Science for Children and the Untutored in Eighteenth-Century England

by

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A dissertation submitted to the Graduate Faculty in History in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1998

UMI Number: 9908354

UMI
300 North Zeeb Road
Ann Arbor, MI 48103

This manuscript has been read and accepted for the Graduate Faculty in History in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

SCIENCE FOR CHILDREN AND THE UNTUTORED
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The popularization of science in eighteenth-century England included books written for children and the untutored. This exploratory study examines five authors who enjoyed recognition in the world of adult literature and who sought to simplify scientific material while conserving sophisticated language and complex ideas. Francesco Algarotti popularized Newton's *Opticks* while John Newbery, under the pseudonym Tom Telescope, used the playthings of childhood to explore Locke's version of Newton's natural philosophy. James Ferguson, in a series of dialogues between a brother and sister, explicated astronomy for young readers. Richard Lovell Edgeworth and his daughter, Maria, regarded observation and experimentation as the primary method of teaching applied science to their young charges. Thomas Day and Edgeworth used popular heroes to explore social issues and changing values. Encouraged by members of the Lunar Society, they utilized their literary and scientific knowledge to further the cause of home schooling. They stressed industry, honesty, self-reliance and hard work as necessary corollaries to scientific exploration and, at the same time, addressed a variety of social issues including the place of women in science, the role of philanthropy, the evils of gambling and the possibilities of a plurality of worlds. This study attempts to bridge the gap between children's literature and the popularization of science.

ACKNOWLEDGMENTS

This dissertation started as an alchemical quest. Fortunately, Algarotti shares the same alphabetical drawer at the Pierpont Morgan Library. As my curiosity took me in a new direction, I found a wonderful place to work and delightful people to assist me. I particularly wish to express my gratitude to Inge Dupont, Vanessa Pintado and Sylvie Merian. The level of concern, helpfulness and extraordinary competence is of the highest quality even in a city marked by superior libraries and librarians. The staff of the New York Public library, both in the Rare Book Division and at the Berg Collection, deserve my gratitude, as does the staff of the CUNY Graduate Center Library.

My committee, headed by Dr. James R.Jacob, offered support, guidance and input far beyond my expectations. Dr. Stewart Prall, Dr. Joseph Dauben, Dr. Randolph Trumbach and Dr. Anna Lou Ashby along with my mentor, Dr. Jacob, have been invaluable in their help.

A special thanks goes to Miss Andrea Ross, whose computer knowledge, patience and ability to get things done has made my life a lot easier. I am especially grateful to my friend and colleague Lowell Schiener, who has been unstinting with time, support and commas. To Liz, who "nagged" me through, and to Jane, who was "interested" -- thank you for lugubrious lunches, laughter and unequaled friendship.

To Elaine and Abigail there will still always be time for "tea at the Morgan." And to the other half of this production team, Mitch, – we have produced two wonderful daughters, two adequate dissertations, and twenty-six years of laughter (and debt) – think what we could do if we could get organized. Thanks for being there.

This dissertation
is dedicated to

Alice Morris Spires (b. 1901)

Her wit and wisdom have guided five
generations of youngsters -- showing them
respect rather than indulgence.

Table of Contents

List of Illustrations

All Illustrations are courtesy of the Pierpont Morgan Library

INTRODUCTION

> The children are gathered at school for a celebration, including the presentation of a rich plumb cake. The teacher, begins to cut the cake amid much merriment. She hands the first slice to Harry, the son of a common laborer. Tommy, a gentleman's son objects, feeling certain that his place in society ensured him the first piece of such a rare treat. The teacher, noticing his discomfort, uses this event to talk about the place of wealth and labor. She tells the children that they are not entitled to respect because of their wealth, but only if they prove worthy of that wealth by increasing it through hard work and labor. At the end of this conversation the children cry out, "Trade and Plumb cake forever, Huzzah!"[1]

In the last ten years, there has been a plethora of studies analyzing the content of children's literature in the eighteenth century.[2] This material has looked at the

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[1]John Newbery, *Nurse Truelove's New Year's Eve Gift* (London: J.Newbery, 1750), 6-8.

[2]These works include, but are not limited to, Gillian Avery and Jules Briggs, *Children and Their Books: In Celebration of the Work of Iona and Peter Opie* (New York: Clarendon Press, 1989); Ruth Bottigheimer, "Bible Reading, Bibles and the Bible for Children in Early Modern Germany," *Past and Present* 139 (May 1993):66-89; Kristen Drotner, *English Children and Their Magazines* (New Haven:Yale University Press, 1988); Mary V. Jackson, *Engines of Instruction, Mischief and Magic* (Lincoln: University of Nebraska Press, 1989), and Alsion Lurie, *Don't Tell the Grown-Ups: Subversive Children's Literature* (Boston: Little, Brown, 1990).

publication of children's books starting in mid-century. It has documented the importance of specific types of books, such as Bibles, religious tracts, geographies and natural-history texts. In addition, there has been a fertile investigation of changes in family structures,[3] new definitions of childhood and, consequently, new ways of defining women. At the same time, there has been an equally large body of literature delving into the popularization of science in the eighteenth century. These writers have looked at coffee-houses, pubs, scientific societies, itinerant lecturers and popular publications.[4] This dissertation looks at the nexus of these concerns. Although much has been written about morals and manners in the field of children's literature, no one has investigated the scientific material presented to children in the eighteenth century. Conversely, while much has been written about various popularizations of science, the

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[3] Some key sources include Bridget Hill, *Women, Work and Sexual Politics in Eighteenth-Century England* (New York: Basil Blackwell, 1989) and *Servants, English Domestics in the Eighteenth Century* (New York: Clarendon Press at Oxford, 1996); Linda Pollock, *Forgotten Children: Parent-Child Relations from 1500 to 1900,* (Cambridge:Cambridge University Press, 1983); Roy Porter, *English Society in the Eighteenth Century* (New York: Penguin Books, 1983); and Randolph Trumbach, *The Rise of the Egalitarian Family: Aristocratic Kinship and Domestic Relations in Eighteenth-Century England* (New York: Academic Press, 1978).

[4] See among others, Gerald L'E Turner, "Scientific Toys -- Presidential Address " *British Journal of History of Science* 20, no.4 (1987):377- 98; Stephen Shapin, "A Scholar and a Gentleman: The Problematic Identity of the Scientific Practitioner in Early Modern England," *History of Science* 24 (1991); Barbara Maria Stafford, *Artful Science: Enlightenment Entertainment and the Eclipse of Visual Education* (Cambridge: MIT Press, 1994); and Larry Stewart, "The Selling of Newton: Science and Technology in Early Eighteenth-Century England" *Journal of British Studies* 25, no.2 (April 1986): 178-92.

material embedded in works written for children and the untutored has been largely ignored.

While several historians[5] have mentioned children's science books as part of the popularization of science, there has not been, to date, a concerted effort to investigate the nature of the science presented in these books. Few have done more than merely mention that children's scientific literature existed. The scope of this dissertation includes a significant body of work that straddles both science and children's literature. While essentially an exploratory study seeking to identify those books written primarily to explicate Newtonian science for children, this paper has selected five authors and their books for investigation. These five were chosen because of the popularity of their work, the impact they had as writers of children's literature and their overall influence in the intellectual community. The books and their authors are

- Francesco Algarotti, *Newton for the Ladies;*
- John Newbery, *The Newtonian System of Philosophy Adapted to the Capacities of Young Gentlemen and Ladies, and familiarized and made entertaining by objects with which they are intimately acquainted. Being the substance of six*

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[5]Betty JoTeeter Dobbs and Margaret C. Jacob, *Newton and the Culture of Newtonianism* (New Jersey: Humanities Press International, 1995); James A. Secord, "Newton in the Nursery: Telescope Tom and the Philosophy of Tops and Balls, 1761 - 1838," *History of Science* 23 (1985):128-51; J. H. Plumb, "The New World of Children in the Eighteenth Century," *Past and Present* 67 (1975):64-95. John Fauvel et al., *Let Newton Be! A New Perspective on His Life and Works* (New York: Oxford University Press, 1988).

Lectures read to the Lilliputian Society by Tom Telescope A. M.;

- James Ferguson, *The Young Gentleman and Ladies's Astronomy familiarly explained in ten dialogues;*
- Thomas Day, *The History of Sandford and Merton;* and
- Maria Edgeworth, *Harry and Lucy concluded.*

This dissertation, while admittedly an exploratory study, proposes to:

- look at the life stories of each of the five authors and to discuss how their lives impinge on the greater scientific community,
- examine the science presented to children and the untutored, and
- briefly look at the social issues that each of the authors selects to incorporate into the scientific discourse.

