152] – may have been made at a meeting

[149]James Wilson, 'The Description and Manner of Using a Set of Small Pocket Microscopes, Made by James Wilson...', *Philosophical Transactions* (1702), 23, pp.1241-1247.
[150] LJL, p. 279.
[151] LJL, p. xix.
[152] Logan to Peter Collinson, 15 April 1746, LJL, p. 334.

of the Royal Society of London which we know Logan visited for a lecture, or at the house of one of Logan's associates as part of a social gathering or demonstration.[153] Another possibility is that Logan purchased a Wilson-type microscope and studied the 'Creatures' in a private setting. We know a purchase had been made by 1716 when, Logan recalled, he had used a 'Microscope (one of E[dmund] Culpeppers [sic] making in imitation of J[ames] Wilsons [sic]' in Philadelphia (see Appendix 1.1).[154] One possible scenario is that Logan accessed the Wilson microscope and made observations alongside other naturalists in London, but purchased Culpeper's 'imitation' at a later date.[155]

As mentioned, Logan practiced microscopy in Philadelphia 'some time in ye summer [of] 1716' and invited colonials to use the Culpeper Wilson-type microscope.[156] Logan recalled his 'astonishing' observations of 'Tartar' in a letter to the Quaker wool merchant Peter Collinson, with whom Logan communicated on the subject of microscopy into the 1740s, and from whom Logan received a solar microscope (see section 3.4). Logan wrote that he had seen a tartar-like substance 'in motion' on casks of wine which he 'immediately applied… to my Microscope', and observed the 'very brisk and entertaining Motion' of 'bright &… somewhat transparent' animals which resembled 'eels' and which, Logan reiterated, he remembered to have been 'all clear & shining &… beautiful'.[157] Furthermore, Logan had invited 'fr[ien]ds and acquaintance', including his 'wife and her brother-in-law Israel Pemberton', to observe the specimens over 'Several days'.[158] The letter contains the most detailed account of Logan's microscopical observations. It is particularly remarkable for its evidence of first, Logan's practice of microscopy in Philadelphia before the botanical investigations in 1728 (see section 3.2) and, secondly, of the social nature of Logan's

[153] LJL, p. xix.
[154] Logan to Peter Collinson, 15 April 1746, Philadelphia, Historical Society of Pennsylvania, Letterbooks of James Logan, Book G, p. 9.
[155] Ibid.
[156] Ibid. This is the same letter in which Logan described his observation of animalcule in London: the extract was not included by the bibliographer Edwin Wolf in his *The Library of James Logan* as it made no mention of a text.
[157] Ibid.
[158] Ibid.

microscopy prior to his engagement with the farmer John Bartram in the mid-1730s (see section 3.3).

The section concludes with a discussion of Logan's collection of microscopy-related publications. By 1747, Logan owned at least ten texts, including the two volumes by Leeuwenhoek. Logan engaged with five of the publications during his experiments into the sexual generation of plants in the late 1720s and 1730s. These were William Wollaston's *Religion of Nature Delineated* (1726) and Richard Bradley's *New Improvements in Gardening* (1726) – both of which inspired Logan to investigate plant generation in 1727 [159] – followed by the publications of two seventeenth-century botanical microscopists, Nehemiah Grew's *Anatomy of Plants* (1682) and Marcello Malpighi's *Opera Omnia* (1686).[160] Logan also responded to the description of animal spermatozoon in John Harris's *Lexicon Technicum* (1710), to John T. Needham's *New Microscopical Discoveries* (1745), George Adams's *Micrographia Illustrata* (1745), and purchased the new edition of Robert Hooke's seventeenth-century text *Micrographia* (1745).[161] Logan was also aware of the London microscopist Henry Baker and the London instrument maker John Cuff, although the bibliographer Edwin Wolf did not find evidence of Baker's and Cuff's publications in Logan's library.[162] In the mid-1740s, Collinson forwarded a letter he had received from his 'fr[ien]d Baker' – this was almost certainly Henry Baker – to Logan in Philadelphia.[163] The content of the letter and Collinson's reasons for sending the correspondence are not known, but Logan did not seem to be aware of Baker's bestselling guide to microscopy, *The Microscope Made Easy* (1742), and asked Collinson to 'inform me who thy fr[ien]d Baker is… and what his business is'.[164] By October 1747, Logan had associated Baker with microscopes, and mentioned Baker alongside the instrument makers

[159] LJL, p. 69, p. 525. Logan owned the 5th edition of Bradley's text.
[160] LJL, p. 196, p. 306.
[161] John T. Needham's *New Microscopical Discoveries* (1745), LJL, p. 334; George Adams, *Micrographia Illustrata* (1745), LJL, p.5.; Robert Hooke, *Micrographia Restaurata* (1745), LJL, p. 253.
[162] There are no entries for Baker or Cuff in LJL.
[163] Logan to Peter Collinson, undated although the letter may have been written in late 1747, Letterbooks of James Logan, Letterbook G, p. 8.
[164] Ibid.

George Adams and John Cuff.[165] However, the extent of Logan's knowledge of Baker's microscopy is not known. We can state with more certainty that Logan received information about John Cuff's microscopes (see section 3.4): as there is no record of Cuff's publications in Logan's library, Logan may have received the information from a correspondent.

This section shows that Logan practiced microscopy in London and Philadelphia, and interacted with other colonials on the subject prior to his microscopical investigations into the generation of plants in 1728. The following three sections discuss distinct phases of Logan's microscopy between 1728 and 1747, during which Logan utilised microscopes and microscopy-related texts, interacted with colonial and European naturalists, and generally engaged with the subject of microscopy.

3.2 'Particles of *Farina*':[166] The Microscopical Element of the Maize Experiments

Between 1727 and 1747, Logan examined pollen, or '*Farina',* with a microscope as part of his investigations into the sexual generation of plants, published his findings in a botanical treatise, and wrote to a small handful of European and colonial naturalists on the subject.[167] Logan examined individual 'Particles of *Farina*' in order to note their physical appearance and to determine whether pollen entered plants to fructify the seed.[168] With the exception of Frederic B. Tolles, who published evidence of Logan's microscopical observations, few historians considered the microscopical element of Logan's botanical experiments.[169] Historians and students of colonial botany will be familiar with the following account: that Logan planted four plots of maize, altered the stamens in order to prevent the pollen from accessing the seed, and counted the number of fertilised and

[165] Logan to Peter Collinson, 26 September 1747, LJL, p. 213.
[166] Logan, *Experiments and Considerations,* quoted in Lokken, 'The Scientific Papers of James Logan', p. 86.
[167] Ibid.
[168] Ibid.
[169] Tolles, *James Logan and the Culture of Provincial America,* p. 200, p. 201.

unfertilised grains. Logan stressed these actions in his initial account of the trials in the *Philosophical Transactions* (1735) and in the opening passages of the *Experimenta* (1739).[170] Earlier scholars did not produce inaccurate accounts of the maize experiments. However, their emphasis on sexual generation, hybrid versions of maize, and on particular passages in Logan's botanical treatise portrayed a distinct version of events which, when perpetuated in later studies, became *the* standard account now known among historians.[171] However, a closer reading of both the *Experimenta* and Logan's published correspondence also reveals the microscopical element of Logan's botany. This chapter therefore enhances and complements the current literature to present a more rounded account of Logan's botany.

Logan used the microscope as part of his investigations into the sexual generation of plants based on the twin theories of preformationism and animalculism. The theories had been put forward in the late seventeenth century by naturalists who argued that plants existed in miniature, preformed states and were carried by the male seed – the pollen – to the female to be nourished.[172] The ideas were supported with experimental evidence, philosophical speculation, and through analogies between the plant and animal kingdoms. Anthers – which released pollen – were considered to be the male parts of plants, whereas stamens – which received the pollen and communicated with the interior of the plant – were considered to be the female organs. Pollen – which had different shapes in different species of plants and was believed to be essential for successful generation – was described as the botanical equivalent of the human spermatozoon which Logan had observed in London in 1710 (see section 3.1). John Farley, in his history of sexual reproduction, described the

---

[170] James Logan, 'Some Experiments Concerning the Impregnation of the Seeds of Plants', *Philosophical Transactions* (1735), vol. 39, pp. 192-195; Logan, *Experiments and Considerations on the Generation of Plants* (Latin 1739; English translation 1747) in Lokken, 'The Scientific Papers of James Logan', pp. 84-85.

[171] Conway Zirkle, *The Beginnings of Plant Hybridization* (University of Pennsylvania Press, 1935), p. 70, p. 102, p. 144.; Zirkle, 'Plant Hybridization and Plant Breeding in 18th-Century American Agriculture', *Agricultural History*, 43:1 (January, 1969), p.30.; Tolles, 'Philadelphia's First Botanist: James Logan', *Isis*, 47:1 (March, 1956), pp. 28-29.; Tolles, *James Logan and the Culture of Provincial America*, pp. 198-200.

[172] Shirley A. Roe, *Matter, Life, and Generation: Eighteenth-century embryology and the Haller-Wolff debate* (Cambridge; London: Cambridge University Press, 1981), pp. 2-3.

'botanical equivalent' of the animalcular theory as 'pollenism'.[173] Of the small number of botanists who provided experimental evidence for the fructifying role of pollen in the late-seventeenth and early eighteenth centuries, few studied the anthers, stamens and pollen of plants in microscopic detail and instead investigated the role of pollen on the visible scale with the naked eye.[174] Logan, however, investigated the role of pollen on both the visible *and* microscopical scales. Based on Logan's earlier use of a Culpeper Wilson-type microscope in 1716 (see section 1.1), I assume that the same instrument was used in the botanical observations. The section discusses Logan's microscopical observations of pollen in the late 1720s, the publication of his findings in 1739, and concludes with a brief discussion of his engagement with the subject in 1746.

The evidence dates Logan's microscopical studies of plants and pollen to spring 1728. Logan examined the 'parts of flowers' in order to observe the minute features of anthers and stamens.[175] The English botanist Nehemiah Grew had used microscopes to study such features in the late seventeenth century.[176] Furthermore, the Linnaean system of classification which was based on the characteristics of anthers and stamens was criticised by a leading contemporary naturalist for, as Schiebinger wrote, its dependence 'on characteristics so minute and inconsequential that a naturalist had to carry a microscope… in order to recognize a plant'.[177] In addition to anthers and stamens, Logan examined the appearance of pollen. By April, Logan had observed the agreeable and entertaining 'forms' and 'Shapes' of pollen 'in different flowers & blossoms':[178] these included the Cherry Peach – which had only a 'very few number' of 'fine' and 'transparent

[173] John Farley, *Gametes & Spores: Ideas about Sexual Reproduction, 1750-1914* (Baltimore; London: The Johns Hopkins University Press, 1982), p. 20.
[174] Sébastian Vaillant and Richard Bradley used microscopes at some stage in their investigations: see Roger L. Williams, *Botanophilia in Eighteenth-Century France: The Spirit of the Enlightenment* (Dordrecht; Boston; London: Kluwer Academic Publishers, 2001), pp. 14-16. A.G. Morton, *History of Botanical Science: an account of the development of botany from ancient times to the present day* (New York; London: Academic Press, 1981), p. 240.
[175] Logan to William Burnet, 18 April 1728, in Tolles, *James Logan*, p. 75.
[176] Nehemiah Grew, *Anatomy of Plants* (1682).
[177] Londa Schiebinger, 'Gender and Natural History', *Cultures of Natural History*, p. 172.
[178] Logan to William Burnet, 18 April 1728, Letterbooks of James Logan, volume III, Section C, p. 202.

globules'[179] – and the tulip. Logan communicated his findings in both written comments and four small sketches. The sketches, which Logan drew in his letter to William Burnet in New York, illustrated Logan's comment that the 'particles' of pollen which he had observed in 'different flowers & blossoms' were 'very distinct in themselves' but did 'not… differ much in their [overall] Shape'.[180] The drawings – which are the only microscopical illustrations by Logan that I could find – therefore became progressively rounder and smaller. Logan did not state the identities of the plants. However, the first sketch may have represented the 'acuminated' shape of tulip pollen which Logan observed in early April.[181] It must be noted that Bradley's *New Improvements in Gardening* (1726), which Logan read before the observations, mentioned the colour of tulip pollen but not its actual shape.[182] Logan described the appearance of the pollen to his brother in Bristol, writing that: 'the tulip of w[hi]ch we have one early sort here already in flower [had been]… cover'd plentifully with a dust, each particle of which', Logan wrote, 'is form'd somewhat like a Grain of wheat, but more acuminated, at both ends, like a plum tree leaf & afford a very entertaining Spectacle'.[183] The shape of wheat – which Bradley likened to the shape of another type of pollen that he illustrated in *New Improvements* (1726), and which Logan described in the *Experimenta* (1739) as 'oblong' – may have been represented by the second sketch.[184] It is not known whether Logan examined the pollen of wheat with the microscope, or based his information on Bradley's illustration.

By the mid-1730s, Logan's knowledge of the different shapes of pollen had improved. In 1728, Logan had believed that pollen from different species of plants did 'not… differ much in their [overall] Shape' and had

[179] Logan to William Logan, 8 April 1728, quoted in Lokken, p. 79.
[180] Logan to William Burnet, 18 April 1728, Letterbooks of James Logan, volume III, Section C, p. 202. There is no evidence that Burnet responded to Logan's observations and few of his letters to Logan are extant.
[181] Logan to William Logan, 8 April 1728, quoted in Lokken, p. 79.
[182] Bradley, *New Improvements in Gardening* (1726), p. 13.
[183] Logan to William Logan, 8 April 1728, quoted in Lokken, p. 79.
[184] Bradley, *New Improvements in Gardening* (1726), p. 13;Logan, *Experiments and Considerations*, p. 86.

illustrated the point with four very similar sketches.[185] However, by the mid-1730s Logan had also learned of the 'indented' and 'angular' shapes of pollen grains.[186] Logan almost certainly continued to examine pollen after spring 1728, but there is no direct evidence for this. Logan's information therefore appears to have been based on the contents of Nehemiah Grew's *Anatomy of Plants* (1682) which Logan received after 1728, and which contained sketches of 'indented' and 'angular' shapes of pollen.[187] Logan published a short summary of the microscopical shapes of pollen in the middle section of the *Experimenta*. We can see that while the first part of the passage referred to Logan's initial observations and sketches of pollen in spring 1728, the latter part of the passage referred to Logan's newly acquired knowledge in the late 1720s and early 1730s:

> The Particles of the *Farina* have all the same Figure in the same Species of Plants; but they are different in different Species. In most Plants they are round or globular; in many others they are oblong, like Grains of Wheat; in some, as the Marigold, Mallow, and others, they appear like an indented Wheel, or as a Globule set round like Prickles. I never saw any angular ones, as *Grew* describes in the Pansy *(Anatom.* TAB.58); for the most part they are smooth and shining; in the Maize they seem flat.[188]

The reference to Grew's *Anatomy* – which Lokken had difficulty finding – referred to table 58 which, as seen in Appendix 1.4, contained sketches of the shapes of pollen from eleven different plants.[189] The 'angular' shape of pansy, which Grew represented using rectangles and diamonds, was figure 10. The passage also reveals that Logan used a microscope to examine the pollen of maize, although it is not known when the observations were made.

---

[185] Logan to William Burnet, 18 April 1728, Letterbooks of James Logan, volume III, Section C, p. 202. There is no evidence that Burnet responded to Logan's observations and few of his letters to Logan are extant.
[186] Ibid.
[187] Logan, *Experiments and Considerations,* p. 86.
[188] Ibid.
[189] Lokken, 'The Scientific Papers of James Logan', p.86n24.; Nehemiah Grew, *Anatomy of Plants* (1682) .