Each of these authors wrote or worked in an arena beyond children's literature; all belonged to scientific societies, including the Royal Society and the Lunar Society. Each saw himself as having influence outside the narrow scope of the work presented in this dissertation. Precisely because of their other works, these writers bring to children's literature a degree of linguistic and philosophical sophistication not found in writers who define children's writings as a series of "talking animals," moral tracts, fairy tales and "gigantik" histories.

This science is of two types: The first is clearly identifiable as Newtonian science, as in the cases of Algarotti's popularization of Newton's *Optics,* Newbery's adaptation of Locke's *Elements of Natural Philosophy,* and Ferguson's presentation of *Astronomy made easy.* The second type is the more narrowly defined combination of applied science and natural history, as is encompassed in *The History of Sanford and Merton* and the popular applied science contained in *Harry and Lucy concluded.* In each case, the science will be examined for its relationship to broader scientific inquiries. At the same time, the scientific methodology recommended to children will be discussed.

These values are disparate but not disconnected. Certain issues are touched on by every author; others are ignored by some but elaborated on by others. The central themes include:

1) How these authors view the education of children, particularly issues such as the place, method and content appropriate to scientific education. Such issues as home schooling, the role of observation and experimentation in the teaching of science, and the specific scientific content will be addressed. This material includes optics, physics, astronomy and botany.

2) The philosophical perspectives of John Locke and Jean Jacques Rousseau will be examined in areas affecting children's socialization. Their contribution to an understanding of how children acquire knowledge will be reviewed.

3) The moral messages linked to the scientific education of children will be treated to the degree that they influence scientific discourse. The issue of life on other planets, or plurality of worlds, is a common topic in each book and discussed in detail by Ferguson. For other authors, moral issues with economic impact take the forefront. These include gambling, philanthropy and the constellation of values treated under the term "industry."

4) The place of women in science, their niche in a world that redefined children, and the new role of teacher will be analyzed.

5) The way in which each author presents other groups and other nationalities will be scrutinized.

The boys at school in the opening excerpt, while enjoying their plumb cake, are being introduced to a new society, one in which respect for social position is being challenged by an emphasis on industry and wealth. The adults of any period serve as curators of the culture, selecting the values and norms they wish to pass on to their offspring. One vehicle for that transmission is literature specifically addressed to children. In the eighteenth century, the linkage between scientific information and the usefulness of that information for improving one's life becomes a major theme in children's literature. Isaac Kramnick[6] argues that science within children's literature

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[6] Isaac Kramnick, "Children's Literature and Bourgeois Ideology: Observations on Culture and Industrial Capitalism in the Later Eighteenth Century," *Studies in Eighteenth-Century Culture* 12 (1983):11-44.

serves both as an end in itself and a tool for teaching a whole new constellation of values: achieved over ascribed status; merit, talent and hard work over privilege, rank and birth; and, finally, individualism, the ability to survive on one's own without recourse to the guild or the social group.

In 1740 Francesco Algarotti's *Newton for the Ladies* was published in England and created a stir because of its denunciation of Descartes, its celebration of Newton, and the depiction of Voltaire's mistress, Madame du Châtelet, on the frontispiece. By placing her image there, Algarotti linked women and Newtonian science in a new way. Two major themes dominate *Newton for the Ladies* and are stated in the preface: to overthrow Descartes and Cartesianism in favor of Sir Isaac Newton and to establish the dominance of Newtonianism. Descartes was still considered the premier natural philosopher and the voice of authority for most of Europe, and Algarotti's attempt to discredit the Cartesian system created a great deal of controversy.

Twenty years later, John Newbery, as part of his lucrative book trade, published *The Newtonian Philosophy*. This was the first work to actually proclaim its intention of teaching Newtonian science to children. Newbery, using notes developed by John Locke (1632-1704), gives a detailed description of the elements of natural philosophy. This book embodies the belief that learning can be fun, and that science is dependent on everyday observation. Tom Telescope not only lectures on science -- using the tots' toys as his laboratory -- but also attacks the problem of gambling, a practice that seems to strike at the heart of scientific inquiry. Gambling leads children away from scientific thinking, creates bad habits and, because it assumes a random and fate-driven world, is anathema to scientific endeavors.

James Ferguson is not so playful in *The Young Gentleman and Lady's Astronomy.* Using limited mathematics, exquisite diagrams, and detailed dialogues between a young Cambridge student and his sister, Ferguson presents a complete course in the astronomy of his day. By explaining the Transit of Venus, which had been predicted by Halley and measured by the Royal Society, he highlights one goal of science: prediction. In addition to the science of the stars, Ferguson was enthralled by the prospect of a plurality of worlds and so offers his readers both astronomy and science fiction. His apparent equating of the inhabitants of the newly discovered regions with the aliens in outer space was not uncommon in the eighteenth century.[7] His treatment of Newtonian science for children cannot be separated from his larger life work as an itinerant lecturer and instrument maker.

Children's literature during the 1780s began to feature applied science, with children engaging in a variety of experiments and demonstrations. The authors of this applied science, which characterized the period from 1780s to the early 1800s, are best understood in their relationship to the Lunar Society.[8] As that society flourished,

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[7] John Adams, "Outer Space and the New World in the Imagination of Eighteenth-Century Writers," *Eighteenth Century Life* 19 (February 1995):70-83.

[8]The Lunar Society was a group of Birmingham industrialists and scientists who created one of the more famous of the local scientific groups in the late eighteenth century. Josiah Wedgwood, Joseph Priestley, James Keir and William Small made up part of the original group. Visitors from all over the world were entertained by the Lunar Society at dinners held at the home of Erasmus Darwin. The best work to date on

became one of its concerns. The group looked to applied science to give answers to emerging industrialists needing solutions to practical problems. The members of the Lunar Society also hoped to apply scientific principles to education. They sought to implement educational reform and to rectify the bleak conditions existing in the majority of the schools.

Two of the members of the Lunar Society who engaged in this endeavor approached the problem from totally different viewpoints. Thomas Day, author of *Sandford and Merton,* adopted the child-rearing philosophy of Jean Jacques Rousseau (1712-1778). Building on these ideas, he developed a series of stories introducing children to the classics and to new and varied tales of other worlds and other cultures. Day demanded respect for lifestyles and systems foreign to his readers and expected both diligence and generosity from them. He, more than any of the other writers, put forth an agenda of values geared to the changing class structure. He championed the cause of the middle class and glorified hard work, economic prosperity and frugality. His antipathy to the aristocracy, his glorification of the simple life, his veneration of the land and his belief in self-sufficiency ensured a long-standing popularity with his readers.

By contrast, Richard Lovell Edgeworth promulgated a completely different agenda. Urged on by Joseph Priestley and Erasmus Darwin, he undertook to revamp

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the society remains Robert Schofield, *The Lunar Society of Birmingham* (Oxford: Oxford at the Clarendon Press, 1963).

education. The first concern was creating educational opportunities for the child at home. He and his wife published their complete educational agenda, but it was left to his daughter, Maria Edgeworth, to write stories that would appeal to children and, at the same time, present basic scientific principles, explain scientific equipment and encourage curiosity and exploration. Within these very readable stories, specific values are reiterated -- hard work, competence and diligence. These virtues, combined with honesty and curiosity, will enable a young person to achieve personal success and, ultimately, to contribute to the greatness of Britain.

The quest for information about the new science served as a significant theme in the eighteenth century as books, magazines, itinerant lecturers and coffee-house discussions made the vocabulary of science part of the fashionable idiom of the day. In turn, popular science was being taught in a world influenced by two philosophical writers, John Locke and Jean Jacques Rousseau, both of whom posed serious questions about the nature of the child. At the end of the previous century, John Locke, in a series of writings, suggested the proper way to rear a child, the proper content for a gentleman's education and the necessary elements to be included in a tradesman's preparation for the business world. He laid out the various elements that contributed to learning, but his most singular accomplishment was the positing of the idea of *tabula rasa.*

Locke's *tabula rasa,* the idea that the mind of the child was a completely blank slate on which all aspects of knowledge can be written, opened up new worlds for the parent. Here was the chance to create a new person. Earlier religious teaching had made much of the innate depravity of the child, tainted by the sin of Adam, not yet in control of his own appetites and already prone to untold evil. Locke's view of the child was a total reversal of generations of preoccupation with punishment and constraints. Locke insisted that entertainment and amusement were crucial to learning and to cultivating a mind receptive to education. With innate moral depravity banished from the nursery, parents could select the virtues and goals they wished for their children.

Rousseau gave superficial assent to Locke's *tabula rasa*, but in his writings he essentially denied the idea by advocating the principle of innate goodness. Rousseau's concept of innate goodness was as strong an influence on the view of child rearing as the concept of innate evil that had dominated an earlier time. Because the child's inborn goodness required unrestrained freedom for full expression, it was necessary for the parent to back away from the child while providing the safety and freedom that would allow the moral development, already preprogrammed in the child, to flourish. Any attempt at constraint would destroy the process, and, rather than developing the "noble savage," the parent would only produce "the plodding peasant." Such a child would be a slave to authority, unable to think for himself and unlikely to contribute much to society.

By the end of the eighteenth century, there were contradictory views of the child and, thus, contradictory views of parenting. Locke argued for the establishment of good habits, arrived at by encouragement, praise and occasional punishment. Habits so ingrained would see the child through difficult times, shield him from outside temptations, and socialize him to his social class and the attendant behavioral expectations. Even though Locke understood that the content of the education might alter from class to class, he argued that the process of acquiring knowledge would always be the same. A child would be trained to think of the world in terms of the environment and the culture in which he existed. Locke argued that the difference between the aristocrat and the peasant was attributable not to "natural parts" but to the different scope given to their understanding and their means of gathering information.[9]

Rousseau agreed with Locke and accepted much of his learning theory; nevertheless, he strongly disagreed with the concept of "habituation," the intensive learning of a behavior until it became second nature. In fact, Rousseau advocated just the opposite: Habits should not be taught but should grow out of what the child finds in nature. Nothing should be imposed on the child that did not emanate from his own inner being. The virtues discovered in nature would flow into his life and, as the occasion demands, direct his decisions.[10]

This concern for children and their learning began in middle-class homes with eager parents. Brian Alderson has given, as an example, the history of Jane Johnson.

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[9] Hans Aarsleff, "Locke's Influence,"in *Cambridge Companion to Locke,* ed. Vere Chappell (New York: Cambridge University Press, 1994), 259.

[10]Jean Marc Gaspard Itard, *The Wild Boy of Aveyron*, trans. George and Muriel Humphrey (New York: Meredith Publishing, 1962). The news of the feral child found in France in the eighteenth century was proof of Rousseau's primitive man. Itard documents, at least to his satisfaction, the innate sense of morality and compassion predicted by Rousseau.

In 1740 she compiled learning cards for her two children, Barbara and George. The cards contained elaborate designs and patterns, the alphabet and numbers that were essential for teaching her children both reading and virtue. Alderson claims that this was the first book written specifically to teach children. These educational cards acknowledged the way in which learning occurred. They included illustrations (pictures taken from adult trading cards) and several original stories. Jane Johnson incorporated sayings, stories, alphabets and proverbs as well as directives for moral behavior. Her work was never published, but it represents a grassroots attempt to bring Locke's views of learning into the family life.[11]

Looking at the period from 1740 to 1781, one can trace a remarkable change as those writing for children attempted to incorporate the philosophy first of Locke, later of Rousseau and, finally, an amalgamation of both. This literature became a vehicle for transmitting a variety of values. Of special importance to this dissertation is a narrow range of books written for children and the untutored that attempted to popularize Newtonian science[12] while utilizing the educational ideas of Locke and, later, those of Rousseau. Because this literature has not been studied for its scientific content, it is

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[11]Brian Alderson, "New Playthings and Gigantick Histories: The Nonage of English Children's Books." Lecture given at the Inaugural Conference of the Cotsen Children's Library, Princeton, N. J., 30 October 1997.

[12]The phrase "Newtonian science" has been interpreted by a variety of writers to mean many things. Here it is used to indicate a non-Cartesian view of matter and motion, and a discussion of the laws of nature, including astronomy. Newton's contributions range from his early work in optics and mathematics to his later work in rational mechanics.

essential to understand what aspects of Newtonianism filtered down to the young and untutored.

Children's literature in the eighteenth century tends to be about twenty years behind the dominant culture. Gillian Avery[13] hypothesizes this may be true not only for the eighteenth century but for more modern children's literature as well. Consequently, science presented in children's literature is always lagging somewhat behind the changes in the larger scientific community. In the three generations covered in this study, one may detect a subtle change in the view of scientific research: from simple descriptive material found in some of the first scientific books written for children in the 1740s to a concern about explanation and description found in the works produced in the 1760s. This, in turn, gave way to an emphasis on experimentation and application of experimental findings as clearly stated goals in books for children in the 1780s.

John Brewer,[14] echoing both Roy Porter[15] and Paul Langford,[16] refers to the search for refinement and education for children. The dismal conditions of the schools caused general consternation. Private schools with no discipline, untrained lecturers

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[13] Gillian Avery and Jules Briggs, *Children and Their Books: In Celebration of the Work of Iona and Peter Opie* (New York: Clarendon Press, 1989).

[14] John Brewer, *The Pleasures of the Imagination* (New York: Farrar Straus and Giroux, 1997).

[15]Roy Porter, *English Society in the Eighteenth Century* (New York: Penguin Books, 1983).

[16]Paul Langford, *A Polite and Commercial People: England 1727-1783* (Oxford, Clarendon Press 1989).

and dilapidated buildings caused parents to keep their children at home. Tutors in the homes of the financially able became the rule. The itinerant lecturer was better prepared in the new philosophy than was the chemistry professor at Cambridge. Dissenter schools and other private establishments, while excellent at their task, often disbanded at the death of a brilliant teacher or able headmaster. Intellectuals, concerned about future generations, considered home schooling and generally concluded that it was the only venue for educating children.

As the idea of the child underwent redefinition, the role of parenting also experienced significant alterations. Lawrence Stone, a noted historian, has summarized considerable research detailing the changes in family living in various social classes and diverse geographical regions. Throughout the eighteenth century, general trends in parenting included more involvement with the child, greater permissiveness regarding his behavior, a larger economic investment in material objects for the youngster and increasing concern about the child's education.[17] This was particularly true for the children of the emerging middle class. These parents wished their children to be properly dressed, correctly educated and continually imbued with the virtues of honesty and hard work. They were more than willing to give financial support to the booksellers and the toy makers who supplied the new market for toys, gifts and objects

[17] Lawrence Stone, *The Family, Sex and Marriage in England: 1500-1800* (London: Oxford University Press, 1977).

promoting appropriate virtues.[18] For the most part, the laboring class did not have the interest or the money to provide such luxuries or to indulge the wants of the child. The aristocracy continued to prize traditional values and patterns that depended primarily on the boarding school as the major agent of socialization,[19] but they also began to experience the changes emanating from the greater economic and social upheavals characteristic of eighteenth-century England.

Randolph Trumbach's analysis of the aristocratic family, with its heavy emphasis on the economics of kinship and the implications of social class, offers rich insight into the changes occurring as the role of the father was reshaped within this new domesticity. Fathers became more involved with their children, either supervising their schooling directly or, more frequently, corresponding with headmasters to ensure both moral and academic success for their offspring. Part of the new definition of children included education for future endeavors that would be both productive and lucrative. Most parents recognized that some type of scientific education would be part of this new educational endeavor. As the family underwent redefinition, parents as primary

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[18]Noel Riley, *Gifts for Good Children: The History of Children's China, 1790-1890* (Somerset: Richard Dennis, 1991), features plates, cups and other forms of china designed for children, including expressions of praise for a job well done- - diligence, industry, a well-turned seam- - and models to be emulated, such as Sir Isaac Newton, Benjamin Franklin, and Queen Caroline.

[19]Randolph Trumbach, *The Rise of the Egalitarian Family: Aristocratic Kinship and Domestic Relations in Eighteenth-Century England* (New York: Academic Press, 1978), demonstrates the extensive use of tutors as part of the home-schooling movement. However, for the members of the Lunar Society, the concept involved parents and children exclusively, not hired outsiders.

educators became a cultural ideal. In this context, the Lennox sisters will be referred to frequently throughout the text.[20]

However, the ideal was hard to realize since the demands of teaching a child presupposed some level of competence. Parents, especially mothers, often had neither the training, the inclination nor the time to devote to educating their offspring. Learned families, such as the Edgeworths, may have been able to accomplish this task, but, for the general population, it was not a realistic alternative. Nevertheless, the notion of home education was discussed broadly, and historical records[21] indicate that some families did, in fact, devote themselves to such a plan.

If a parent wanted to become well versed in science, he had innumerable resources available. Presentations by itinerant lecturers, books and magazines, common conversation and membership in scientific societies all presented opportunities for informing oneself about the scientific endeavors of the day. The assertion that much that was written for children was also aimed at adults is supported by the nature of the language used in such material. The books are highly sophisticated in terms of their

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[20]Dr. Trumbach was the first to discover the remarkable cache of letters detailing the activities of this aristocratic family. His suggestion pointed me to Stella Tillyard, *Aristocrats: Caroline, Emily, Louisa and Sarah Lennox, 1740-1832* (New York: Farrar Straus and Giroux, 1994). This book provides rich insight into the daily lives and beliefs of these women.