For instance, Logan may have practised microscopy during the initial maize experiments in 1727, therefore dating Logan's botanical microscopy to before spring 1728. Alternatively, the observations may have been made during August 1728 or in subsequent years, when maize released its pollen. However, it is highly likely that Logan studied the shape of the pollen alongside his observation of its presence in the stamen of maize, discussed below.

The final part of this section discusses Logan's microscopical evidence for the theory that pollen fructified the seed by travelling down the stamens of plants. The theory had been 'asserted', but not proven, by the English botanist Samuel Moreland in the *Philosophical Transactions* (1703) whose suggestion Logan read in Bradley's *New Improvements* (1726).[190] Logan published evidence for the theory in the *Experimenta*: referring to Moreland's assertion that pollen grains 'enter'd the *Uterus* thro' the Canal of the Style [stamen]' of plants, Logan stated that he 'once saw a small Grain in the Middle of this Canal' in the maize, adding that 'stricter Inquiries will discover more of them passing the same way'.[191] The statement develops our understanding of the ways in which Logan studied the stamen of maize which, in traditional accounts of the maize experiments, were cut and covered with fine muslin. Roy N. Lokken, who edited and provided useful notes on the *Experimenta*, wrote only that Logan took 'very great pains' in his 'remarkable observation'.[192] The observation, however, was made with a microscope. The sighting may have been made during the same trials in which Logan had observed the 'flat' appearance of the pollen in 'Maize', mentioned above.[193]

Logan replicated the findings between the late-1730s and the mid-1740s. In 1746, Logan communicated his evidence to Peter Collinson in London in response to John Turberville Needham who, in his *New Microscopical*

[190] Logan, *Experiments and Considerations*, Lokken, pp.85-86. Bradley mentioned Moreland in *New Improvements* (1726), p. 10.
[191] Ibid, p. 86.
[192] Lokken, 'The Scientific Papers of James Logan', p. 86 n.22.
[193] Ibid, p. 86.

Discoveries (1745), doubted that pollen entered the stamen of plants.[194] However, and as Logan reminded Collinson, evidence for the mechanism – which Logan acknowledged had not been included in his initial account of the maize experiments in the *Philosophical Transactions* – had been published in the *Experimenta* (1739).[195] If, Logan wrote, Needham had read the *Experimenta,* rather than the account in the *Philosophical Transactions,* he would have found evidence for the mechanism.[196] Furthermore, Logan was 'perswauded [sic]' that, after the mid-1730s, he had 'occasionally' seen a pollen 'grain… going down ye Silk or Style of ye Maiz[e]' and had therefore taken the mechanism 'for a certainty'.[197] The use of the word 'perswuaded [sic]' suggests that Logan may have encountered difficulties during his practice; for instance, the clarity of the magnified image may have been unclear. Needham's comment prompted Logan to reflect on his earliest observations of pollen, the publication of his microscopical evidence, and subsequent findings.[198] The letter therefore contains evidence of Logan's microscopical practice between the late 1720s and early 1740s.

This section has shown that Logan studied plant generation on the visible as well as microscopical scales, and engaged with the theories, illustrations, and observations of seventeenth and eighteenth-century botanical microscopists. Furthermore, Logan communicated his findings in the form of visual and written communication to colonial and European naturalists. The exposure of the microscopical element of Logan's botanical experiments significantly enriches our understanding of Logan's skill as a botanist and the nature of Logan's botanical investigations.

[194] Logan to Peter Collinson, 15 April 1746, LJL, p. 334.
[195] Ibid, p. 334; Logan, 'Some Experiments Concerning the Impregnation of the Seeds of Plants', *Philosophical Transactions,* pp. 192-195.
[196] Logan to Peter Collinson, 15 April 1746, LJL, p. 334.
[197] Ibid.
[198] Logan also recalled his sighting of human spermatozoon in London in 1710 (see section 3.1).

3.3 James Logan's tutelage of John Bartram

Between 1736 and 1737, Logan introduced John Bartram (1699-1777) – a farmer and internationally renowned plant collector in Philadelphia whom Logan tutored in botany – to the subject of microscopy. This section examines this brief but important period in Logan's microscopy, during which Logan supplied Bartram with botanical texts including Grew's *Anatomy of Plants* and, as is well known, with a microscope that Logan 'taught' Bartram to use.[199] Despite being the most widely cited of Logan's microscopy-related actions in the existing literature, few historians questioned why Logan supplied Bartram with a microscope, or how Logan came to communicate his knowledge of using microscopes. We have little understanding of the immediate significance of Logan's actions, or their wider context. This section exposes the place of microscopy in another of Logan's familiar roles and improves our understanding of his relationship with Bartram.

Both Logan and Bartram acquired reputations in the trans-Atlantic world as skilled botanists prior to their introduction in 1736. In the early 1730s, Bartram, a lapsed Quaker and self-educated botanist, had been recommended to the London naturalist Peter Collinson as a reliable supplier of American plants, and Logan's earliest description of the maize experiments (which made no mention of microscopy) had been published in the *Philosophical Transactions* in 1735.[200] The two men differed considerably in their age, social position and education. Logan was twenty-five years Bartram's senior, owned a large estate at Stenton approximately

[199] See Burt, *The Perennial Philadelphians: The Anatomy of an American Aristocracy,* p. 503; *Chain of Friendship: Selected Letters of Dr. John Fothergill of London, 1735-1780,* eds. Betsy C. Corner and Booth, Christopher (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 1971), p.50.; Stearns, *Science in the British Colonies of America,* p. 577.; David S. Wilson, *In the presence of nature* (University of Massachusetts Press, 1978), p. 92. For Logan's and Bartram's joint observations see Tolles, *James Logan,* p.201. For Logan's presentation of a microscope to Bartram, see A.V. Precup, 'John Bartram: 1699-1777, *Bioscience,* 26:5 (May, 1976), p. 359.

[200] Logan, 'Some Experiments Concerning the Impregnation of the Seeds of Plants', pp. 192-195.

twelve miles from Bartram's farmhouse,[201] and was a prominent member of the political and judicial communities of Philadelphia. Bartram's interest in plants had been fostered independently of Logan, but the latter introduced Bartram – whom Collinson described as Logan's 'pupil'[102] – to 'formal scientific knowledge'.[103] Prior to their introduction in 1736, Bartram's knowledge of plants had been fairly basic: Bartram had had little formal schooling and knew little Latin. As the historian Nathaniel Burt explained, Bartram was '"Logan-educated", for it was under Logan's patronage… that he was first exposed to formal scientific [botanical] knowledge'.[202] We can begin to detail the microscopical nature of this education and exposure, based on Logan's and Bartram's written and verbal communication.

The correspondence of both Logan and Bartram enables us to present a basic timeline of events between 1736 and 1737. In June 1736, Logan intended to speak with Bartram about 'microscopical observations';[203] by July 1737, Bartram had used a microscope;[204] and in August 1737, at Logan's request, Bartram produced a visual and written account of the shapes of magnified pieces of pollen.[205] These dates act as useful signposts around which we can place other activities for which we have no dates: these include Logan's and Bartram's joint observations of plants, and Logan's provision of botanical texts and an unidentified microscope. These activities, particularly Logan's and Bartram's joint observations, are discussed at this point because of the uncertainties which surround their date(s), frequency, and location. The previous section discussed the ways in which Logan utilised Richard Bradley's *New Improvements in Gardening* (1727) and Nehemiah Grew's *Anatomy of Plants* (1682) during his practice of microscopy. This information enables us to understand why Logan also presented the texts to Bartram as part of his botanical tutelage. Previous

[201] O'Neill and McLean, *Peter Collinson and the Eighteenth-Century Natural History Exchange*, p. 91, p. 103; Earnest, *John and William Bartram, Botanists and Explorers*, p. 10.
[202] Burt, *The Perennial Philadelphians*, p. 503.
[203] Logan to John Bartram, 19 June 1736, CJB, p. 225.
[204] We know from this Collinson's letters to Bartram in 1737. These letters can be found in *Memorials of John Bartram and Humphry Marshall,* ed. William Darlington (New York: Hafner, 1849): 14 December 1737,p. 105; 20 December 1737, p.107.
[205] John Bartram to Logan, 19 August 1737, CJB, pp.61-63.

historians who were unaware of Logan's microscopy, but also historians who stated that Logan 'taught' Bartram to use a microscope, cited Logan's provision of the texts simply as evidence of Logan's patronage and his general tutelage of Bartram.[206] Scholars did not make the connection between the microscope and the microscopical contents of Grew's *Anatomy* (1682). However, based on our knowledge of Logan's earlier botanical practice and the recognition that Logan introduced Bartram to microscopy, we can suggest that Logan almost certainly drew Bartram's attention to Bradley's and Grew's descriptions and illustrations of the shapes of pollen, as well as to his personal observations. Bartram 'borrowed' Grew's *Anatomy* until his receipt of a copy of the text from London in 1743, but it is not known when Logan provided the texts.[207]

Unfortunately, one of the most interesting activities in Logan's tutelage – Logan's and Bartram's joint observations of plants which Frederic B. Tolles referred to, but did not reference, in *James Logan and the Culture of Provincial America* – is also the least understood.[208] I have been unable to trace Tolles's source(s) and we have to rely, for now at least, on his description of the material: that Logan 'peered through the microscope with him [Bartram] at the stamens and pistils [anthers] of the thorny mallow, the convolvus, the succory, [and] the motherwort'.[209] We know from a letter between Bartram and Logan in mid-1737 (this letter is discussed in more detail below) that Bartram microscopically examined the pollen of twenty-nine plants, including the four plants which Tolles referred to, but there is no evidence that Logan was present at these observations.[210] This suggests that the observations which Tolles referred to may have been made on a separate occasion, prior to mid-1737. Tolles's account suggests that Logan and Bartram arranged the specimens, and then alternately 'peered' at them through the microscope.[211] Logan almost certainly offered example-led instructions on how to arrange specimens, adjust the focus of the lens, and

[206] See footnote 199.
[207] John Bartram to Alexander Catcott, 24 November 1743, CJB, p. 225.
[208] Tolles, *James Logan and the Culture of Provincial America,* p. 201.
[209] Ibid.
[210] Bartram to Logan, 19 August 1737, CJB, pp.61-63.
[211] Tolles, *James Logan and the Culture of Provincial America,* p. 201.

interpret the image which was produced. However, there is no indication of the number of times Logan offered these example-led demonstrations: the specimens might have been observed at a single demonstration, or at multiple meetings. We are also left to wonder whose account of the meeting(s) Tolles used, of how the different perspectives and also experiences of Logan and Bartram during the meeting(s) may have affected the account, and of whether the evidence was in the form a journal entry, or a letter to another naturalist. However, based on Logan's possession of a microscope and his higher social standing, we can assume that the social interaction(s) almost certainly took place at Logan's residence. It is also highly likely that Logan offered his instructions between mid-1736 and mid-1737. Finally, it is of interest that Tolles referred to the 'stamens and pistils' of plants but did not mention.[212] Pollen may not have been the subject of study when the observations took place, or the observations may have been made outside of the pollen season. However, this may also have been a simple omission by Tolles in his summary of the source. Possible dates and scenarios for the meeting(s) are raised at relevant points throughout the remainder of this section.

The evidence dates Logan's and Bartram's earliest interaction to June 1736. In a note dated 19 June, Logan invited Bartram to 'step to town tomorrow' to one of two printing and business establishments between '12 to 3' to discuss botany.[213] Logan intended to translate and to discuss Linnaeus's classification for plants which was based on the number and position of anthers and stamens, and 'to say something further to thee, on microscopical observations'.[214] It is difficult to ascertain what Logan meant by 'something further'.[215] For instance, Logan may have wanted to resume a previous conversation on the subject – which would date their social interaction to before mid-June – or to discuss how the anthers and stamens in Linneaus's classification system could be studied with a microscope. The 'observations' may have alluded to Logan's personal observations, or those

[212] Ibid.
[213] Logan to John Bartram, 19 June 1736, CJB, p. 225.
[214] Ibid.
[215] Ibid.

of Nehemiah Grew's in *Anatomy of Plants* (1682). Logan's intention might have been to propose a demonstration during which they would study specimens, or to discuss the quality of microscopes. Furthermore, it is not known whether Bartram did 'step to town'.[216] It is of interest, however, that Logan invited Bartram to discuss botanical matters and to discuss microscopy, whether for the first time or not, in his business premises. The note contains the only explicit mention of a space in which Logan *intended* to interact on the subject of microscopy, and offers insights into the ways in which Logan continued to engage with botany alongside his profession.

Although little is known of the subsequent events which took place between mid-June 1736 and mid-1737, it is highly likely that the meeting(s) during which Logan and Bartram studied the 'stamens and pistils of the thorny mallow' and other plants took place during this period.[217] We know from Collinson's replies to Bartram's letters of 6 July and 19 July that Bartram had used a microscope by mid-1737, but had found the practice time-consuming and difficult: Bartram requested 'a magnifier for flowers'[218] which would produce a single image of the specimen rather than 'parts' of the specimen.[219] It is of interest that Bartram appears to have referred to Collinson for advice: this raises questions concerning the nature of Bartram's relationship with Logan, and the nature and effectiveness of Logan's tutelage. For instance, verbal and written communication between Logan and Bartram may have been limited due to their political and botanical duties, the distance between their respective homes, or their differences in social positions. For instance, Bartram 'occasionally chafed' under Collinson's patronage and may have been reluctant to ask Logan for advice.[220] However, there is no evidence to suggest that Bartram did *not* Logan for advice. It is also important to note that within a month of Bartram's letters to Collinson in July 1737, Bartram provided Logan with an extensive set of microscopical observations which are discussed in more

[216] Ibid.
[217] Tolles, *James Logan,* p. 201.
[218] Collinson to Bartram, 20 December 1737, *Memorials of John Bartram,* p. 107.
[219] Collinson to Bartram, 14 December 1737, *Memorials of John Bartram,* p. 105.
[220] Wilson, *In the presence of nature,* p. 95.

detail below. We can suggest that Logan's and Bartram's joint observations of plants took place around the time that Bartram expressed his complaints to Collinson. There are two possible scenarios. In the first scenario, Logan may have provided both the example-led demonstrations and the microscope, after which Bartram complained to Collinson of his difficulties and requested a simpler 'magnifier for flowers'[221] In the second scenario, a similar order of events took place after which Bartram referred to Logan for advice who, possibly at Bartram's request, offered additional instruction.