[21]Iona Sinclair, *The Pyramid and the Urn: The Life in Letters of a Restoration Squire: William Lawrence of Shurdington, 1636 - 1697* (Dover: Alan Sutton Press, 1994), and Stella Tillyard, *Aristocrats: Caroline, Emily, Louisa and Sarah Lennox 1740-1832* (New York: Farrar Straus and Giroux, 1994). Both authors look at the issues of education for the young and the option of home-schooling.

story lines, vocabulary, and metaphysical discussions. The authors challenge the child to think through basic scientific methodology and, simultaneously, direct the child to more complex material, outside sources and scientific publications. One such publication was *The Philosophical Transactions.*

Most of the material categorized as science for children (or the untutored) also makes a strong case for curiosity and inquisitiveness over rote learning and passive acceptance of older authorities. One remarkable trait in this material is the lack of the authoritarian parent. The parent is not seen as having the last word, obedience is not stressed, and the parent's role seems to be to lead the child to knowledge, to create the conditions for learning and then to retreat and allow the child to make his own mistakes. The child is left to his own ingenuity and understanding of scientific principles. He must learn the correct use of scientific equipment and the interpretation of scientific data. Ultimately, observation and experimentation become the only learning experiences that are valid.

Ten years ago, James A. Secord argued that a neglected area of research in the eighteenth century was the impact of children's literature upon the dissemination of scientific information. In truth, he stated, "Many would see children's books seated securely on the bottom rung of historical significance." Yet, he argued, they provide an acceptable barometer of the changing social, moral and religious ideas bound up with the pressures of a book-buying commercial public and its desire for knowledge.[22] J. H. Plumb has also commented on eighteenth-century children's literature as an indication of the newly defined place of children in the eighteenth-century social world and has suggested that more work needs to be done, specifically in the area of children's literature as historical documents.[23] Recently, Ruth Bottigheimer reviewed several pieces of scholarship concerning children's literature in this early period.[24] While she elaborated on the relationship between children's literature and changing social conditions, she did not mention any books related to science. A decade earlier, however, Isaac Kramnick suggested that the eighteenth century saw the advent of the "scientist as hero" in the new literature for children.[25] He, of all the writers on this topic, is the only one who links the study of science with the interest of the emerging middle class. As Kramnick observes, since science is the vehicle for upward mobility in the factory, the individual scientist, taking charge of his fate while investigating the laws of nature, epitomizes the new hero. No longer bound by issues of birth and class, any hardworking, earnest and competent scientist can lead the way to greater prosperity for himself and those around him. He relates that interest to certain bourgeois values

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[22]James A. Secord, "Newton in the Nursery: Telescope Tom and the Philosophy of Tops and Balls, 1761-1838," *History of Science* 23 (1985):128-51.

[23]J. H. Plumb, "The New World of Children in the Eighteenth Century," *Past and Present* 67 (975):64-95.

[24]Ruth Bottigheimer, "Review Essay: Recent Scholarship in Children's Literature, 1980 to the Present," *Eighteenth-Century Life* 17 (November 1994):89-103.

[25]Isaac Kramnick, "Children's Literature and Bourgeois Idealogy," 11-44.

and sees the emergence of interest in children's literature as part of a larger pattern of economic and social change dominating the eighteenth century. Kramnick sees these changing values, especially industry and thrift, as part of a pattern characterizing the Industrial Revolution.

Samuel Pickering[26] discusses the impact of Locke's education theory on the development of books written to entertain children. This idea of entertainment as an educational tool is a direct response to Locke's view of education, particularly scientific education. It is interesting that Pickering does not make this connection. In fact, he argues that Newtonianism and science have no impact on children's literature. Harvey Darton[27] takes a similar position in his examination of children's literature because, he says, he is only interested in books that provide entertainment for children. Apparently, science and entertainment are mutually exclusive.

Geoffrey Summerfield,[28] on the other hand, maintains there is a real link between the Lunar Society and the proliferation of children's books related to science. He states that one can trace a direct line from this politically radical group to a series of books written to explore both science and social issues for children. This group of industrialists and natural philosophers looked to applied science to transform the

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[26]Samuel F. Pickering, Jr. *John Locke and Children's Books in Eighteenth-Century England* (Knoxville: University of Tennessee Press, 1981), 54-55.

[27]Harvey Darton, *Children's Books in England* (New York: Cambridge University Press, 1983).

[28]Geoffrey Summerfield, *Fantasy and Reason: Children's Literature in the Eighteenth Century* (Athens: University of Georgia Press, 1984), 120.

economic basis of the British society. At the same time, they relied on the values of frugality and industry to further the interests of the individual and the larger society. Needless to say, they were not assuming this would be accomplished by a few children's stories. However, they were determined that popular science would not be isolated from such values. This dissertation will show how the worlds of science and children intersect. It will attempt to document that the writing for children was not unrelated to a larger agenda of linking science and industry. Many of these authors, members of the Lunar Society, people like Darwin and Wedgwood would have echoed Newbery's cry of "Trade and Plumb cake forever,Huzzah!"

Chapter 1

Algarotti and *Newton for the Ladies*

In 1727 Voltaire, living in exile in London, attended the funeral of Sir Isaac Newton (1643-1727). Later, writing about the experience, he expressed his admiration of the British adulation of the hero-scientist and, at the same time, underscored an important eighteenth-century controversy:

> The famous Newton, the Destroyer of the Cartesian System, died in March Anno 1727. His countrymen honour'd him in his Life -Time and interr'd him as tho' he had been a King who had made his people happy.[1]

This passage summed up Voltaire's perception of the events at Westminster, Newton's burial place, but it also announced the demise of the Cartesian system in favor of the Newtonian worldview. This demise was neither as quick nor as complete as Voltaire seemed to imply. While Newton's view certainly prevailed in London, Paris was quite reluctant to abandon the vortices of René Descartes (1596-1650) for what Voltaire described as "the vacuum" of the Newtonian world.

> A Frenchman who arrives in *London,* will find Philosophy, like every Thing else, very much chang'd there. He left the World a *plenum*, and he

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[1]Voltaire, *Letters Concerning the English Nation,* ed. Nicholas Cronk (New York: Oxford University Press, 1994), 62.

> now finds it a *vacuum*. At *Paris*, the universe is seen, compos'd of Vortices of subtile Matter; but nothing like it is seen in *London*. In *France*, 'tis the Pressure of the Moon that causes the Tides; but in *England* 'tis the Sea that gravitates towards the Moon . . . . [2]

Newton, at his death, had not yet been accepted on the Continent. Returning from London, Voltaire determined not only to study Newton but to popularize Newton's ideas within the intellectual circles of Europe. He was not alone in this goal. Pierre Louis Moureau de Maupertuis (1698-1759) also visited London and in 1732, having returned to Paris, wrote his first work on the principles of Newtonian philosophy, *Discours sur le différentes figures des astres.* This work and the subsequent publication of *Sur la figure de la terre et sur les moyens que l'astronomie et la gèographie fournissent pour la dèterminer* the following year earned him the title "The First Newtonian in France."[3] It was his friend and mentor, Clairaut, who coined the term. This work brought him to the attention of Voltaire and his mistress, Madame du Châtelet, both of whom were already grappling with the complexities of the Newtonian philosophy. Voltaire contacted Maupertuis. Initially, Maupertuis was credited with having tutored Voltaire in Newtonian science. Later, Voltaire rejected Maupertuis and refused to give him credit for any such help.

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[2]Ibid., 61.

[3]David Beeson refutes the idea of Maupertuis as the first Newtonian, calling it a gross simplification. Maupertuis, according to Beeson, did not start out as a Newtonian nor did he ever complete his apprenticeship. However, Beeson supports the view that Maupertuis inspired Madame du Châtelet and Voltaire to explore Newton's work. David Beeson, "Maupertuis: An Intellectual Biography," *Transactions of the Eighth International Congress on the Enlightenment* (Oxford: Voltaire Foundation at the Taylor Institute, 1992).

Maupertuis, a student of Leibniz, aspired to merge the opposing views of Newton and Leibniz. As a mathematician, Maupertuis was curious about Newton's optical experiments, and he began to replicate the conditions of the "crucial experiment."[4] This experiment, which lies at the heart of Newton's *Opticks*, is based on passing a small beam of sunlight through two prisms placed several feet apart. The refraction of the light causes sunlight to be broken down into the color spectrum, thus proving that light is made up of all the colors. As Maupertuis worked on the mathematics of this problem, he became convinced of Newton's position and was soon an ardent Newtonian. He enjoyed a short period of fame in Paris and was elected to the Academy of Science in 1723, at the age of twenty-five.

Madame du Châtelet remained a loyal pupil of Maupertuis and tried to entice him to come to Cirey, her country home in the Champagne region of France. He refused, but Maupertuis' affiliation with Madame du Châtelet was lifelong, even though tempered by his stormy relationship with Voltaire, with whom he traded both insults and injuries with great frequency.[5]

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[4]The exact nature of the "crucial experiment" is laid out in Allen E. Shapiro's article, "The Gradual Acceptance of Newton's Theory of Color, 1672-1727," *Perspectives on Science* 4:1 (1996):59-140. Shapiro makes it clear that the experiment was carried out with slight variations. In Figure 5, p. 73, of Shapiro's article, it is clear that the prisms are not placed symmetrically with respect to the incident and emergent beams, contrary to Newton's instructions. This increases the impact of impure prisms on the outcome of the experiment.

[5]Madame du Châtelet served as a mistress to both at various times, which may explain the stormy relationship between the two men — it was more physical than physics. Reported in Theodore Bestman, *Voltaire* (Chicago: University of Chicago Press, 1976), 187.

Madame du Châtelet, an interesting character in her own right, pursued natural philosophy, mathematics and fame. Wishing to be considered one of the great intellectuals of her age, she cajoled numerous intellectuals to visit Cirey, where she and Voltaire held court. Here Voltaire wrote some of his most celebrated work, while Madame du Châtelet translated Newton and conducted philosophical discussions. Several hours of each day at Cirey were spent in solitary contemplation or study, while the evenings were devoted to discussions of philosophical topics and current gossip.[6]

A young Italian mathematician entered this circle early in 1735. Called by Voltaire "the Swan of Padua,"[7] Francesco Algarotti (1712-1764) traveled from Italy to France and to England. He joined an expedition to Russia and later served as chamberlain to Frederick II of Prussia who made him a count in 1740. He also served as adviser to Augustus II, King of Poland and Elector of Saxony. An art aficionado, an adviser to kings and a music critic, Algarotti was also an accomplished Newtonian. At the age of sixteen Algarotti worked with his mentor, Francesco Zarotti, disproving the claims of Giovanni Rizzetti,[8] an early detractor and critic of Isaac Newton. It was

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[6]Nancy Mitford, *Voltaire in Love* (New York: Harper and Brothers, 1957): 72-86.

[7]Voltaire was supposedly alluding to the "ease" with which Algarotti glided through the courts of Europe. Quoted in Robert Halsband, *Lord Hervey: Eighteenth-Century Courtier* (New York: Oxford University Press, 1974), 190.

[8] In 1721 Giovanni Rizzetti launched the first major attack on Newton's theory and experiments since the publication of the *Opticks*. He claimed that his experiments in casting color images did not get the same results as Newton's. Newton, by this time well into his eightieth year, dismissed Rizzetti's paper as "a banter." The followers of Leibniz, however, saw Rizzetti as a new ally in their attack on Newton and supported the work of Rizzetti. Shapiro, "Newton on Colour," 125.

Algarotti who introduced the controversy of the manufacture of prisms into the Newtonian argument.

Rizzetti had used Venetian glass prisms in his experiments. Algarotti, in his work with Zarotti, discovered that most of the errors in Rizzetti's calculations could be traced to the bubbles and imperfections in the prisms he was using. Algarotti's arrival in France seemed to bring this discussion to the fore.[9] Supposedly, Algarotti made the pronouncement that English glass was to be preferred to Venetian glass in any attempt to replicate Newton's experiments with light and color. This perception, that only British glass prisms were pristine enough to be used for scientific experiments, created a great deal of animosity toward Newton on the part of Venetian glassmakers.

Algarotti was invited by Madame du Châtelet to visit Voltaire at Cirey in the winter of 1735. Here, they discussed Newton's work. Voltaire was working on a popularization of Newton, Madame du Châtelet was engaged in translating Newton's *Principia* into French and Algarotti resumed his earlier attempt to popularize Newton's *Opticks*. Algarotti visited at Cirey in both 1735 and 1736.

Later visiting England, and carrying a letter of introduction from Voltaire, Algarotti presented himself to Lord Hervey and thereby gained a lifelong friend and

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[9] Currently, two views exist as to the importance of the origin of the prisms under consideration. Simon Schaffer argues that the issue of instrumentation, specifically the type of crystal used, was a major consideration of Newton's. Alan E. Shapiro dismisses the issue and challenges the time frame. Shapiro takes the position that while Newton comments on the need for pure prisms, it is only after Algarotti's work was published that a new controversy, with international implications, emerged. Simon Schaffer, "Glass Works," in *Newton*, ed. I. Bernard Cohen and Richard S. Westfall (New York: W. W. Norton, 1995), 202-217. Shapiro, "Newton on Colour," 126-28.

lover.[10] Through Hervey, Algarotti was presented at court and received an introduction to Queen Charlotte, with whom he regularly discussed science and literature. While in London, he renewed his acquaintance with Martin Folkes, whom he had known in Rome. Folkes invited Algarotti, along with his friend, Andres Celsius, to attend a meeting of the Royal Society on April 1, 1736. Folkes, as vice president of the Royal Society, presided over the meeting and moved to make both Algarotti and Celsius honorary members of the Society of Antiquaries in the category of "Foreigners of Eminent Note and Learning."

Shortly thereafter, Algarotti rejected Maupertuis' offer to join the expedition to Lapland and, instead, journeyed to Russia with Lord Baltimore. After his return from Russia, he accepted a diplomatic mission to Tunis at the request of Frederick. Eventually, disillusioned by the lack of monetary support from the court, Algarotti placed himself under the protection of Augustus I of Poland. As part of his contribution to the court, he aided in the selection of art for the gallery in Dresden. Finally, by 1753 Algarotti had quit the courts of Europe for retirement in Italy. He settled in Pisa, sharing a villa with the painter Mauro Tesi. Algarotti was still pursued by Lady Mary Wortley Montagu, until her death in 1762. Algarotti died two years later, famous for a wide

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[10]This relationship was complicated by the fact that Lady Mary Wortley Montagu, a close friend of Hervey, became intensely infatuated with Algarotti. Although twenty years his senior, Lady Mary followed him across Europe, settling in Italy. She wrote innumerable letters complaining of his neglect of her despite the fact that she had sacrificed all for him. Robert Halsband, *Lord Hervey: Eighteenth-Century Courtier,* 193, 274.

variety and range of scientific and literary writings but none as well read as *Il Newtonianismo per le dame.*

Algarotti published *Il Newtonianismo per le dame* in 1737 in Milan.[11] It was republished in six subsequent years and repeatedly reprinted, with the sixteenth Italian edition appearing in 1812.[12] Immediately after its original publication, it was translated into French, English, German, Russian and Portuguese.[13] The focus of this investigation will be on the English edition, since it was this popularization of Newton that first introduced Newtonian science to the general public in England. Many writers argue that it was the model subsequently used by Voltaire in his popularization of Newton published two years later. In six dialogues between the philosopher and a young Marchioness, Algarotti popularized Newton's *Opticks.* Using nontechnical and nonmathematical language, he attempted to undermine the Cartesian philosophy and replace it with Newtonianism.

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[11]Francesco Algarotti, *Il Newtonianismo per le dame; ovvero, Dialoghi sopra la luce e I colori,* (In Napoli, 1737). The original edition shows the work as printed in Naples, but Marta Fêher in "The Triumphal March of a Paradigm: A Case Study of the Popularization of Newtonian Science," *Tractrix* 2 (1990): 93-110, fn.18, 100, reports that Algarotti actually had it printed in Milan to confuse the Office of the Index and to buy time before Rome placed it on the Index.

[12]Shapiro points out that only in the sixth edition does Algarotti correct the conditions of the *crucial experiment,* correctly identifying the need for the light to pass through two holes and not one, as originally published. Shapir, "Newton on Colour," 126, Algarotti, (2) 62-82.

[13]Marta Fêher notes a rumor of a Spanish edition, but neither she nor I have been able to locate such an edition.