Uncertainty also surrounds the nature of Logan's supply of a microscope which, Logan wrote Collinson, he had 'furnished' Bartram with 'to enable him to make the proper Scrutiny'.[222] The 'proper Scrutiny' alluded to the microscopic features of anthers, stamens and pollen which Logan had studied, as discussed in 3.2, and which Logan encouraged Bartram to examine in mid-1737.[223] However, it is not known whether Logan purchased a new microscope for Bartram, or 'furnished' Bartram with his Culpeper Wilson-type microscope which Logan had used in 1716 and 1728 (see section 3.1).[224] In the latter scenario, we can suggest either that Bartram gained temporary access to the instrument at Logan's residence, or that Logan allowed Bartram to use the microscope on his farm. We can, however, state with some certainty that Bartram used the instrument in his investigations of 'pollen in different plants' which Logan 'encouraged' Bartram to examine.[225]

Bartram presented his findings to Logan in a letter dated 19 August 1737.[226] The letter is the last extant piece of evidence for Logan's and Bartram's interaction on the subject of microscopy. It contained both small sketches of twenty-nine different types of pollen as seen with the

---

[221] Collinson to Bartram, 20 December 1737, *Memorials of John Bartram*, p. 107.
[222] Logan to Collinson, 20 August 1737, LJL, p. 289.
[223] Ibid.
[224] Ibid.
[225] The letter was in Latin. The quote is taken from a summary of the letter in English. James Logan to Carl Linnaeus, 28 October 1738, *The Linnaean correspondence*, linnaeus.c18.net, letter LO259 (consulted 15 April 2013).
[226] Bartram to Logan, 19 August 1737, CJB, pp. 61-63.

microscope and written notes which described the appearance of thirteen types of pollen.[227] Bartram used the microscope's 'fourth magnifier' which he may have selected on Logan's recommendation.[228] Bartram's acknowledgment of Logan's 'many favours & ye kind instructions' almost certainly alluded to Logan's earlier provision of the microscope, books, and personal assistance during their joint observations of plants.[229] Bartram believed his observations were 'near right', adding 'if thee sees mistakes I hope thee will consider that I am at ye best but A learning'.[230] The comment reflected the deference which Bartram – as Logan's 'pupil' – was expected to show his patron, social superior, and instructor who, moreover, was an experienced microscopist.[231] However, the comment also reflected Bartram's lack of confidence in his practice and the accuracy of his observations, which he had expressed to Collinson shortly before writing to Logan. It is therefore possible that Bartram's complaints were made *during* his microscopical examinations of pollen, which would date Logan's supply of a microscope to early July 1737. As mentioned, Bartram described the appearance of pollen in thirteen plants: the majority were 'limpid' – clear and transparent under the lens – although the echium's pollen was 'darkish'.[232] The majority of the specimens were 'smooth', 'round' or 'roundish', although Bartram described the Jacea as 'burry & oval' and both the scrophulary and motherwort as 'oval'.[233] The great wild nettle was 'limpid smooth of several forms'.[234] A small sketch accompanied each of the descriptions: the sketches were drawn in the margins of the letter.

There is no direct evidence that Logan received the letter, or responded to Bartram's observations. However, Logan's description of Bartram as a skilled botanist in a letter to Collinson in a letter dated 20 August 1737, almost certainly referred in part to Bartram's letter.[235] In this scenario,

---

[227] Ibid.
[228] Bartram to Logan, 19 August 1737, CJB, pp.61-63.
[229] Ibid.
[230] Ibid.
[231] Collinson to Bartram, 20 December 1737, CJB, p. 72.
[232]Bartram to Logan, 19 August 1737, CJB, p. 63.
[233] Ibid, pp. 62-63.
[234] Ibid.
[235] Logan to Collinson, 20 August 1737, LJL, p. 289.

Logan received and assessed Bartram's account within a day of its dispatch. The letter is the last extant piece of evidence for Logan's and Bartram's interaction on the subject of microscopy. Both Logan and Bartram continued to utilise microscopes and microscopy-related texts during the 1740s, but there is no evidence that they discussed the subject after August 1737.

This section has enhanced our understanding of Logan's tutelage of Bartram and has attempted to place Logan's most widely cited microscopy-related action into a more suitable context. This phase of Logan's microscopy is based on limited evidence which, unfortunately, raises unanswered questions regarding the precise chronology of events and the nature of Logan's tutelage. Notwithstanding these uncertainties, the evidence clearly demonstrates Logan's and Bartram's interaction on the subject of microscopy – their written and verbal communications, and their practice of microscopy – between 1736 and 1737.

3.4 The 'Solar Microscope… no way exceeds mine of Wilsons':[236] Logan's Knowledge of Instruments and Bestselling Texts

This final section moves forward to the period between 1745 and 1747. It was during this period that Logan responded to John T. Needham's *New Microscopical Discoveries* (1745), as discussed in the previous section, and that the English edition of the *Experimenta* (1747) was published. As this section shows, Logan continued to engage with microscopy and, shortly before his death in 1751, learned of the latest developments in the London instrument and book trades.

In the mid-1740s, Logan extended his collection of microscopy-related books to include bestselling publications which were more suited to the tastes of the general public to whom Logan bequeathed his library. The

[236] Edwin Wolf published different sections of the letter in LJL on p. 5 and p. 213. Logan to Peter Collinson, 26 September 1747, LJL, p. 213.

publications included Needham's *New Microscopical Discoveries* (1745), *Micrographia Illustrata* (1745) by the London instrument maker George Adams, and the new edition of Robert Hooke's bestselling seventeenth-century text *Micrographia* (1745).[237] Logan also enquired about a new copy of Antoni van Leeuwenhoek's *Arcana Naturae Detecta* (1695) that Logan had purchased in London in 1710 but had been damaged on the return journey to Philadelphia.[238] Logan may have learned of Henry Baker's publications on microscopy and certainly knew of John Cuff's microscopes, but there is no evidence that Logan owned either Baker's or Cuff's publications (see section 3.1). Unfortunately, Logan left little written evidence of his reactions to Leeuwenhoek and Hooke: the texts themselves were not annotated, and the bibliographer Edwin Wolf found few references to the texts in Logan's correspondence.

The last extant piece of evidence for Logan's microscopy is his letter to Collinson, dated 26 September 1747, in which Logan first, referred to his use of a 'Solar Microscope' and his discussion of the instrument's quality with the printer Benjamin Franklin and, secondly, commented on the newly improved microscopes of the London instrument makers George Adams and John Cuff.[239] It must be noted that Logan was seventy years of age when he used the solar microscope in 1747. The instrument, which Logan accessed through Franklin's 'favour',[240] was 'sent over' by Collinson in London in mid-late 1747.[241] A number of uncertainties surround Logan's access to the solar microscope, his knowledge of the instrument, and use of the instrument. For instance, the nature of Franklin's 'favour' is not clear, and further research into Franklin's engagement with microscopy is needed. According to Margaret B. Korty, Collinson sent Logan an unidentified microscope via the Library Society of Philadelphia with which Franklin was

[237] John T. Needham, *New Microscopical Discoveries* (1745),LJL, p. 334; George Adams, *Micrographia Illustrata* (1745), LJL, p.5.; Robert Hooke, *Micrographia Restaurata* (1745), LJL, p. 253.
[238] Logan to Peter Collinson, 1743 and 1745, LJL, p. 279.
[239]Logan to Peter Collinson, 26 September 1747, LJL, p.213.
[240] Ibid. p. 213.
[241] Logan to Peter Collinson, undated although the letter was written in late 1747, Logan's Letterbooks, Letterbook G, p. 8.

associated:[242] the 'favour' may therefore have alluded to Franklin's having forwarded the microscope to Logan from the Library. It is not known whether Logan attended the demonstrations which had been advertised by itinerant lecturers at Mr. Videll's house and the Library Company of Philadelphia in 1744 (see sections 2.1 and 2.2). There is also no mention of the specimens which were examined. Based on Logan's earlier practice of microscopy, however, these may have included tartar, animalcules, plants and pollen: other popular displays included the circulation of blood in frogs and fishes.

Logan compared the quality of the solar microscope with the Culpeper Wilson-style microscope and concluded that the 'Solar Microscope… no way exceeds mine of Wilsons [sic] ', adding that Franklin agreed with his judgement.[243] Logan either used the instrument *with* Franklin, or discussed his findings with Franklin at a later date. One possible scenario is that Franklin delivered the instrument and witnessed the microscopical demonstration with Logan at Stenton. There is no evidence that Logan converted the Wilson microscope into a solar instrument, although he may have been aware of the conversion. The method, which was first suggested in Henry Baker's *The Microscope Made Easy* (1742), was included in George Adams's *Micrographia Illustrata* (1745) which Logan received in late 1747, and which Logan read shortly before writing to Collinson.[244]

Finally, Logan compared Adams's microscopes with the microscopes of the London instrument maker John Cuff, writing that he had 'seen this week past Adams's collection [of single, compound and solar microscopes]… in which he seems to have outdone Cuff yor [sic] engineer'.[245] The source of Logan's information for Cuff is not known: there are no records for Cuff's publications in Logan's library and the bibliographer Edwin Wolf found no other mention of the instrument maker in Logan's correspondence.[246] One

[242] Margaret B. Korty, 'Benjamin Franklin and Eighteenth-Century Libraries', *Transactions of the American Philosophical Society*, 55:9 (1965), p. 14.
[243] Logan to Collinson, 26 September, LJL, p. 213.
[244] Henry Baker, *The Microscope Made Easy* (1742), pp. 22-23; George Adams, *Micrographia Illustrata* (1745), pp. 15-16; Logan to Collinson, 26 September, LJL, p. 213.
[245] Logan to Collinson, 26 September, LJL, p. 213.
[246] LJL. There is no entry for Cuff in the catalogue.

possibility is that Logan received his information from a correspondent. Both Adams and Cuff designed and manufactured newly improved versions of single, compound and solar instruments. The microscopes which Logan had in mind may have been Adams's Universal single and double microscopes which, Adams wrote, provided clearer images, allowed users to practice microscopy while sitting down, and were generally easier and more convenient to use.[247]

This section has shown that, by the mid-1740s, Logan's interests in microscopy were much more diverse. Logan continued to engage with microscopy, practice microscopy, and discuss microscopy with European and colonial naturalists on issues which were directly related to the latest developments in the book and instrument trades in London.

Conclusion

This chapter has shown that Logan actively engaged with the subject of microscopy between 1710 and 1747. Logan studied botanical and other specimens both on an individual basis and alongside other colonials; communicated his observations with colonial and European naturalists in written, visual and verbal forms; and, shortly before his death, learned of the latest instruments and publications in London. By exposing Logan's practice of microscopy and other microscopical activities the chapter enhances our understanding of Logan's botanical skills and knowledge, and demonstrates that microscopy-related materials circulated between London and Philadelphia in the first half of the eighteenth century.

[247] Adams, *Micrographia Illustrata*, pp. 1-9.

Chapter 4. Charleston as a Site of Microscopy: The Observations of Alexander Garden, 1755–61

This final chapter examines the microscopy of the elite naturalist Alexander Garden (1730-1791), the Scottish physician who migrated to Charleston, South Carolina, in 1752. Between 1755 and 1761, Garden examined plants and corals with a microscope, communicated with a small number of naturalists on the subject, and produced an account of the microscopical features of insects in collaboration with the London microscopist John Ellis. The chapter builds on the work of Edmund and Dorothy Berkeley, who made only passing references to Garden's microscopy but identified useful sources for his activities, and supplements their evidence with new source material.[248] In addition to extending our current understanding of Garden's knowledge, skills and roles as a colonial naturalist, the following sections show that microscopes, microscopy-related texts, and observations circulated between London and Charleston in the second half of the eighteenth century.

The chapter begins with a general introduction to Garden, followed by two sections which explore different phases of his microscopy. Section 4.1 discusses the ways in which Garden's colonial and European correspondents encouraged his interests in plants and animals, and attempts to understand the nature of Garden's initial exposure to microscopy. It also introduces the London microscopist John Ellis, with whom Garden corresponded and collaborated. The animal nature of corallines – marine specimens which resembled both plants and animals – may have been one of the earliest microscopy-related subjects which Garden and Ellis discussed. Section 4.2 charts Garden's reactions to Ellis's discovery that corallines were 'Animalls

[248] Berkeley and Berkeley, *Dr. Alexander Garden.* For Garden's botanical microscopy see p. 9, p. 67, pp. 249-250, p. 186. For Garden's animal microscopy see pp. 58-59, p.90, pp. 128-129, p. 167, pp. 252-253. Garden also asked the London microscopist Henry Baker to teach Barnard Elliot, a 'young gentleman' from Charleston, to use microscopes, pp. 176-177. Garden also asked the London microscopist John Ellis to entertain his half-brother, Francis Garden, who was in London: Ellis showed Francis an insect magnified with a microscope, p. 218. Unfortunately, for reasons of space I cannot discuss Garden's botanical microscopy in the 1770s, or Garden's possible exposure to microscopic animalcules in the 1760s.

[sic]' rather than plants, which Ellis based on microscopical evidence.[249] The final section discusses Garden's microscopical observations of indigenous cochineal beetles which he examined at Ellis's request and which were published by Ellis in a joint letter in the *Philosophical Transactions*.[250]

4.1 Alexander Garden as a Naturalist in Charleston, South Carolina.

This section serves as a general background for understanding Garden's interest in natural history and attempts to understand his initial exposure to microscopy. Garden began his systematic study of plants and animals from the mid-1750s onward, shortly after his arrival in Charleston, South Carolina in 1752. Although proficient in botany before his migration, Garden's knowledge of the plant, animal and mineral kingdoms changed considerably upon his arrival to the colonies, particularly as a result of his correspondence with colonial and European naturalists. Garden collected and examined a large number of animal and plant specimens from the early 1750s onward, and the vast majority of Garden's observations appear to have been made with the naked eye. However, Garden's microscopical studies of plants and animals can be dated to the mid-1750s, and therefore appear to have coincided with his initial studies of indigenous specimens in Charleston, and his correspondence with the London microscopists Henry Baker and John Ellis. The section concludes with a discussion of Garden's receipt of two different types of microscopes in 1755 and 1756.

Garden studied botany alongside his medical studies in Scotland. Garden attributed his initial 'relish' for botany to Dr. John Gordon at Marischal College, Aberdeen, who, Garden wrote, 'initiated' him into the subject.[251] Garden continued to attend the botanical lectures of Charles Alston, professor of botany at Edinburgh: Alston's criticism of the Linnaean system

[249] Alexander Garden to Cadwallader Colden, 27 October 1755, V, LPCC, p. 34.
[250] John Ellis, 'An Account of the Male and Female Cochineal Insects, That Breed on the Cactus Opuntia . . . in South Carolina and Georgia', *Philosophical Transactions,* vol. 52 (1761), p.664.
[251] Quoted in Berkeley and Berkeley, *Dr. Alexander Garden in Charleston,* p. 10.

of classification – which relied on the number and position of minute anthers and stamens – left Garden unaware of the widely accepted system until his arrival to the American colonies in 1753.[252] Garden first learned of the system from a colonial botanist, the New York Governor Cadwallader Colden, whom Garden visited for 'several days' in 1754.[253] Although the primary intention of Garden's visit to the 'cooler' climes of New York and Philadelphia had been to escape the tropical heat of Charleston, Garden used the opportunity to meet and to discuss natural history with elite naturalists including Colden, John Bartram and Benjamin Franklin.[254] Garden's penchant for communicating with colonial and European naturalists – which the Berkeleys described as Garden's 'favorite avocation'– increased after his meetings with Colden and Franklin, during which Garden had seen the letters of leading naturalists in Europe.[255] Inspired to maintain and to cultivate correspondence with such naturalists, Garden extended his initial contacts in Scotland to include naturalists in New York, Philadelphia, and London. Garden's colonial and European correspondents encouraged Garden to collect, describe and supply a range of indigenous plants, insects, corals, and land and marine animals. Their requests for natural specimens, and their supply of equally interesting specimens in return provided Garden with the intellectual conversation and stimulation that he desired. This can be seen in Garden's letter to John Bartram in which Garden wrote that: the 'approbation of… Learned men' in the American colonies and in Europe induced him to 'make what observations I can on anything here either in the Animall [sic], Vegetable, or Mineral Kingdoms'.[256]

By 1755, Garden's 'worthy acquaintances' in London included the London microscopists John Ellis and Henry Baker, both of whom are discussed in more detail towards the end of this section.[257] Garden's association with Ellis – a linen merchant whose skill as a microscopist was celebrated by contemporaries – is of particular importance to this study. The

[252] Berkeley and Berkeley, *Dr. Alexander Garden in Charleston,* pp. 23-24, p. 168.
[253] Ibid. pp. 40-41.
[254] Alexander Garden to Henry Baker, 25 March 1755, HBC, VI, 137.
[255] Berkeley and Berkeley, *Dr. Alexander Garden of Charleston,* ibid. p. 36, p. 51.
[256] Garden to Baker, 25 March 1755, HBC, VI, 137.
[257] Garden to Henry Baker, March 14 1756, HBC, II, 226.

subject of microscopy appears to have been raised at an early stage in Garden's and Ellis's association, although the vast majority of their letters appear to have touched on non-microscopical matters. Over a period of twenty years, Garden and Ellis discussed requests for plant, animal and mineral specimens, the naming of plants, methods for preserving seedlings on trans-Atlantic voyages, medicine, war, and family matters.

Garden cultivated his inter-colonial and international networks in order to overcome his perceived isolation from like-minded naturalists in Charleston. Garden presented Charleston – which was situated outside of the main hub of scientific activity in Philadelphia and the northern colonies – as a scientific desert. Garden's emphasis on communication with 'worthy correspondents' outside of Charleston – such as Colden, Bartram, Ellis and Baker – reflected Garden's low opinion of the naturalists, botanists, and physicians in the southern colony. The town was 'a dry sandy Spot'[258] where 'Negroe Swollers & Old Women'[259] knew more of the medicinal properties of plants than the physicians and where, Garden complained to Bartram, he was 'confined to… sandy streets… where the ox, where the ass, and where men as stupid as either, fill up the vacant space'.[260] The lack of like-minded individuals with whom Garden could discuss natural history, as well as stifling tropical temperatures, lack of time to pursue botany due to the demands of the medical practice, and the frustration at the 'Lame' and 'erroneous' descriptions of indigenous flora and fauna by Europeans, were some of Garden's most common complaints.[261] The extent of Garden's involvement with the Library Society of Charleston (1748), which owned a collection of microscopes and hosted a microscopical demonstration (see section 2.1 and section 2.2), is not known. There is no direct evidence that Garden – who was a member of the society and owned a botanical and aquatic microscope before the society's first purchase in 1763 – influenced the society's requests for microscopes. There is also no evidence that Garden used the society's Universal and solar instruments, utilised the

[258] Garden to Henry Baker, April 22 1757, HBC, II, 328
[259] Garden to Charles Alston, January 21 1753, quoted in Berkeley and Berkeley, *Dr. Alexander Garden*, p. 32
[260] Garden to John Bartram, February 12 1766, CJB, p. 399.
[261] Garden to Henry Baker, 25 March 1755, HBC, VI, p. 201.

society's collection of bestselling microscopy-related books, or attended the public demonstration that was advertised in 1767.[262]

Uncertainty also surrounds the date, location and nature of Garden's initial exposure to microscopy. Garden received two microscopes from the London microscopists Henry Baker and John Ellis between late-1755 and mid-1756. The evidence dates Garden's microscopy to April 1755, when Garden requested a microscope from Henry Baker.[263] The motivation for the request is discussed in more detail below. However, Garden may have been aware of the subject before early 1755. For instance, one possibility is that Garden practised microscopy in Scotland during his medical studies at Marischal and Edinburgh; for instance, to study the circulation of blood in animals, or to examine the composition of bodily fluids. Another possibility is that Garden used a microscope to 'Ocularly' study the economy of silkworms in Charleston between 1754 and 1755.[264] This is suggested by Garden's use of the term ocular. The term was used to denote vision, but did not distinguish between vision with the naked eye, and vision with aids such as magnifying glasses and microscopes. However, Garden repeatedly used the phrase to describe John Ellis's microscopical observations of corallines (see section 4.2) and may, therefore, have examined the indigenous silkworms with a microscope.[265] Furthermore, Garden almost certainly knew of Baker's interest in microscopy prior to the request – this would explain, for instance, why Garden asked Baker for a microscope – although we do not know when Garden's and Baker's association began, or whether they discussed microscopy before April 1755.

---

[262] The society's microscopy-related books included Robert Hooke's *Micrographia Illustrata* (1667) which it owned by 1750, George Adams's *Micrographia Illustrata* (1745) which was lost in 1756 and re-ordered in 1763, and Henry Baker's *Microscope made Easy* (1742): see Raven, *London Booksellers and American Customers,* p. 182, p. 176. For the microscopical demonstration see Whitfield B. Junior, *Patriot-Improvers,* p. 363.
[263] Garden to Henry Baker, 20 April 1755, HBC, II, 150.
[264] Garden to Henry Shipley, 5 April 1755, HBC, II, 143.
[265] The anatomy of the silkworm and the appearance of its silk had been studied by the seventeenth-century microscopist Robert Hooke, and brief allusions to the appearance of the insect's eyes, head and silk as seen with a microscope were published in gazettes in Philadelphia and New York in the late 1760s. See Robert Hooke, *Micrographia* (London, 1665), pp. 181-182; *New York Gazette, 26* March 1767 and 21 May 1767, EAN; *Pennsylvania Chronicle, 5* June 1769, EAN.

We can state with certainty, however, that Garden requested a microscope in April 1755 in order to examine botanical specimens.[266] The request followed Garden's exposure to the Linnaean system of classification which, as Garden learned in late 1754, was based on the minute features of anthers and stamens. As mentioned in section 3.2, the system was criticised by a leading eighteenth-century naturalist for, in the words of Londa Schiebinger, its dependence 'on characteristics [which were] so minute and inconsequential that a naturalist had to carry a microscope… in order to recognize a plant'.[267] Garden complained to Baker that 'My progress [in botany] is much retarded for want of Good Glasses which', he added, 'are not to be had here at any price'.[268] Baker sent the unidentified microscope in August 1755. Garden acknowledged the receipt of the instrument in December, writing that the instrument was of an 'acceptable' quality and that 'they [the lenses] will be most usefull [sic] in my examination of Plants in the Spring'.[269] Garden's 'want of *Good Glasses*' and his description of Baker's microscope as 'acceptable', suggest either that Garden sought to replace an existing microscope, or that he had had experience of using lenses prior to the request.[270] Did Garden compare the 'acceptable' quality of Baker's microscope with the quality of another instrument? Unfortunately, Baker's accompanying letter is not extant, and the make, type or price of the instrument that he sent are not known. Based on Baker's earlier activities – Baker had sent microscopes at the request of correspondents in Norwich and Italy in the 1740s– Garden may have received a John Cuff microscope, or 'the lowest priced microscope' that Baker 'could find'.[271]

---

[266] Garden to Henry Baker, 20 April 1755, HBC, II, 150.
[267] Londa Schiebinger, 'Gender and Natural History', *Cultures of Natural History*, p. 172.
[268] Garden to Henry Baker, 20 April 1755, HBC, II, 150.
[269] Garden to Henry Baker, 23 December 1755, HBC, VI, 198. Garden also examined the shapes of pollen, and the anthers and stamens of plants in the 1770s: see Berkeley and Berkeley, *Dr. Alexander Garden*, pp. 249-250, p. 186.
[270] Garden to Henry Baker, 20 April 1755, HBC, II, 150, my italics; Garden to Henry Baker, 23 December 1755, HBC, VI, 198.
[271]For reasons of space, Garden's botanical microscopy in the 1770s is not discussed in this chapter. William Arderon to Henry Baker, 16 May 1745, HBC, II, 45; Giuseppe Bruni to Henry Baker, 14/25 June 1745, HBC, II, 62; Henry Baker to Giuseppe Bruni, June 1745, HBC, II, 51.

Finally, Garden received a Cuff-Ellis aquatic microscope from Ellis between March and May 1756 (see Appendix 1.3). The instrument – which was designed by Ellis and manufactured by the London instrument maker John Cuff – allowed naturalists to follow the movements of living animals such as insects and marine specimens. Ellis improved the design to allow greater movement of the adjustable arm and recommended the instrument in *An Essay Towards A Natural History of the Corallines* (1755) which Garden received in mid-late 1755 (see section 4.2). Garden almost certainly requested the instrument after learning of 'The Treatise' that Ellis was 'about publishing' in early 1755, or after receiving the publication.[272] By January 1756, Garden had already been 'promise[d]' the instrument and appears to have had waited long enough for its delivery before putting Ellis 'in mind' of his 'promise as to the water microscope for viewing… sea productions' which, Garden wrote, would 'be a most acceptable present, as were some glasses which Mr. Baker sent me this last year'.[273] In March, Garden sent another prompt and thanked Ellis for being 'kind enough to promise me a water microscope' which, however, had not yet arrived.[274] Garden received the instrument between March and August 1756, and wrote to Cadwallader Colden in New York that he had been 'highly diverted' with the Cuff microscope that he had '*provided myself* with'.[275]

By the mid-1750s, Garden was therefore in possession of two microscopes which he received via his London correspondents, both of whom were practicing microscopists. Garden continued to communicate with Henry Baker and particularly John Ellis on the subject of microscopy during the 1750s and 1760s. The remainder of this chapter discusses Garden's reactions to Ellis's controversial argument that corallines were animals during the 1750s in section 4.2, and Garden's microscopical examinations of indigenous cochineal beetles in section 4.3.

---

[272] Garden to Cadwallader Colden, 18 February 1755, LPCC, V, p.5. Garden wrote that he had mentioned Ellis in a previous letter to Colden dated 14 January – Garden to Colden, 14 January 1755, LPCC, V, p.4 – but there is no reference to Ellis in the letter.
[273] Garden to John Ellis, 13 January, 1756, *A Selection of the Correspondence of Linnaeus*, ed. James E. Smith, volume 1, (London, 1821), p. 368.
[274] Garden to John Ellis, 22 March 1756, *A Selection of the Correspondence of Linnaeus*, p. 373.
[275] Garden to Cadwallader Colden, 14 August 1756, LPCC, V, p. 90. My italics.

4.2 Alexander Garden's Engagement with Coral Microscopy

Between 1755 and 1758, Garden actively responded to Ellis's discovery that 'Corallines' – marine specimens which exhibited both plant and animal characteristics, and which Ellis studied with an aquatic microscope – were 'Animalls [sic]' and not 'Vegetables'.[276] Garden received Ellis's work – *An Essay Towards A Natural History of the Corallines* (1755) and draughts which illustrated both the presence of animal polyps on corallines and the microscopical features of corallines – and communicated his reactions to a small handful of correspondents in London and New York. Coral microscopy appears to have been the first microscopy-related subject that was discussed by Garden and Ellis. The section discusses Garden's responses to Ellis's theories, thereby extending the geography of the coral debate beyond the European geography in which Ellis's arguments are currently known to have been received and debated. It extends Julius Groner's and Paul Cornelius's joint study into the reactions of European naturalists to Ellis's arguments, and situates Ellis's work within wider trans-Atlantic circuits.[277] It also builds on the work of Berkeley and Berkeley who identified sources for Garden's knowledge of coral microscopy, and supplements their findings with additional evidence taken from *The Letters and Papers of Cadwallader Colden*.[278]

It must be noted that Garden did not contribute *evidence* to the debate. Garden was also unsuccessful in his attempts to forward news of Ellis's work to the botanist Cadwallader Colden in New York. Furthermore, the evidence for Garden's knowledge of coral microscopy has been taken from Garden's correspondence with naturalists *other than* Ellis: neither the letters which accompanied Ellis's publications, nor Garden's acknowledgment of the materials can be found. It is also important to note that Garden's pride at being associated with Ellis, and Garden's gratitude for the favours which Ellis granted in the form of interesting natural specimens reflected his

[276] Garden to Cadwallader Colden, 22 November 1755, LPCC, V, pp. 42-43.
[277] See Julius Groner and Cornelius, Paul, *Merchant, Microscopist, Naturalist and King's Agent* (Pacific Grove, California: Boxwood Press, 1996).
[278] Berkeley and Berkeley, *Dr. Alexander Garden* and LPCC.

enthusiastic endorsement of Ellis's discovery.[279] The limited and indirect evidence nevertheless presents valuable information regarding Garden's knowledge of coral microscopy.

Prior to Ellis's 'great discovery' of the animal nature of corallines,[280] Garden had 'laboured' under the 'error' that the marine specimens – which exhibited both plant and animal characteristics – were 'vegetables'.[281] Corallines and other zoophytes resembled plants in their appearance and method of reproduction, but also demonstrated animal characteristics such as sensory perception and movement. Their ambiguous nature created uncertainty as to whether the specimens were plants, animals, or intermediate links between the plant and animal kingdoms. It is not clear when Garden first learned of the plant nature of corals. However, Garden may have discussed the subject with Colden in New York, whom Garden visited in 1754. In 1743, Colden had read a treatise on 'the History of the Polypus'[282] – minute marine specimens which resembled plants but, when studied with a microscope, were shown to be animals – which Colden believed demonstrated 'the Chain between Vegetables & Animals'.[283] A discussion of the general topic of the nature of corallines in late 1754 would explain why Garden repeatedly sent Colden word of Ellis's publications and offered to forward copies of draughts of polyps and corallines. Garden also appears to have been aware of Ellis's *An Essay Towards A Natural History of the Corallines* (1755) before its publication. In February, shortly after Garden's return to Charleston, Garden sent Colden word of 'The Treatise on the Sea Productions that Mr Ellis is about publishing'.[284] By the following month, Garden wrote to Henry Baker that he had been 'promised' Ellis's 'performance on the Corallines Substances, which I sincerely believe will be admirably curious'.[285] A possible scenario is that Garden discussed the

[279] Garden to Henry Baker, 14 March 1755, HBC, II, 226.
[280] Garden to Henry Baker, 23 December 1755, HBC, VI, 198.
[281] Garden to John Ellis, Garden to John Ellis, 24 December 1755, *A Selection of the Correspondence of Linnaeus*, p. 357.
[282] Peter Collinson to Cadwallader Colden, 4 September 1743, LPCC, III, p.29.
[283] Cadwallader Colden to Peter Collinson, December 1743, LPCC, III, p. 45.
[284] Garden to Cadwallader Colden, 18 February 1755, LPCC, V, p.5. Garden wrote that he had mentioned Ellis in a previous letter to Colden dated 14 January – Garden to Colden, 14 January 1755, LPCC, V, p.4 – but there is no reference to Ellis in the letter.
[285] Garden to Henry Baker, 25 March 1755, HBC, VI, p. 139.

subject with Colden in New York and agreed to inform him of further developments on the subject.