By 1742 two different individuals had translated Algarotti's book into English. The translation that is most frequently referred to and most easily examined was first published in 1739, the work of a twenty-two-year-old woman, Elizabeth Carter (1717-1806).[14] Brewer labels Carter one of the bluestockings of English society. A self-taught linguist with an abiding interest in science, she translated other works during her life but none enjoyed the popularity of *Newton for the Ladies.*[15]

A second translation, published in 1742, is rather rare, and the translator has never been identified. A side-by-side comparison shows the Carter translation to be more fully fleshed out in terms of footnoting specific historical references. The 1742 edition uses much the same material but reduces the commentary contained in the footnotes. The author seems to have worked from the Carter translation but added the convention of translating the poetry that Carter had left in the original Italian. Whereas

[14]In 1739 she published her translation of Francesco Algarotti's *Newtonianismo per le dame*, under the title of *Sir Isaac Newton's Philosophy Explain'd for the use of the Ladies. In Six Dialogues on Light and Colour. From the Italian of Sig. Algarotti*, 2 vols. (London: Cave, 1739). The second translation, Algarotti, Francesco, *Sir Isaac Newton's Theory of Light and Colors and his Principle of Attraction* (London: Printed for G. Hawkins, 1742), is by an unknown. Both of these translations have become extremely scarce, and though Mrs. Carter never willingly referred to her own translation in her more mature years, it is undoubtedly the cause of any small fame she enjoyed among her contemporaries. *Dictionary of National Biography, CD-ROM,* Oxford University Press, 1985. John Brewster, *The Pleasures of the Imagination: English Culture in the Eighteenth Century* (New York: Farrar Straus Giroux, 1997), 78-79.

[15]George Truett Hollis, "Count Algarotti and the Society"in *The Virtuoso Tribe of Arts & Sciences: studies in the eighteenth-century work and membership of the London Society of the Arts* ed. D. G. C. Allan and John L.Abbott (Athens: University of Georgia Press, 1992), 253-64. The authors make reference to an English translation of *Newton for the Ladies* that includes the comment "proofs revised by Dr. Johnson, 1737." This would indicate the existence of a translation that predates the Carter translation by two years.

Carter called her work *Sir Isaac Newton's Philosophy Explain'd for the use of the Ladies In Six Dialogues on Light and Colour*, the translator of the 1742 version entitled the work *Sir Isaac Newton's Theory of Light and Colours and his Principle of Attraction made familiar to the ladies in several entertainments.*[16] The latter version lacks the introduction written by Algarotti dedicating the work to Fontenelle. Neither edition housed in the New York Public Library contains the famous frontispiece[17] depicting the Philosopher (the unnamed protagonist who surely represents Algarotti) and Madame du Châtelet strolling in the garden. There is an Italian version at the New York Public Library, in a rich leather binding, containing poems of praise written by Algarotti's most ardent English supporters, Lord Hervey and Lady Mary Wortley Montagu. These poems celebrate both his science and his place in society. They laud his efforts to bring Newton to the attention of the aristocracy and praise his attempts to make science available to young ladies aspiring to appear scientifically literate in polite society.

Algarotti was very taken with Fontenelle's *Plurality of Worlds* and the resultant popularization of Descartes. Algarotti obviously admired Fontenelle's style of writing because he borrowed whole passages of his text. The aim, however, was to discredit

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[16]Marjorie Nicolson comments that the only copy of the 1742 edition that she could find was in the New York Public Library. Marta Fêher claims to have examined both editions at the Princeton University Library. The only English copy of Algarotti in the Princeton Library is a microprint put out by the Landmarks of Science, which is the Carter translation. Only Yale University and the New York Public Library house both English editions. However, Princeton does have the French and the Italian editions.

[17]See page 59 for a copy of the frontispiece provided by courtesy of the Pierpont Morgan Library.

Fontenelle's championing of Descartes' cosmology and to persuade Algarotti's readers of the validity of Newtonian science. In his preface, Algarotti dedicates the work to Fontenelle while simultaneously announcing his intention to discredit Fontenelle's *Plurality of Worlds*. In the preface to *Newton for the Ladies,* Algarotti writes to Fontenelle:

> If you addressed your ingenious and entertaining Dialogues to the illustrious Dead . . . how much greater reason have I to dedicate these discourses to one of the most illustrious among the living — Fontenelle.[18]

The combination of the dedication of the work to Fontenelle and the frontispiece featuring Madame du Châtelet linked each of them to a text they both objected to, though on different grounds. Fontenelle still championed Descartes' cosmology, and Madame du Châtelet disparaged the simplicity of both Fontenelle and Algarotti in their scientific presentations. She felt strongly that no book on natural philosophy could neglect to address metaphysical issues and, consequently, believed there was little value in such popularizations. As a woman who desperately wished to be taken seriously in the academic world, Madame du Châtelet hesitated to be linked to such a work. Her concerns seemed to stem from a fear of being pictured as a young woman apparently incapable of grasping complex issues. Madame du Châtelet considered herself intellectually superior to the Marchioness depicted in the dialogues. She viewed herself as a contributor to the new philosophy and not merely an observer. Because she is so closely identified with *Newton for the Ladies,* it is inevitable that one might consider the

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[18]Algarotti, Preface, 1. All references to *Newton for the Ladies* refers to the Carter 1739 translation unless specifically noted.

plight of Madame du Châtelet. Better known as Voltaire's mistress than as a natural philosopher, she wanted to be remembered for her scientific contributions. She spent fourteen to eighteen hours a day studying and working on various scientific papers. Largely responsible for the translation of Newton's *Principia* into French, she learned mathematics and contemplated serious metaphysical questions. She bested Dortoud de Mairan (1728) in a dispute on the nature of force. Her papers were accepted by the French Academy of Science. Still, she never felt accepted as a natural philosopher and was convinced that she was excluded from the arena precisely because she was not a man. Voltaire, toward the end of his life, always referred to her in the masculine form. He did this as a tribute to her intellect. The message is obvious: Only a man could be intellectually gifted.

Voltaire described Algarotti as a brilliant and sage man, one whom the heavens blessed with the art of loving, writing and pleasing.[19] Madame du Châtelet was not as complimentary. Although she had known about the frontispiece, she was appalled by Algarotti's work, finding it "frivolous" and fit only for the "boudoirs, where technical arguments and calculations have no place."[20] As she wrote to Maupertuis:

> They say that M. Algarotti's book is called "Newtonianism for the Ladies." What I see in his work is some joking about light. I don't know what kind of a joke he will find to make about the inverse ratio of the square of the distances. . . M. De Voltaire is very angry that the Dutch publishers added to the title of his

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[19]Fêher, "March of a Paradigm," 100.

[20]Quoted in Mary Terrall, "Emilie Châtelet and the Gendering of Science," *History of Science* 33 (1995):292-306.

> *Elements de la philosophie de Newton* "for everyone" [mis à la portée de tout le monde].[21]

Her condemnation is even more interesting since she had wanted the honor of having her picture published as the frontispiece, although she feared that she would be forever connected to a work that was of little philosophical value. She had assumed that the book would be dedicated to her, not to Fontenelle. Madame du Châtelet was translating Newton's *Principia,* and her commitment to a more rigorous work may explain her ambivalence about Algarotti's more casual approach. Piqued because of the dedication to Fontenelle, she wrote to Maupertuis:

> Next to this title, there's perhaps nothing so ridiculous as his dedication to a man who has always ridiculed the system of gravitation. I think he wanted to be in the Academy.

Nevertheless, in a subsequent letter to Algarotti, she stated:

> I warn you that I absolutely wish my portrait to be [in the book]. Settle your accounts as you will: M. De Fontenelle has more wit than I do, but I have a prettier face.

To Algarotti, she expressed her pleasure at the use of the portrait:

> You took a sketch of my face away with you. So I'll have the honor of being at the head of this work filled with wit, grace, imagination and learning. I hope that by placing my portrait on the frontispiece you will let it be understood that I am your marquise.[22]

Newton for the Ladies, though modeled after Fontenelle's six dialogues on the *Plurality of Worlds,* has a totally different objective. Algarotti wanted to explain

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[21]Best,124, 9 May 1738, as quoted in Harth, *Cartesian Women,* 200.

[22]Ibid., 203.

Newton, while Fontenelle used the Cartesian cosmology primarily to explore the question of life on other planets. Like Fontenelle, Algarotti had the man of science enticing the lovely Marchioness of E. into an acceptance of the beauty of science. Through a succession of walks in the garden, they discussed light and colors. Throughout the work, Algarotti segued into comparisons of poets, painters, and ancient philosophers and highlights of Italian history. He used poetry repeatedly to make points about nature and Newton. This book was clearly written to appeal to women and those on the periphery of science.

European philosophers exalted René Descartes, but England championed Sir Isaac Newton as the better philosopher. While it was assumed that some aspects of the Cartesian system would undergo modification, the bulk of scientists on the Continent looked at Newton's work as a correction of, but not a replacement for, Descartes' system of knowledge. Algarotti saw the two systems as incompatible and sought to discredit Descartes totally.