Garden received Ellis's 'valuable treatise on Corallines'[286] – which Ellis had 'promised to send' in late 1754 or early 1755[287] – between March and December 1755. Garden enthusiastically endorsed Ellis's argument, writing to Henry Baker of the 'esteem' in which he held the 'great discovery in Natural History'.[288] Shortly after receiving the text, Garden thanked Ellis for having freed 'my mind from the error it [had] laboured under in believing the Corrallines to be vegetables'.[289] Garden particularly praised the accuracy of Ellis's microscopical 'observations' of corallines and other specimens in his letters to Colden in New York, describing the ease with which Ellis had 'Ocularly & most Curiously demonstrated these productions to be Animalls [sic]'.[290] Garden also informed Colden of the contrasting reactions of European naturalists to Ellis's observations. Whereas Linnaeus – the renowned taxonomist who had previously classified 'most of the Sea productions' as plants – had been 'Convinced of his Error', the Royal Society of London were more critical of Ellis's evidence for the animal nature of corallines.[291] Sympathising with Colden, whose treatise on Newtonian physics had been rejected by the Royal Society, Garden comforted the botanist by providing one of many 'other Instances of' the Society's 'irksome' and dismissive behaviour towards perfectly reasonable arguments.[292] For instance, 'Ellis's history of Corallines' had met 'with general approbation abroad' but, Garden wrote, only 'now begins to be cooly [sic]& indifferently beleived [sic] at home even tho [sic]', he added, 'there [is] being nothing advanced but what is easily proved by ocular demonstrations'.[293] We are left to wonder whether Garden received his information directly from Ellis. Ellis referred to the reactions of two

[286] Garden to Henry Baker, 23 December 1755, HBC, VI, p. 198.
[287] Garden to Baker, 25 March 1755, HBC, V, p. 139.
[288] Garden to Baker, 23 December 1755, HBC, VI, 198.
[289] Garden to John Ellis, 24 December 1755, *A Selection of the Correspondence of Linnaeus*, p. 357.
[290] See Garden's letters to Colden in LPCC, V: 27 October 1755, p. 34; 22 November 1755, p. 42; 14 March 1758, p. 228-229.
[291] Garden to Cadwallader Colden, 27 October 1755, LPCC, V, p.34.
[292] Garden to Colden, 14 March 1758, LPCC, V, p. 229.
[293] Ibid, pp. 228-229.

European naturalists to Garden in 1767, but I was unable to locate evidence of similar communications prior to this date.

Notwithstanding the absence of letters which accompanied Ellis's publications in the 1750s, we can identify the materials which Ellis sent Garden based on the latter's correspondence with Colden in New York. Garden received a single 'Copper Plate' which showed 'the method by which the Marine Polype produce one another' in 1755,[294] followed by 'two or three' more copies of the same plate which Garden offered to send Colden in 1756.[295] Garden wished to be kept informed of developments and 'beg[ged]' Ellis 'to send… any new thing which you discover in the Corallines'.[296] In 1758, Ellis therefore sent Garden a 'Draught' which showed the magnified features of a 'beautifull [sic] blood red, Stony and Spongy Coral' which 'clearly' demonstrated the coralline's 'Animal Nature', shortly after its publication in the *Philosophical Transactions* in 1757 (see Appendix 1.5).[297] The 'natural size[s]' of 'ye knobbly joints', 'tubes' and 'holes' of the coralline were illustrated alongside larger sketches of their appearance when 'magnified' with the aquatic microscope.[298] Garden 'Inclosed… a Copy' of the 'Draught' in a letter to Colden in the hope that he would 'have an opportunity of carefully Examining it'.[299] Finally, Garden wrote to Colden of the Cuff-Ellis aquatic microscope he had 'provided' himself with and which he had used to examine 'water Animals'.[300] Although Colden appears to have replied to this letter, he did not respond to the section on microscopy.[301] With the exception of this

[294] Garden to Colden, 22 November 1755, LPCC, V, pp. 42-43.
[295] Garden to Colden, 14 August 1756, LPCC, V, p. 90.
[296] Garden to Ellis, 13 January 1756, *A Selection of the Correspondence of Linnaeus,* p. 364.
[297] Garden to Colden, 14 March 1758, LPCC, V, pp. 228-229; John Ellis, 'An Account of a Red Coral from the East Indies . . .', *Philosophical Transactions,* 1757, vol. 50, pp. 188-194, the illustration is on p.189.
[298] Ellis, 'An Account of a Red Coral from the East Indies', *Philosophical Transactions,* p. 189.
[299] Garden to Colden in LPCC, V, 14 March 1758, pp. 228-229 and 10 May 1758, pp.231-232.
[300] Garden to Colden, 14 August 1756, LPCC, V, p. 90.
[301] Colden to Garden, 23 June 1758, LPCC, V, pp. 151-155.

letter, there is no evidence to suggest that Colden received Garden's materials.[302]

After a lengthy interval – during which Garden examined the minute features of cochineal beetles with Ellis's aquatic microscope (see section 4.3) – Garden discussed the subject of coral microscopy with the collector John Gregg in Charleston. Gregg was commissioned by Ellis to collect natural specimens in Charleston and South Carolina. In 1768, Garden and Gregg held 'many conferences on [Peter] Pallas's scheme', the German naturalist who questioned the animal nature of corallines in his *Miscellanea Zoologica* (1766).[303] Garden had received 'Dr. Pallas's two volumes' at an earlier date, but I could not find the letter in which Garden described his initial reactions to the publication.[304] In his later letter to Ellis in 1768, Garden – who described himself as a 'novice in all these marine productions' – considered Pallas's 'latinity' as the 'best part of his book' which suggests that he dismissed Pallas's claim.[305] Garden made the comments in reply to Ellis who, having noticed Pallas's argument, informed Garden of the ways in which he had refuted Pallas's claim that corallines were plants.[306] Ellis also discussed his 'refutation' of Dr. Job Baster who made a similar argument.[307] In addition to discussing 'Pallas's scheme' with John Gregg, Garden 'sent' him Ellis's 'book on Corallines'.[308] We are left to wonder whether Garden also presented Gregg with Ellis's draughts of the magnified parts of corals, or offered to show the aquatic microscope. Their verbal conversations, however, are of immense significance and show that Garden discussed coral microscopy with another naturalist in Charleston.

---

[302] Colden's correspondence was occasionally stolen, or mislaid as a result of the political instability in New York during this period.
[303] Garden to Ellis, 6 June 1768, *A Selection of the Correspondence of Linnaeus*, p. 567.
[304] Ibid, p. 565. Garden wrote that he had written to Ellis 'what occurred to me in reading him [Pallas], but there is no mention of Pallas in earlier letters, ibid, p. 565.
[305] Ibid, pp. 565-566.
[306] Only a summary of Ellis's letter is available: John Ellis to Garden, 9 February 1768, *A Selection of the Correspondence of Linnaeus*, p. 561.
[307] Ibid.
[308] Garden to Ellis, 6 June 1768, *A Selection of the Correspondence of Linnaeus*, p. 567.

This section has shown that Garden actively responded to Ellis's 'great discovery' that corallines were animals, examined the specimens with a microscope, and communicated with other naturalists on the subject.[309] The evidence for Garden's knowledge of coral microscopy is based on a small handful of letters, some of which did not reach their intended recipient. Nevertheless, there is sufficient evidence to show that Ellis's written and visual demonstrations of the animal nature of corallines circulated between London and Charleston, and were enthusiastically endorsed by Garden.

4.3 'I examined the insect… by your microscope':[310] Garden's Examinations of Cochineal Beetles

Between 1757 and 1761, Garden collected, examined, and described the cochineal beetle – a minute and indigenous insect whose features could only be seen with a microscope – at the request of Ellis in London. This section details each stage of their collaboration. The cochineal episode involved the procurement and supply of cochineal, Garden's examination of their anatomy and economy with Ellis's aquatic microscope, and the joint publication of Garden's and Ellis's findings in the *Philosophical Transactions.*[311] Ellis desired Garden's 'examination of the Cochineal insect'[312] in order to fill the 'chasms' in his account of the specimen, and utilised Garden's ability to study the insects in their natural environment.[313] The cochineal episode is therefore an excellent example of what Parrish described as a 'horizontal exchange' between naturalists in Europe and colonial America, and contributes more widely to recent studies into eighteenth-century entomology.[314] For instance, the cochineal episode

[309] Garden to Baker, 23 December 1755, HBC, VI, 198.
[310] Ellis, 'An Account of the Male and Female Cochineal Insects', *Philosophical Transactions,* 52, p.664.
[311] Ibid.
[312] Ellis to Garden, 25 March 1759, *The Linnaean correspondence*, linnaeus.c18.net, letter L5499 (consulted 20 February 2013).
[313] Ellis to Garden, 25 August 1759, *The Linnaean correspondence*, linnaeus.c18.net, letter L5503.17.256.257 (consulted 20 February 2013).
[314] See Parrish, *Cultures of Natural History.* The history of eighteenth-century entomology has been neglected by historians of natural history. Deirdre Coleman, 'Entertaining Entomology: Insects and Insect Performers in the 18th Century' in *Eighteenth-Century Life,*

complements Terrall's recent study into the distribution of insects between metropolitan and provincial naturalists in eighteenth-century France.[315] Terrall's article, which also touched on the practice of microscopy and discussed the role of provincial naturalists in the production of knowledge, is a useful model for this study.

Ellis initiated the collaboration in order to provide an accurate description of the male cochineal beetle. Both Garden and Ellis were aware that cochineal, which had been described as a fruit, was an insect. Two years prior to Ellis's request, Garden described the specimens which he passed in the nearby vicinity of Charleston as 'Animal[s]' and 'insects'.[316] Garden's source may have been Patrick Browne's *Civil and Natural History of Jamaica* (1756) which contained a description of the insect's minute features, and which Garden received as a 'gift' from Browne in 1755.[317] However, Ellis believed that naturalists lacked an accurate description of the male insect. In his letter to Garden, Ellis explained that an earlier description by the apothecary James Petiver had been 'a very false & bad one,' and that 'no body since the time of Petiver' had produced a better account.[318] This must have resonated with Garden who, as mentioned in section 4.1, criticised the unreliable and inaccurate figures of insects and other natural specimens which were indigenous to colonial America. Garden was therefore aware that his observations would be of value to colonial and European naturalists.

The first stage of the cochineal episode involved the collection of the beetles. Ellis utilised Garden's ability to collect and study the indigenous insects in their natural environment, although Garden found the process difficult due to the physical exertion that was involved. At the beginning of their collaboration, Garden cautioned Ellis that his collection and supply of

---

30:3 (Fall, 2006), p. 107.; Mary Terrall, 'Following Insects around: tools and techniques of eighteenth-century natural history', *British Journal for the History of Science*, 3, (December 2010), pp. 573-588.

[315] Terrall, 'Following Insects around', pp. 573-588.

[316] Garden to Henry Shipley, 5 April 1755, HBC, II, 143.

[317] Berkeley and Berkeley, *Dr. Alexander Garden*, p. 90; Patrick Browne, *The Civil and natural history of Jamaica* (1756), p. 436.

[318] Quoted in Berkeley and Berkeley, *Dr. Alexander Garden* p. 113.

individual cochineal insects – as opposed to their larger nests – would be hampered by the 'plaguy hot' tropical heat.[319] Garden explained that 'the season [for collecting cochineal… is the time that I am generally sick every year' adding, rather forlornly and perhaps deliberately in order to gain sympathy for missing and delayed supplies, that he would probably die before he managed to procure them.[320] Aside from Garden's ill health, the insect itself was difficult to collect. The small, 'nimble and active' males were outnumbered by the larger, more copious females and, unless quickly intercepted with a cloth net, jumped off the plant 'too quickly to be caught'.[321] These challenges were also hinted at in the final letter which was published in the *Philosophical Transactions.*

Despite these difficulties, Garden managed to collect male and female specimens and examined them with Ellis's aquatic microscope in 1758. Garden compared his observations with the Latin description of cochineal in Browne's *Civil and Natural History of Jamaica* (1756).[322] Garden's initial descriptions of the insects, which he sent in 1758, was lost at sea, and the original letter was copied and sent to Ellis in February 1759. With the exception of a fine piece of 'hair' that protruded from the insect and which Garden did not always observe, he nevertheless found 'the insect…. answer[ed] pretty much to Dr. Browne's description', and described the appearance of the minute eggs in some detail.[323] The 'small gritty particles' were 'elliptical, quite smooth, shining, transparent', were large in relation to the size of the female, and were the 'richest' source of the cochineal dye.[324] Garden made further examinations of the anatomy of the male insects on 21 August 1759, and communicated his findings to Ellis in July 1760.[325] Ellis published the letter in his account of cochineal in the *Philosophical Transactions.* Garden did not supply a sketch of the insect, having admitted

[319] Garden to Henry Baker, 10 May 1759, HBC, VIII, 118.
[320] Garden to John Ellis, 17 February 1759, in Stephanie Volmer, 'Planting a New World: Letters and Languages of Transatlantic Botanical Exchange, 1733-1777', PhD Dissertation (The State University of New Jersey, May 2008), p. 149.
[321] Ibid.
[322] Browne, *The Civil and natural history of Jamaica,* p. 436.
[323] Garden to Ellis, 17 February 1759, quoted in Volmer, 'Planting a New World', p. 149.
[324] Ibid.
[325] Garden to John Ellis, 16 July 1760, *A Selection of the Correspondence of Linnaeus,* p. 498.

to Henry Baker in 1757 that he was not capable of even the 'Simplest Draught'.[326] Instead, Garden relied on his ability to accurately and faithfully describe the natural specimens. The accuracy and reliability of Garden's written description was hinted at by Ellis who, in the published account, wrote that Garden's observations agreed 'very nearly with [the] annexed microscopical drawings' which Ellis had provided.[327]

In the published account, Garden omitted his earlier references to eggs and instead emphasised the size, anatomy, colour, and movement of the male and female specimens as seen with Ellis's microscope. Garden noted the shape and also the relative dimensions of the antennae, legs, wings, fine hairs, length of the nerve inside the wing, and the joints in the male's antennae and legs. Garden also commented on the size and appearance of the female, such as the appearance of its wrinkles. The male, in contrast to the larger female, was 'slender', not as swollen, and was less prolific. Garden estimated that there were '150 or 200 females for one male'. The male was also faster and more 'active' than the 'overgrown' females who, Garden wrote, could 'scarce… move themselves' across the lens. Garden commented on the speed with which the male moved its legs and antennae, thereby explicitly demonstrating his use of the aquatic microscope's adjustable arm to follow the movements of the living specimens. Garden studied the male insect while 'walking', observed that it moved its legs 'very briskly and with great speed', and its 'two long antennae… every way very briskly'.[328] The account was read at a meeting of the Royal Society and published in the *Philosophical Transactions*.[329] Unfortunately, it is not known if Garden communicated the results of his observations, or the publication of his account to other colonial naturalists in the same vein as his earlier attempts to distribute news of Ellis's draughts to Colden in New York (see section 4.2).

[326] Garden to Henry Baker, 22 April 1757, HBC, II, 239.
[327] Ellis, 'An Account of the Male and Female Cochineal Insects' *Philosophical Transactions,* p.664.
[328] Ibid, pp. 663-664.
[329] Berkeley and Berkeley, *Dr. Alexander Garden,* p. 128.

However, the section has shown that Garden practised microscopy at the request of Ellis, examined multiple indigenous insects, and communicated his findings to Ellis. The joint publication of Ellis's and Garden's observations marked the culmination of an active, two-way collaboration. The cochineal episode was arguably the most complex phase of Garden's microscopy. Furthermore, Garden made the examinations in the knowledge that his microscopical observations would be communicated to European naturalists and readers of the *Philosophical Transactions.*

Conclusion

This chapter has shown that Garden actively engaged with microscopy between the mid-1750s and mid-1760s. There are further instances of Garden's botanical and animal microscopy which cannot be discussed here for reasons of space. Nevertheless, the chapter has presented two of the most significant phases of Garden's microscopy, both of which enrich our current understanding of Garden's practice of microscopy, knowledge of the subject, and relationship with the London microscopist John Ellis. Garden's enthusiastic response to Ellis's ocular demonstrations, and his practice of scientific microscopy in collaboration with Ellis, point to Garden's written but also verbal communication with other naturalists on the subject of microscopy. By bringing to light Garden's roles as advocate, distributor, practising microscopist, and author, the study has demonstrated that microscopes, texts and observations circulated between London and Charleston in the second half of the eighteenth century.