Newton's *Opticks* had already received a great deal of attention in the poetry of eighteenth-century England. Poets either proclaimed the glory of the light and color of Newton's universe or like, Blake, condemned to hell the man who had dared to deconstruct the rainbow.[23] *Newton for the Ladies* is the first and most celebrated prose

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[23]See Marjorie Hope Nicolson, *Newton Demands the Muse* (Princeton: Princeton University Press, 1966), especially chapter II and the Epilogue. In an impressive list of early English poets, including Shelley and Keats, Nicolson shows the influence of Newton's *Opticks* almost from the date of its initial publication. While not all poets lauded Newton's work, they could hardly help reacting to it in some form or another since it was a major topic of conversation in intellectual circles.

in the tug of war between Newtonianism and Cartesianism as it was distilled for the general public. Newton and Newtonianism dominated society in eighteenth-century England even impinging on religion and politics.[24] The mathematical genius of Isaac Newton was credited with redefining the world in quantitative terms. He also clarified the relationships between matter and motion, as his formulation of the law of gravity moved nature outside the realm of a priori reasoning. Theological explanations were replaced with empirical evidence and mathematical predictability. In doing so, Newton negated the worldview characterized by preconceived principles and imaginary vortices that Descartes had established. Controversies and disagreements characterized the early view of the Newtonian revolution as it spread to every aspect of English society. Both the content and methods of science fueled the debates carried on in learned societies as well as outside academic walls. As J. H. Plumb argued:

> Too much attention, it seems to me, is paid to the monopoly of ideas among the intellectual giants, too little to their social acceptance. Ideas acquire dynamism when they become social attitudes, and this was happening in England. Reason was no longer the propaganda of philosophers. It had become the weapon of the middle class. [25]

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[24] The vast literature on this issue is well summarized in Steven Shapin's "Social Uses of Science" in *The Ferment of Knowledge*, ed. G.S. Rousseau and Roy Porter (New York: Cambridge University Press, 1980), 93-103. He argues for a closer look at all aspects of Newtonianism. In this seminal article, Shapin favors the arguments put forth by Margaret and James Jacob in their various discussions of the relationship among Newton, religion, science and politics. He lauds E. P. Thompson for seeing the connection between science and the bourgeois, grants the political implications of the Leibniz-Clarke debates, and dismisses George Grinnell's argument that the essence of Newtonianism is anti-Catholic. Overall, Shapin argues that the writers who focus on science without a consideration of the social implications clearly miss the point.

[25] J. H. Plumb, *Some Aspects of the Eighteenth Century England* (Los Angeles: University of California Press, 1971), 22.

London was alive with philosophical debates in coffee houses,[26] at the Royal Society and in the local lecture hall.[27] Itinerant lecturers used home-made instruments and cleverly crafted demonstrations to reveal the wonders of nature, the ability of man to harness the energy of the natural world and the notion that experimentation constitutes an essential ingredient of learning. Those interested in the new philosophy recognized that new approaches to thinking about the world had to become part of the public experience. Experimentation and demonstration took precedence over simple rote learning.

The Cartesian scheme was well established and recognized by the Roman Catholic Church as a viable resolution of science and theology. Although Descartes' work had been placed on the *Index Romanus* in 1663, by the early 1740s it was considered to be less a threat to theology than the Newtonian system. Cartesian dualism left the soul superior to the body and did not propose a material explanation for the

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[26]Aytoun Ellis, *The Penny Universities: A History of the Coffee-houses* (London: Secker & Warburg, 1956).

[27] F. W. Gibbs, "Itinerant Lecturers in Natural Philosophy," *Ambix* 7 (1960): 111-117, and John Millburn, "The London Evening Courses of Benjamin Martin and James Ferguson; Eighteenth-Century Lecturers on Experimental Philosophy," *Annals of Science* 40 (1983):437-55, both discuss the extent to which the population attended these lectures. Both Ferguson and Martin made a good living and were able to attract an audience in London and,even when they traveled to the outlying regions, they lectured to groups of fifty or more.

soul.[28] However, Cartesianism was not the only system in contention with Newtonianism.

Newton's contemporary, Gottfried Wilhelm Leibniz (1646-1716), also a force to be reckoned with, enjoyed a great deal of popularity on the Continent. Leibniz and Newton both claimed to have developed the calculus independently. Controversy raged as individuals became fanatical about defending the priority of one over the other. The friends of Newton, led by Nicolas Fatio de Dullier[29] (1664-1753), shouted accusations of plagiarism while the partisans of Leibniz accused the Newtonians of accepting occult qualities inherent in gravity in order to make their philosophical system work. In 1716 the famous Clark-Leibniz debates centered on opposing views of God. The central issue debated most fiercely was the nature of God's intervention into the natural world. If God functions as the clockmaker, the question remains as to when and how the clock gets rewound.[30] At this stage of the controversy the issues were not scientific but theological. The theologian Samuel Clark (1675-1729), who was effectively Newton's spokesperson, focused on defending the Newtonian position on religious grounds. In

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[28]Mario Biogioli, "Scientific Revolution, Social Bricolage, and Etiquette, in *The Scientific Revolution in National Context*, eds. Roy Porter and Mikulás Teich (New York: Cambridge University Press, 1992), 11-54.

[29]Carl B. Boyer, *A History of Mathematics* (New York: John Wiley and Sons, 1991), 414. Fatio de Dullier is an interesting study in his own right. Because of his peculiar millennial religious beliefs, he lost favor with Newton, with whom he had been quite close for several years. Margaret Jacob, "Newton and the French Prophets: New Evidence," *History of Science*, 56 (1978):132-42.

[30]Carolyn Merchant, *The Death of Nature* (New York: Harper and Row, 1980), gives a detailed discussion of the theological dispute between Newton and Leibniz, especially in chapter 12.

France, the bulk of the sympathy still rested with Descartes and Leibniz, and, within a generation of Newton's death his science had become more a rallying point than his theology.

Newton occupied the spot as the English national hero, but, ironically, the greatest impetus to the popularization of Newton came not from England but from a French philosopher visiting England and an Italian writer visiting France. The publication of the English translations of *Newton for the Ladies* in 1739 heralded the introduction of Newtonian science into middle-class British homes. Here was a clearly written treatment of Newton's *Optiks* that could be understood by readers who did not have extensive training in philosophy.

Algarotti had studied in Bologna and, reportedly, had learned his Newtonian theory from two female professors.[31] He assumed that women (and the untutored) would be interested in Newton and more than able to comprehend his work. Additionally, Algarotti wished to induce his countrymen to accept Newtonianism. In the early eighteenth century, the scientists in Italy were sharply divided into several camps, with most championing Leibniz or Descartes over Newton. Several reasons existed for

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[31]Supposedly these were the only two female professors of physics in Europe at the time. See Mary Hamer, *Signs of Cleopatra: History, Politics, Representation* (New York: Rutledge, 1993), 51. Hamer cautions that one should treat this assertion with skepticism since the University of Bologna has never been able to document it. Londa Schiebinger, *The Mind Has No Sex?: Women in the Origins of Modern Science* (Cambridge, Mass: Harvard University Press, 1989), 24-26, documents a rich tradition of female professors in the sciences at the University of Bologna. It is even possible that Algarotti actually studied under, or attended lectures of, Laura Bassi who was a professor of physics at the University of Bologna in 1733. He would have been twenty-one at the time.

the reluctance to embrace Newtonianism. First, in Italy scientists were more interested in medicine and gardening than physics and mathematics. Secondly, as a result of the economic and political decline of Italy after the 1600s, the loss of patronage left little room for the study of physics and what has been termed "techno-scientific" issues.[32] Finally, Newton, because he was English, was lumped with the rest of the British as anti-Catholic and heretical.

Algarotti hoped *Newton for the Ladies* would move the Italian scientists to adopt a Newtonian view. The ongoing debate between Rizzetti and the English Newtonians still served to increase the animosity in Italy. At one point, Algarotti's Marquise observes, "Sir Isaac Newton's system comes from a country too far beyond the Alps, to be favorably received among the Italians." She proved to be correct, and Algarotti explains, "It would be very surprising if a system, produced in England, had not been treated by aversion by some persons in a country so near the sun as ours."[33]

Although the title page shows Naples as the city of publication,[34] it was actually printed and issued in Milan because Algarotti feared that its controversial nature would draw down the condemnation of the Catholic Church.[35] He rightly suspected there would be repercussions from his attack on Descartes. The Roman Catholic Church

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[32]Biogioli, "Scientific Revolution," 12-13.

[33]Algarotti, (2),52.

[34]Francesco Algarotti, *Il Newtonianismo per le dame; ovvero, dialoghi sopra la luce e i colori* (Napoli, 1737).