Chapter 5: Conclusion

This study has established that scientific microscopy was practiced on both sides of the Atlantic Ocean. It has demonstrated that microscopy-related materials – instruments, texts and letters – and microscopical knowledge circulated between elite naturalists in London and colonial America, between London instrument makers and colonial institutions, and, within the colonies themselves, between lecturers, merchants and ordinary colonials. The study thus complements recent studies of eighteenth-century European microscopy, colonial science and the circulation of scientific knowledge across different geographical boundaries. Furthermore, it has developed these historiographies in new ways by drawing together their as yet separate insights: identifying the American colonies as sites of microscopy and microscopy as a part of colonial scientific culture, and by demonstrating the trans-Atlantic nature of microscopy. The study has thereby raised new questions for the wider historiography of eighteenth-century science.

The study has widened the picture of the dynamism of eighteenth-century microscopical practice by showing that botanical microscopy was practiced in Philadelphia during the first half of the eighteenth century and that animal microscopy was practiced in Charleston during the second half of the eighteenth century. Logan and Garden are particularly useful case studies for exploring the practice of scientific microscopy in the American colonies because of the multiple ways in which they engaged with the subject. As chapter three and chapter four show, Logan and Garden published their microscopical observations, communicated their findings to colonial and European correspondents through verbal and written communication, actively responded to theories in microscopy-related texts, used different types of microscopes and expressed interest in microscopy over lengthy time periods. They also assumed multiple roles throughout the different phases of their microscopy: in addition to their roles as practicing microscopists and published authors, both discussed the subject face-to-face

with at least one other naturalist and collaborated with at least one other individual in some capacity. It must also be noted that there was also considerably more evidence for Logan's and Garden's microscopical activities in the secondary literature compared with other elite naturalists. The thorough examination of previously published evidence together with newly sourced evidence of Logan's and Garden's microscopical activities has provided us with fresh perspectives of some of their most familiar achievements and relationships. At a time of much research into non-heroic and ordinary colonials, the accounts of Logan's and Garden's microscopy are examples of how opportunities for research into more familiar figures such as elite naturalists have not yet been exhausted. The point was made by Joyce Chaplin regarding the printer Benjamin Franklin, but can be applied to other elite colonials as demonstrated in this thesis.[330]

The study has demonstrated that microscopy-related materials and knowledge circulated within trans-Atlantic networks. The activities of Logan, Garden, and the professors, students, patrons, demonstrators and retailers who were discussed in chapter two, testify to the circulation of microscopes that took place within trans-Atlantic commercial networks and, in the case of Logan and Garden, to the transmission of microscopical knowledge and texts within trans-Atlantic correspondence networks. Situating microscopy within colonial and trans-Atlantic geographies develops Marc Ratcliffe's extensive research into European scientific activity and his call for historians to consider a 'New Historiography' of eighteenth-century microscopy.[331] This study has shown that this 'New Historiography' can include the history of microscopy in colonial America and the trans-Atlantic world. Ratcliffe's revisionist perspective of the history of eighteenth-century microscopy in Europe and the chapters in this thesis will help draw the attention of scholars to the history of eighteenth-century microscopy on *both sides* of the Atlantic. As this study has shown, colonial Americans in Philadelphia, Charleston, Boston, New York and the colonies of Connecticut, New Jersey, Rhode Island and Virginia, received

[330] Chaplin, 'Benjamin Franklin and Science, Continuing Opportunities for Study', pp. 232-251
[331] Ratcliffe, *The Quest for the Invisible*, pp. 1-10.

information about microscopical discoveries, had access to different types of microscopes at a number of outlets, and practised microscopy as part of their investigations into plants and animals. The publications of prominent London-based microscopists – Nehemiah Grew, Richard Bradley, George Adams, Henry Baker and John Ellis – and the microscopes of London instrument-makers – George Adams, Edmund Culpeper and Benjamin Martin – were distributed to institutions, stores and individual naturalists in the American colonies and were utilised by colonial Americans.

These materials moved in different directions across the Atlantic and over different geographical boundaries. On one level, the necessary material requisites – the books and microscopes which were produced in London – had to be sent to the colonies. On another level, however, and as the chapters on James Logan and Alexander Garden show, information – in the form of letters and treatises – also moved back across the Atlantic to London. While microscopes and texts generally moved one-way in the trans-Atlantic circuits (except when sent for repair), microscopical observations and ideas circulated in both directions. Furthermore, and as the second chapter reveals, microscopical knowledge and its material culture also circulated both within and between the institutional, public, and private spheres of colonial America. The transmission of information – for instance, between college professors and students, lecturers and paying customers, and wholesale retailers and the public – usually took place within individual settlements, although inter-colonial interaction also took place. Knowledge of microscopy was transmitted between colonials in the form of printed advertisements, visual displays and verbal communication: these activities point to the dynamic and diverse nature of microscopy in eighteenth-century colonial America. The study therefore opens up new possibilities for research into the history of eighteenth-century microscopy, the history of colonial science and the history of eighteenth-century natural history. These possibilities have the potential to broaden our understanding of the geographies of eighteenth-century microscopy, the scientific culture of microscopy in colonial America, and the use of microscopes in natural historical investigations.

The study opens up new avenues for research in the history of colonial microscopy. Perhaps the most immediate starting point for future research is for historians to use the details of Logan's and Garden's microscopy – the types of microscopes which they used, the types of texts they received, the specimens which they examined, and the overall nature of their microscopy – as templates for future research. For instance, did other colonials use Culpeper Wilson-style microscopes and aquatic microscopes to examine pollen and insects,[332] and read the publications of Nehemiah Grew, John T. Needham, George Adams and John Ellis? Who else corresponded with the London microscopist Henry Baker? [333] Did many other colonials publish their observations, and with whom did they share their findings?[334] As seen in this page's footnotes, the existing literature is a good starting point for identifying other examples of colonial microscopy.[335]

Building on my findings, scholars might also elaborate on the cultures of microscopy in the institutional and public spheres of colonial America. To what extent were microscopes used as teaching aids in colleges, and were microscopes owned by smaller societies situated away from the main settlements? [336] Can we identify other individuals whose microscopes were auctioned for sale, and did such individuals practice microscopy? Is there evidence that colonials purchased microscopes from wholesale merchants? How widespread were microscopical displays in the colonies and are there additional eyewitness accounts? James Delbourgo's chapter on electrical

---

[332] In 1766, Moses Bartram, the son of John Bartram, sent his descriptions of the eggs and anatomy of the American mole locust to Peter Collinson, see Samuel Hazard's Register of Pennsylvania, vol. 14 (1834), p. 76. See the footnotes below for other observations.

[333] Baker sent his *The Microscope made Easy* to Richard Brooke in Maryland, Richard Brooke to Henry Baker, 15 October 1754, HBC, VI, 74.

[334] Three examples include the following. The observations of 'Dr. Hill in Baywater' in Massachusetts, who was asked to examine small insects which a colonial gave him, was published in *Boston Evening Post,* 30 March 1772, EAN; The observations of an unidentified 'Gentleman' in Massachusetts who studied the pollen of local plants which had swept over a town, and the spores of nearby ferns, were published in *Boston Post-Boy & Advertiser,* 11 July 1763, EAN; Colonel Landon Carter's observations of a 'moth or flyweevil' in North Carolina was published in the *Virginia Gazette,* see 'Diary of Col. Landon Carter', *William and Mary Quarterly,* 14:4 (April, 1906), pp. 252.

[335] The identities of eight individuals who engaged with microscopy in colonial America are provided in Bell, *Patriot Improvers,* p. 107, p. 153, pp. 477-478, p. 352, p. 519, p. 282, p. 363, p. 172.

[336] The instrument collection at Juliana Library Company (1759) in Lancaster, Pennsylvania, included 'a solar microscope, telescopes and electrical apparatus, see Bell, *Patriot-Improvers,* p. 352.

demonstrations in colonial America, entitled 'Wonderful Recreations', is a useful model for such research. Were microscopical demonstrations also a form of recreational activity in Enlightenment America, were they also performed in parlours, and were they as widespread and 'fashionable' as the electrical demonstrations discussed by Delbourgo?[337] Research into such issues would help fill out the current history of colonial and civic science to include microscopy-related activities, develop the literature on colonial scientific culture, and provide evidence of the use of microscopes in natural history.

Other strands of research might include the development of the study's brief allusions to public activity in Philadelphia and Charleston, the religious responses of colonials to microscopical knowledge and the participation of women in microscopy-related activities (see section 2.2). The study presents considerably less information about public demonstrations and trade in Philadelphia and Charleston, focusing instead on retailers and auctioneers in Boston and New York. The evidence was weighted in this way simply because *Early American Newspapers* – an online, searchable database which was my only access to printed media – produced few results for Philadelphia and none at all for Charleston.[338] Historians will require direct access to colonial archives in order to investigate the retail culture of microscopy in Philadelphia and Charleston, build on the general snapshot of commercial activity presented in this thesis and provide an idea of the environments in which Logan and Garden practised their microscopy. Unfortunately, there is little evidence that the Quakers Logan and Bartram, and the Scottish Presbyterian Garden expressed their religious responses to microscopy, although section 2.2 did allude to the preaching of a minister and to the published poem of a young woman who had described a microscopical demonstration as an 'Act of Praise' which had displayed 'The Wonders of… God'.[339] As Cantor has

[337] Delbourgo, *A Most Amazing Scene of Wonders*, pp. 87-128, p. 89.
[338] A free month's trial to the database – Early American Newspapers, <http://0-infoweb.newsbank.com.wam.leeds.ac.uk/> – was provided by the University of Leeds in 2013.
[339] *Boston Newsletter*, 21 August 1746. The poem is published in full in Shipton, *New England Life in the Eighteenth Century*, p. 485.

shown, Quakers in England responded to a number of different sciences such as astronomy in the eighteenth century, and Delbourgo discussed the religious responses of colonial Americans to electricity.[340] Drawing on these insights, historians might develop the literature on science and religion in the eighteenth century by also considering the ways in which colonial Quakers, Presbyterians, Puritans and other religious denominations responded to microscopy.

Similarly, research into the participation of women in microscopy-related activities – a small number of which were also referred to in the thesis – would add to the literature on gender and natural history, and supplement Delbourgo's and Parrish's studies of the engagement of colonial women with botany and electricity.[341] In her article 'Women's Nature', Parrish commented on the exposure of colonial women to microscopy-related texts and demonstrations: further research into the subject might determine the extent to which women – such as the young woman who wrote the poem, mentioned above, and the 'ladies' who appear to have been specifically targeted by an itinerant lecturer in Charleston[342] – engaged with microscopical knowledge.[343] A useful model for such a study might be Meyer's *The Scientific Lady in England, 1650-1760: An Account of Her Rise, with Emphasis on the Major Roles of the Telescope and Microscope* (1955).[344] In addition to raising issues such as religion and gender, the published poem also draws attention to literature studies and the history of the book. For reasons of space, I did not consider the library collections of societies, the publication of microscopical discoveries (taken from London media) in colonial magazines, or the availability of Henry Baker's guide to

---

[340] Cantor, *Quakers, Jews, and science: religious responses to modernity and the sciences in Britain, 1650-1900* and Delbourgo, *An Amazing Scene of Wonders.*
[341] For instance see Schiebinger, *Nature's Body: Sexual Politics and the Making of Modern Science* (London: Pandora, 1994); Schiebinger, 'Gender and Natural History', *Cultures of Natural History*, pp. 163-177; Delbourgo, *A Most Amazing Scene of Wonders,* pp. 110-119; Parrish, 'Lavinia's Nature', *Cultures of Natural History,* pp. 174-214; Parrish, 'Women's Nature', pp. 202-204.
[342] *South Carolina Gazette,* 16 February 1767 quoted in Shipton, *New England Life in the Eighteenth Century,* pp. 362-363.
[343] Parrish, 'Women's Nature', pp. 202-204.
[344] Gerard D. Meyer's *The Scientific Lady in England, 1650-1760: An Account of Her Rise, with Emphasis on the Major Roles of the Telescope and Microscope* (Berkeley: University of California Press, 1955).

microscopy, *The Microscope Made Easy* (1742), in colonial stores. Evidence of such activities exist, however, and might be investigated in greater detail by subsequent scholars.

Finally, historians might extend the study even further by, first, identifying other trans-Atlantic geographies of microscopy and, secondly, by researching the history of other optical instruments which circulated within eighteenth-century trans-Atlantic networks. In regard to the first of these, it should be noted that the study focused on the circulation of microscopy-related materials in the commercial and correspondence networks which existed between London and Philadelphia, Charleston, Boston, New York and other settlements in the colonies of Virginia, Rhode Island and New Jersey. However, materials also circulated between other European and colonial settlements. For instance, while searching the original correspondence of the London microscopist Henry Baker, I found evidence that Baker sent *The Microscope Made Easy* with an inscription to 'his much esteemed Friend' Richard Brooke in the colony of Maryland.[345] There is also evidence that a Wilson pocket microscope was offered for sale in the southern colony of Georgia, and that microscopy was practiced by European and colonial naturalists in the Bahama Islands, and the French territories of Canada and Hudson Bay in the eighteenth century, information which, if investigated further, might open up other geographies of microscopy in the trans-Atlantic world.[346] In regard to the second point, the thesis may be taken to invite research into the understudied history of other optical instruments other than microscopes, and their associated practices. An object of future research may be to build on the existing literature on the history of colonial astronomy and to demonstrate the circulation of telescopes and astronomical knowledge in the trans-Atlantic world during the eighteenth century.

---

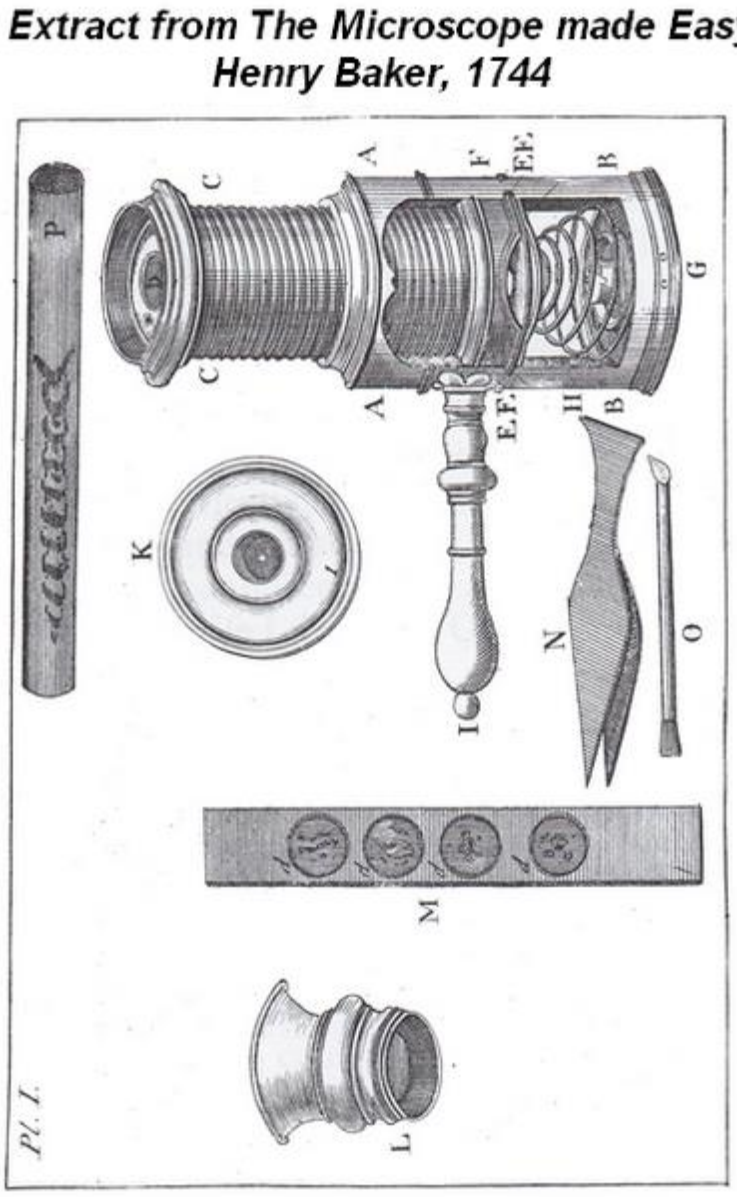
[345] Richard Brooke to Henry Baker, 15 October 1754, HBC, VI, 74.

[346] *Georgia Gazette,* 7 July 1763 and 1 December 1763, EAN; Alan Feduccia, *Catesby's Birds of Colonial America*, 2nd edition, (Chapel Hill: University of North Carolina Press, 1999), p.22.; Frederic T. Lewis, 'The Advent of Microscopes in America, with notes on their earlier history', *Scientific Monthly* , 57:3 (September, 1943), pp. 257-258; Stuart Houston, Tim Ball, Mary Houston, *Eighteenth-Century Naturalists of Hudson Bay* (Montréal: McGill-Queens University Press, 2003), p. 76, pp. 86-87, p. 271.

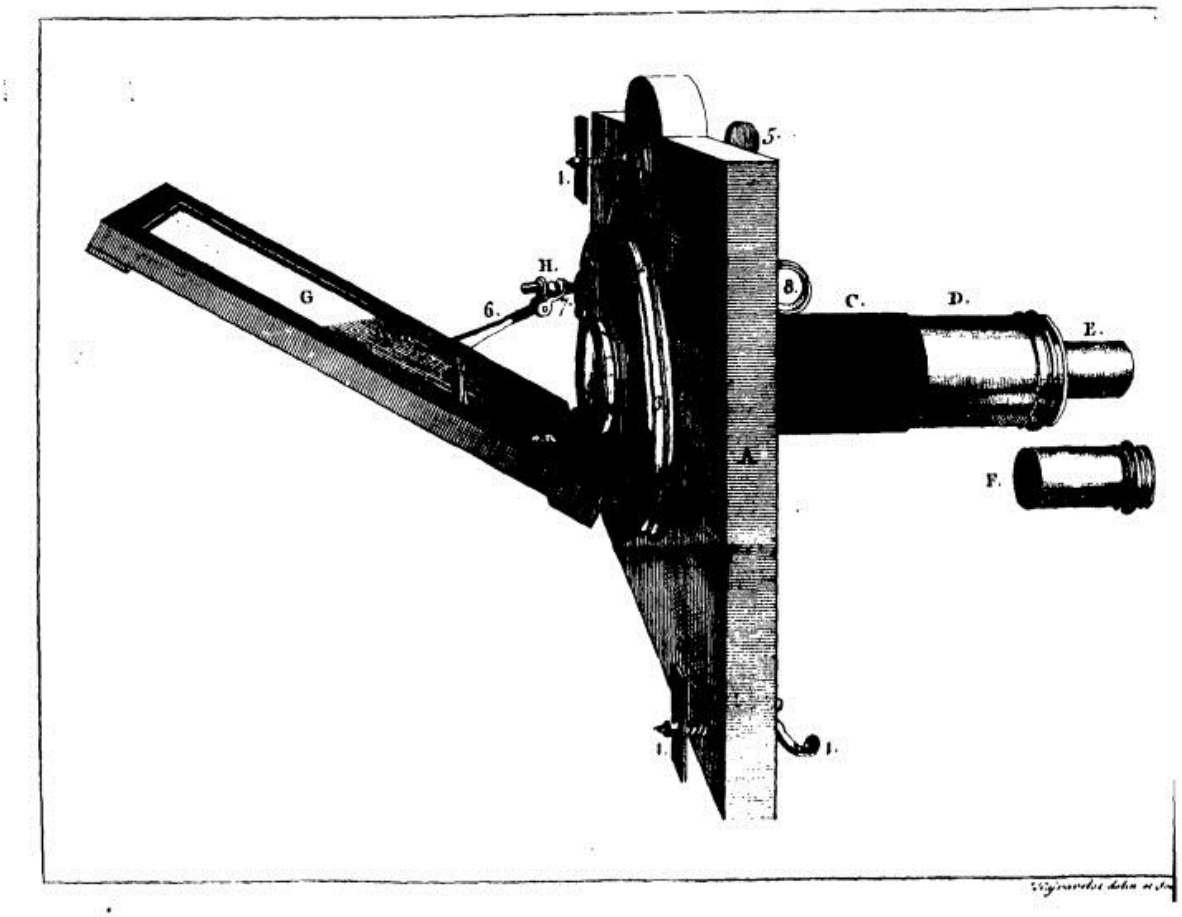
Studying the 'transatlantic career[s]' of instruments can 'hold object lessons' for understanding American and trans-Atlantic knowledge cultures.[347] This thesis is an example of this type of study: by charting the 'transatlantic career' of microscopes and other microscopy-related materials in the eighteenth century and assessing the extent to which such materials were utilised by colonial Americans, this study has modified recent historiography of eighteenth-century microscopy, colonial science, scientific communication and natural history. The history of eighteenth-century microscopy, which is itself a new area of study, can be studied within the wider geography of the trans-Atlantic world. The study has also opened up new possibilities for research into religious, gender, instrumentation and other issues which would contribute to the literature on eighteenth-century science. By drawing on the insights of recent scholars in their studies of eighteenth-century microscopy, and of colonial and trans-Atlantic science, and by bringing these insights to bear on the history of colonial microscopy, the study has presented an exciting new area of research that is of significance not just to historians of eighteenth-century microscopy and colonial science, but to historians interested in wider issues related to natural history, scientific practice and scientific communication in the eighteenth-century trans-Atlantic world.

[347] Delbourgo, 'Common Sense, Useful Knowledge, and Matters of Fact in the Late Enlightenment', pp. 648-649.

Appendix

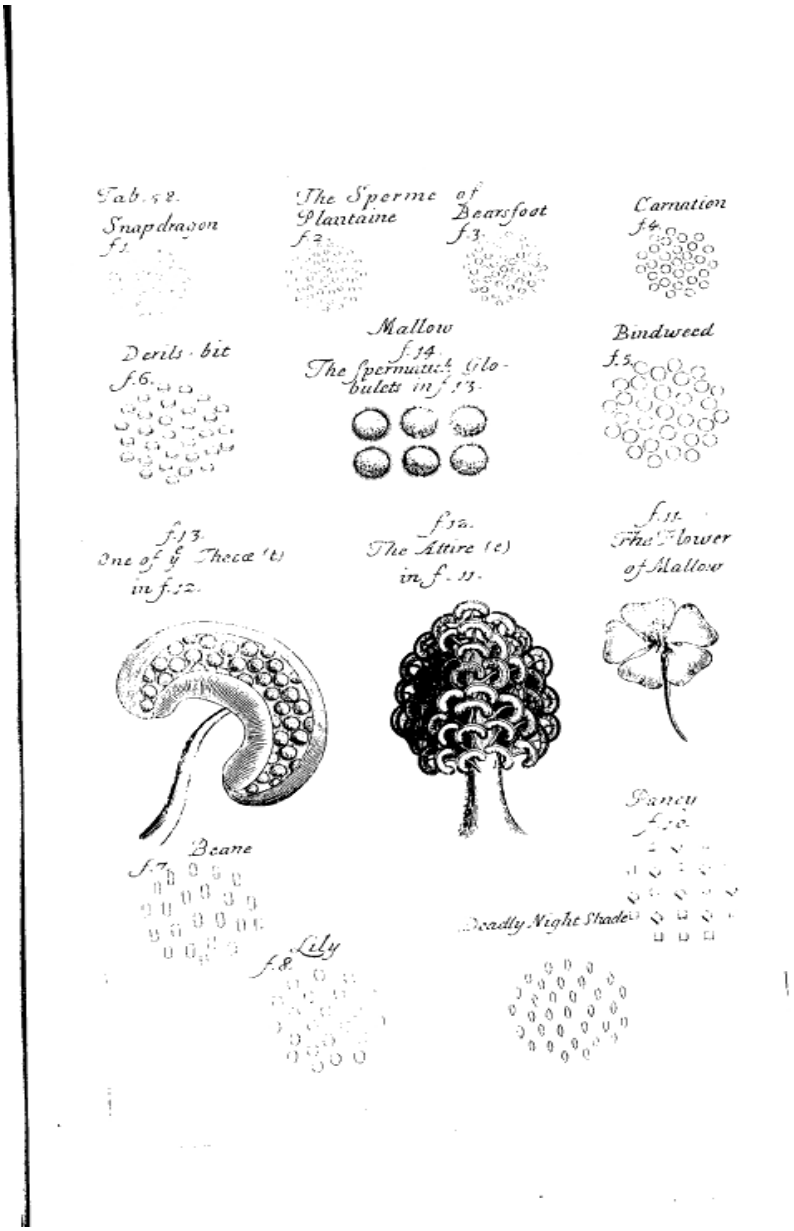


1.1 Wilson screw-barrel microscope, in Henry Baker, *The Microscope made Easy* (London, 1744)

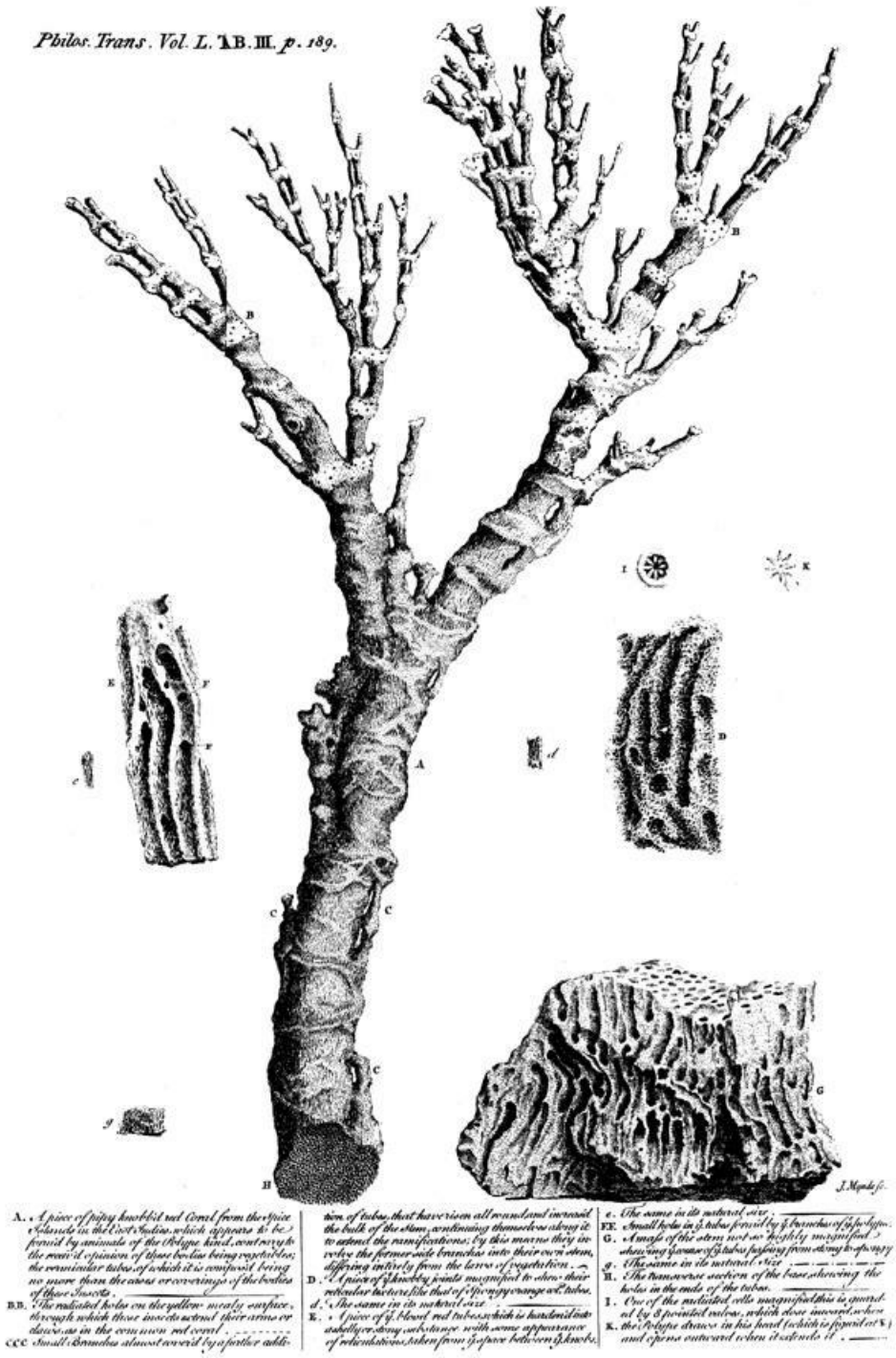


1.2 Solar microscope from Henry Baker, *The Microscope Made Easy* (London, 1744)

1.3 Ellis-Cuff aquatic microscope from John Ellis, *An Essay towards understanding the Natural History of Corallines* (London, 1755)



1.4 Nehemiah Grew, *Anatomy of Plants… and several other lectures read before the Royal Society* (1682), table 58.



1.5 John Ellis, ‘An Account of a Red Coral from the East Indies…’, *Philosophical Transactions*, 1757.

Bibliography

Primary sources

A Selection of the Correspondence of Linnaeus, ed. James E. Smith, volume 1, (London, 1821).

Adams, George, *Micrographia Illustrata* (1745).

Baker, Henry, *The Microscope Made Easy* (1742).

Bradley, Richard, *New Improvements in Gardening* (1726).

Browne, Patrick, *The Civil and natural history of Jamaica* (1756).

Correspondence of John Bartram, 1734-1777 , ed. Berkeley, Edmund and Dorothy Berkeley (Gainesville: University Press of Florida, 1992).

Cuff, John, *The description of a pocket microscope* (1744).

EAN *Early American Newspapers* <http://0-infoweb.newsbank.com.wam.leeds.ac.uk/>.

Ellis, John, 'An Account of the Male and Female Cochineal Insects, That Breed on the Cactus Opuntia . . . in South Carolina and Georgia' in *Philosophical Transactions,* vol. 52 (1761-1762).

Ellis, John, 'An Account of a Red Coral from the East Indies . . .', *Philosophical Transactions,* 1757.

Grew, Nehemiah, *Anatomy of Plants* (1682).

Henry Baker Correspondence, John Rylands Library, Manchester, II-VIII.

Logan, *Experiments and Considerations,* quoted in Lokken, Roy N., 'The Scientific Papers of James Logan', pp. 84-88.

Logan, James, 'Some Experiments Concerning the Impregnation of the Seeds of Plants', *Philosophical Transactions* (1735), vol. 39, pp. 192-195.

LPCC, *The Letters and Papers of Cadwallader Colden,* vols. III (1919) and V (1921) (New York: New York Historical Society, 1918-1937).

Memorials of John Bartram and Humphry Marshall, ed. William Darlington (New York: Hafner, 1849).

Philadelphia, Historical Society of Pennsylvania, Letterbooks of James Logan.

Smith, James E., *A Selection of the Correspondence of Linnaeus and other naturalists, from the original manuscripts* (London, 1821).

The Linnaean correspondence, an electronic edition prepared by the Swedish Linnaeus Society, Uppsala, and published by the Centre international d'étude du XVIII^{e} siècle, Ferney-Voltaire.

Wilson, James, 'The Description and Manner of Using a Set of Small Pocket Microscopes, Made by James Wilson. . .', *Philosophical Transactions* (1702), 23, pp.1241-1247.

Secondary sources

Bedini, Silvio A., *Early American Scientific Instruments and their Makers* (Washington: Smithsonian Institution, 1964).

Bedini, Silvio, *Thinkers and Tinkers: Early American Men of Science* (New York: Charles Scribner & Sons, 1975).

Bedini, Silvio, '"That Awfull Stage" (The Search for the State House Yard Observatory)' in *Science and Society in Early America: Essays in Honor of Whitfield J. Bell*, ed. Klein, Randolph and Whitfield Bell (Philadelphia: American Philosophical Society, 1986), pp. 155-200.

Bedini, Silvio. 'Of 'science and liberty': The scientific instruments of King's college and eighteenth-century Columbia colleges in New York', *Annals of Science*, 50:3 (1993).

Bell, Whitfield, *Patriot-Improvers: Biographical Sketches of the American Philosophical Society*, vol. 1, 1743-1768 (Philadelphia: American Philosophical Society, 1947).

Bellion, Wendy, *Citizen Spectator: Art, Illusion, and Visual Perception in Early National America* (Chapel Hill: University of North Carolina Press, 2011).

Berkeley, Edmund and Dorothy Berkeley, *Dr. Alexander Garden of Charles Town* (Chapel Hill: University of North Carolina Press, 1969).

Brasch, Frederick E., 'The Royal Society of London and Its Influence Upon Scientific Thought in the American Colonies', *Scientific Monthly*, 33:4 (October, 1931), pp. 336-355 and 33:5 (November, 1931), pp. 448-469.

Bridenbaugh, Carl and Jessica Bridenbaugh, *Rebels and Gentlemen: Philadelphia in the Age of Franklin*, 2nd ed. (Westport, Connecticut: Greenwood Press, Publishers, 1970).

Brooke, John and Geoffrey Cantor, *Reconstructing Nature: The Engagement of Science and Religion* (Edinburgh: T & T Clark, 1998).

Burt, Nathaniel, *The Perennial Philadelphians: The Anatomy of an American Aristocracy*, 2nd edition (Philadelphia: University of Pennsylvania Press, 1999).

Cantor, Geoffrey N., *Quakers, Jews, and science: religious responses to modernity and the sciences in Britain, 1650-1900* (Oxford: Oxford University Press, 2005).

Cantor, Geoffrey, 'Quakers and Science' in *The Oxford Handbook of Quaker Studies*, ed. Stephen Angell and Dandelion, Pink (Oxford; New York: Oxford University Press, 2013), p. 520-534.

Chaplin, Joyce E., *Subject Matter: Technology, the Body, and Science on the Anglo-American Frontier, 1500-1676* (Cambridge, Massachusetts: Harvard University Press, 2001).

Chaplin, Joyce E., *The First Scientific American: Benjamin Franklin and the Pursuit of Genius* (New York: Basic Books, 2006).

Chaplin, Joyce, 'Benjamin Franklin and Science, Continuing Opportunities for Study', *Perspectives on Science*, 14:2 (Summer, 2006), pp. 232-251.

Cohen, I. Bernard, *Some Early Tools of American Science The Account of the Early Scientific Instruments and Mineralogical and Biological Collection in Harvard University* (Cambridge, Massachusetts; Harvard University Press, 1950).

Cohen, I.B, *Benjamin Franklin's Science* (Cambridge, Mass.: Harvard University Press, 1990).

Commager, Henry S., *The Empire of Reason: How Europe Imagined and America Realized the Enlightenment* (Garden City, New York: Anchor Press/Doubleday, 1977).

Cultures of Natural History, eds. Nicholas Jardine, Secord, James, and Spary, E.C (Cambridge; New York: Cambridge University Press, 1996).

Davis, Elisabeth and Diane Schmidt, *Guide to Information Sources in the Botanical Sciences*, 2nd edition, (Englewood, Colorado: Libraries Unlimited, 1996).

Delbourgo, James, *A Most Amazing Scene of Wonders: Electricity and Enlightenment in Early America* (Cambridge, Massachusetts; London: Harvard University Press, 2006).

Delbourgo, James, 'Common Sense, Useful Knowledge, and Matters of Fact in the Late Enlightenment: The Transatlantic Career of Perkins's Tractors', *William and Mary Quarterly*, 61:4 (October, 2004), pp. 643-684.

Earnest, Ernest, *John and William Bartram, Botanists and Explorers, 1699-1726, 1739-1823* (Philadelphia: University of Pennsylvania Press, 1940).

Farley, John, *Gametes & Spores: Ideas about Sexual Reproduction, 1750-1914* (Baltimore; London: The Johns Hopkins University Press, 1982).

Ford, Brian, *The Leeuwenhoek Legacy* (Bristol: Biopress; London: Farrand, 1991).

Fournier, Marian, *The Fabric of Life: Microscopy in the seventeenth century* (Baltimore; London: Johns Hopkins University Press, 1996).

Fortune, Brandon B. and Deborah Warner, *Franklin & His Friends: Portraying the Man of Science in Eighteenth-Century America* (Washington, D.C.; Philadelphia: Smithsonian National Portrait Gallery and University of Pennsylvania Press, 1999).

Gage, Simon H. 'Microscopy in America (1830-1945), ed. Oscar Richards, *Transactions American Microscopical Society*, LXXXIII, no.4 (October 1964), pp.1-125.

Genuth, Sara S., 'From Heaven's Alarm to Public Appeal: Comets and the Rise of Astronomy at Harvard', in *Science at Harvard University: Historical Perspectives*, Clark A. Elliott and Rossiter, Margaret W (London; Toronto: Associated University Presses; Bethlehem: Lehigh University Press, 1992), pp. 28-54.

Geographies of the Book, eds. Ogborn, Miles, and Withers, Charles (Farnham: Ashgate, 2010).

Geography and Enlightenment, eds. David N. Livingstone and Withers (Chicago; London: University of Chicago Press, 1999).

Gillingham, Harrold, 'Some Early Philadelphia Instrument Makers, *Pennsylvania Magazine of History and Biography*, 51:4 (1927), pp. 289-308.

Gillingham, 'Old Business Cards of Philadelphia', *Pennsylvania Magazine of History and Biography*, 53:3 (1929), pp. 203-229.

Groner, Julius and Paul Cornelius, *Merchant, Microscopist, Naturalist and King's Agent* (Pacific Grove, California: Boxwood Press, 1996).

Gronim, Sara, *Everyday Nature: Knowledge of the Natural World in Colonial New York* (New Brunswick, New Jersey; London: Rutgers University Press, 2007).

Guenther, Michael B. 'Enlightened Pursuits: Science and Civic Culture in Anglo-America, 1730-1760' PhD thesis (Northwestern University, December 2008).

Heering, Peter, 'The enlightened microscope: re-enactment and analysis of projections with eighteenth-century solar microscopes', *British Journal for the History of Science*, 41:3 (September 2008).

Hindle, Brooke, *The Pursuit of Science in Revolutionary America 1735-1789* (Chapel Hill: The University of North Carolina Press, 1956).

Hindle, Brooke, *David Rittenhouse* (Princeton, New Jersey: Princeton University Press, 1964).

Hoermann, Alfred R., *Cadwallader Colden: A Figure of the American Enlightenment* (Westport, Connecticut; London: Greenwood Press, 2002).

Howe, Daniel W., *American History in an Atlantic Context: An Inaugural Lecture delivered before the University of Oxford 3 June 1991* (Oxford: Clarendon Press, 1993).

Kamen, Michael, *Colonial New York: A History*, 2nd edition (Oxford: Oxford University Press, 1996).

Kastner, Joseph, *A Species of Eternity* (New York: E.P. Dutton, 1977).

Kershaw, Gordon E., *James Bowdoin II: Patriot and Man of the Enlightenment* (Lanham; New York: University Press of America, 1991).

Lewis, Frederic T.,'The Advent of Microscopes in America, with notes on their earlier history', *Scientific Monthly*, 57:3 (September, 1943).

Lokken, Roy N., 'The Scientific Papers of James Logan', *Transactions of the American Philosophical Society,* 62:6 (1972).

Meinig,W. *The Shaping of America: A Geographical Perspective on 500 Years of History*, vol. 1, Atlantic America, 1492-1800 (New Haven; London: Yale University Press, 1986).

Morison, Samuel E., 'The Harvard School of Astronomy in the Seventeenth Century' in *New England Quarterly* 7:1 (March, 1934), pp.3-24.

Morton, A.G. *History of Botanical Science: an account of the development of botany from ancient times to the present day* (New York; London: Academic Press, 1981).

Muthyala, John, *Reworlding America: Myth, History and Narrative* (Athens, Ohio: Ohio University Press, 2006).

Nature and Empire: Science and the Colonial Enterprise, ed. Roy MacLeod, (Chicago: University of Chicago Press, 2000).

Nickelsen, Kärin, *Draughtsmen, Botanists and Nature: The Construction of Eighteenth-Century Botanical Illustrations* (Dordrecht: Springer, 2006).

O'Neill, Jean and Elizabeth P. McLean, *Peter Collinson and the Eighteenth-Century Natural History Exchange* (Philadelphia: American Philosophical Society, 2008).

Padgitt, Donald L., *A Short History of the Early American Microscopes* (Chicago; London: Microscope Publications Ltd, 1975).

'Papers Relating to the College' in *William and Mary Quarterly,* 16:3 (January, 1908).

Parrish, Susan, *Cultures of Natural History in the Colonial British Atlantic World: American Curiosity* (Chapel Hill: University of North Carolina Press, 2006).

Parrish, Susan S., 'Women's Nature: Curiosity, Pastoral, and the New Science in British America', *Early American Literature,* 37:2 (2002), pp. 195-245.

Raatz, Simon, 'Science: Colonial Era', in *The Oxford Companion to United States History,* eds Paul S. Boyer and Dubofsky, Melvyn (New York; Oxford: Oxford University Press, 2001), p. 686.

Raistrick, Arthur, *Quakers in Science & Industry,* 2nd edition,(York: Sessions Book Trust, 1993).

Ratcliff, Marc J., *The Quest for the Invisible: Microscopy in the Enlightenment* (Farnham: Ashgate Publishing Limited, 2009).

Raven, James, *London Booksellers and American Customers: Transatlantic Literary Community and the Charleston Library Society, 1748-1811* (Columbia: University of South Carolina, 2002).

Richards, O.W., *Three American Microscope Builders* (Buffalo: American Optical Company, 1945).

Roe, Shirley A, *Matter, Life, and Generation: Eighteenth-century embryology and the Haller-Wolff debate* (Cambridge; London: Cambridge University Press, 1981).

Rooseboom, Maria, *Microscopium* (Leyden: National Museum for the History of Science, 1956).

Ruestow, Edward, *The Microscope in the Dutch Republic: The Shaping of Discovery* (Cambridge: Cambridge University Press).

Schechner, Sara, 'John Prince and Early American Scientific Instrument Making' , in *Sibley's Heir: A volume in memory of Clifford K. Shipton,* eds. Frederick S. Allis Jr and Smith, Philip C.F., (Boston: The Colonial Society of Massachusetts, 1982), pp. 431-504.

Secord, James, 'Knowledge in Transit', *Isis,* vol. 95:4 (December 2004), pp. 654-672.

Shipton, Clifford K., *New England Life in the Eighteenth Century: Representative Biographies,* 2nd edition (Cambridge: Harvard University Press, 1995).

Shryock, Richard and Otto Beale,*Cotton Mather: First Significant Figure in American Medicine* (Baltimore: Johns Hopkins Press, 1954).

Sloane, Philip, 'Review: Cultures of Natural History', *British Journal for the History of Science,* 30:2 (June, 1997), pp. 241-243.

Stearns, Raymond P., *Science in the British Colonies of America* (Urbana: University of Illinois Press, 1970).

Struik, Derek, 'American Science between 1780 and 1830', *Science*, new series 129:3, (April, 1956).

The American Enlightenment: The Shaping of the American Experiment and a Free Society , ed. Adrienne Koch (New York: George Braziller, 1965).

The Atlantic Enlightenment, eds. Manning, Susan and Francis Cogliano (Aldershot: Ashgate Publishing Limited, 2008).

The Brokered World: Go-Betweens and Global Intelligence, 1770-1820, eds. Simon Schaffer et al. (Sagamore Beach: Science History Publications, U.S.A, 2009).

The Evolution of the Microscope: Important Names and Contributions Aiding Its Progressive Development (Buffalo, New York: Spencer Lens Company, 1947).

Thomson, Keith, *Jefferson's Shadow: The Story of His Science* (New Haven;
London: Yale University Press, 2012).

Tolles, Frederic B., 'Philadelphia's First Botanist: James Logan', *Isis*, 47:1 (March, 1956), pp. 20-30.

Tolles, Frederic B., *James Logan and the Culture of Provincial America*, 2nd edition (Westport, Connecticut: Greenwood Press, 1978).

Tucker, Leonard, 'President Thomas Clap of Yale College: Another "Founding Father" of American Science' in *Isis,* 52:1 (March, 1961).

Turner, Gerard L'E, 'Eighteenth-Century Scientific Instruments and Their Makers', in *Cambridge History of Science*: *Eighteenth-Century Science,* volume 4 (Cambridge; New York: Cambridge University Press, 2008), pp. 511-535.

Volmer, Stephanie, 'Planting a New World: Letters and Languages of Transatlantic Botanical Exchange, 1733-1777', PhD Dissertation (The State University of New Jersey, May 2008).

Warner, John H. 'Exploring the Inner Labyrinths of Creation: Popular Microscopy in Nineteenth Century America' in *Journal of the History of Medicine and Applied Sciences,* 37:1, (1982).

Williams, Roger L., *Botanophilia in Eighteenth-Century France: The Spirit of the Enlightenment* (Dordrecht; Boston; London: Kluwer Academic Publishers, 2001).

Wilson, Catherine, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton, New Jersey: Princeton University Press, 1995).

Withers, Charles, *Placing the Enlightenment: Thinking Geographically about the Age of Reason* (Chicago; London: The University of Chicago Press, 2007).

Wolf II, Edwin, *The Library of James Logan of Philadelphia* (Philadelphia: The Library Company of Philadelphia, 1974).

Woodruff, Lorande L., 'The Advent of the Microscope at Yale College', *American Scientist*, 31:3 (July, 1943), pp. 241-245.

Yeomans, David, 'The Origin of North American Astronomy – Seventeenth Century', *Isis*, 68:3 (September, 1977), pp. 414-425.

Zirkle, Conway, 'Plant Hybridization and Plant Breeding in 18th-Century American Agriculture', *Agricultural History*, 43:1 (January, 1969), pp. 25-38.

Zirkle, Conway, *The Beginnings of Plant Hybridization* (University of Pennsylvania Press, 1935).

Zuidervaart, Huib J., 'The 'Invisible' Made Visible: Telescope Making in the Seventeenth and Early Eighteenth-century Dutch Republic', in *From Earth-Bound to Satellite: Telescope, Skills and Networks*, ed. Alison Morrison-Low et al. (Leiden; Boston: Brill, 2012), pp. 41-102.