[35] Marta Fêher, "The Triumphal March of a Paradigm: A Case Study of the Popularization of Science,"*Tractix* 2 (1990): 93-110.especially p.100, fn. 18.

responded by immediately placing *Il Newtonianismo per le dame* on the *Index Romanus*. Forbidden in Rome, the book was well received across Europe and quickly translated into French, German, Russian, and Portuguese. The English upper class read *Il Newtonianismo per le dame; ovvero, dialoghi sopra la luce e i colori* prior to its translation into English. Hervey read the work in Italian and reportedly gave it to many of his political colleagues, among whom it was well received.[36] While the book seemingly had little impact on the acceptance of Newtonianism in Italy,[37] it did have great impact in England.

Marta Fêher maintains that Algarotti's *Newton for the Ladies* stands as the most important work for the popularization of Newton in both England and on the Continent. Prior to its publication, she argues, there was little understanding of what Newton had actually accomplished. As Fêher explains, "His views were explained and distorted, defended and refuted, preached and criticized, admired and ridiculed, praised and condemned, glorified and deprecated."[38] Citing an impressive list of such detractors and defenders, Fêher argues that Algarotti's work presented a form of Newtonianism that could be embraced by laymen.

Algarotti, like all good popularizers, used persuasion to advance one scientific view over the other. However, the persuasion was not based solely on scientific or

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[36]Halsband, *Lord Hervey,* 245.

[37]See Roy Porter and Mikuláš Teich, eds., *The Scientific Revolution in National Context* (New York: Cambridge University Press, 1992).

[38]Fêher, "March of a Paradigm," 95.

metaphysical grounds; rather, it was an appeal to a new thought process. Algarotti interpreted the role of the popularizer as essentially that of the gadfly forcing people to embrace new images and new ways of contemplating old ideas. He wanted to move the discussion away from religious and dogmatic assertions to a more probing and inquisitive view of the new philosophy. By embedding science in the lighthearted exchange in the garden, Algarotti hoped to render difficult material less threatening to the neophyte.

> The ancients were fonder of what raised their admiration than increased their knowledge. . . and perhaps thought experiments were too material to employ the attention of the philosopher. Nor could they see how experiment would help us calculate how much we daily lose through perspiration, how many million tons of water does the Mediterranean Sea perspire in a summer's day or how much does the muscle of a man decrease by weakness from morning to night?[39]

The philosopher continues in this vein, showing the Marchioness that only through experiments will one ever know the answers; and it is by experiments that one may be able to counterfeit nature herself.

In the dialogues, Algarotti clearly states his goals. He first takes the time to set up the Cartesian universe and then systematically destroys it. But he destroys it without recourse to elaborate philosophical or mathematical argument. He simply sets up the conditions for science. Science must depend entirely on experimentation and observation. It cannot be based on a priori assumptions about the world. While this is the essence of the message, the two volumes proceed toward their goal amid a great deal

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[39]Algarotti, (1), 102.

of flirtatious behavior, as well as literary and historical discussion accompanied by witty and colorful repartee.[40]

The first of the two volumes contains three dialogues devoted to exploring the Cartesian system, showing why it is limited in its ability to explain phenomena and why it ultimately must be discarded. The second volume, also made up of three dialogues, dedicates the fourth and fifth dialogues to a detailed description of each of the experiments that Newton performed before arriving at his theory of light and colors. The sixth dialogue is a summary of the principles contained in the *Principia.* All the dialogues include detailed discussion of famous people and strange cultures. Algarotti clearly felt the impact of perception in a variety of areas. He used cross-cultural items as well as Newtonian physics to make his points.

> Whole nations esteem black teeth, or paints on eye white while a Beau scarifies and gashes his face to appear more agreeable to the Eyes of a brutish Creature, who is alone the Mistress of his heart.[41]

The first dialogue began by exploring the history of science from antiquity to Galileo. Roger Bacon received praise but Socrates was condemned, the first for his inventiveness and the latter for his dogmatism. Algarotti lauded only one of his contemporaries, his compatriot Laura Maria Katherine Bassi, hailing her as the only serious Newtonian in Italy.[42] A remarkable woman, she taught at the University of

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[40]Ibid, Preface, viii.

[41]Ibid., (1), 101.

[42]She was only nineteen when she held a philosophical disputation at Bologna and earned the degree of Doctor. Algarotti does not mention any of his other peers in this

Bologna, conducted private classes in physics, wrote scientific papers and held her own in disputations with philosophers from all over Europe. She, more than Madame du Châtelet, might have been the impetus for Algarotti's decision to write a science book specifically dedicated to "the Ladies." Though gracious in his praise of Bassi, Algarotti awards Sir Isaac Newton the title "the Head of the Species." Algarotti applauded a variety of authors and poets, especially Milton, Pope and Shakespeare. Most of his criticism he saved for the Cartesians and the Russians, whom he regarded as backward. "Their policy against immigration is similar to their policy against philosophy — no new people and no new ideas are to be admitted." [43]

Algarotti discussed a diverse range of topics. His treatment of phosphorous was typical of his approach. First, he discussed the many beliefs about this remarkable substance, then moved on to describe the almost mystical way the ancients viewed this element. Next, he contrasted that view with the more rigorous experiments carried out by the virtuosi.[44] All of these discussions presented science in a positive light, established its place in the intellectual realm, and traced an unbroken line from Aristotle to Newton.

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same light. Although she is not mentioned by name, Carter as well as everyone else of that period easily identified her. Alberto Elena, "In Lode Della Filosofess di Bologna": An Introduction to Laura Bassi," *ISIS* 82 (1991): 511-18.

[43]Algarotti, (1), 38.

[44]J. V. Golinski, "A Noble Spectacle, Phosphorous and the Public Culture of Science in the Early Royal Society," *ISIS* 80 (1989):11-39.

In the second dialogue, he focused on the attributes of light and color, but only as they are seen in the Cartesian system. The questions centered on issues of color: where it resided and whether or not it was an essential quality of matter. "If colors come from the sunlight, then do the colors in a picture disappear after dark?" Algarotti explained: "Qualities such as light, colors and the like are not really in bodies. . . ."[45] In this chapter, he proposed to discuss the metaphysical doubts concerning the sensations of perceptions. The Marchioness argued that the color in her cheeks was real, but the colors in the rainbow exist just by analogy. Nevertheless, further into the discussion she used another analogy to explain the color in her cheeks. "It is not necessary for me to have pain in the needle for me to feel the prick of the pin, it is not necessary for color to be in the object for me to see color."[46] At this point, more subtle philosophical arguments on the nature of perception and epistemology were introduced into the discussion. The philosopher and the lady explored ideas about the knowable and the unknowable. Careful attention was given to the "essential qualities" of matter. Galileo had a small list of so-called "essential qualities." Newton had placed gravity in the list of essential qualities and then withdrew it. Descartes had assumed that matter had only extension, not color or weight or density.

Since the question of essential qualities was still at the heart of several debates surrounding the new philosophy, Algarotti explored whether Cartesian extension was sufficient for an explanation of all matter. Needless to say, he found it wanting.

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[45]Algarotti, (1), 39.

[46]Ibid., (1), 83.

Algarotti maintained an ongoing attack on "clear and distinct" ideas. He described Cartesianism as a "mass of matter whirled around a point, with a common center — the world is full of such vortices."[47] The process continues, the bouncing back and forth, until "by bouncing against one another the dye changes from its original shape to that of a ball."[48] He ridiculed this as a valid description of the universe, but the Marchioness resisted his attack on Descartes, arguing that she was a woman who "loves people who start out on grand schemes."[49]

In the third dialogue, Algarotti continued to elaborate the Cartesian view of light and color. As Algarotti explains the Cartesian view: "Light is principally subject to the two activities of reflection and refraction . . . . Descartes saw reflection as the collision of globules of light with the solid part of bodies and refraction was caused by globules of light passing through air, water, glass." Examples of refraction could be seen in a variety of instances including an oar which appeared broken in the water, or the distortion of our image in the lake, as well as objects viewed through a prism.[50]

Early on, the philosopher assured the Marchioness that she would begin as a Cartesian, move to become a mathematician [51] and be obligated to embrace the

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[47]Ibid., (1), 47.

[48]Ibid., (1), 50.

[49]Ibid., (1), 51.

[50]Ibid., (1), 13-14.

[51]Madame du Châtelet considered Malebranche the quintessential mathematician and she wished to study under him. She invited him to Cirey with a promise of a seat in Frederick's Academy, but he never accepted the invitation. Harth, *Cartesian Women,*

Newtonian system at last.[52] The opening of the third dialogue depicted the Marchioness expressing her impatience with the rate of progress toward her goal. She desired to be more learned than Christiaan Huygens, a noted mathematician. To accomplish this she had set herself the task of excelling in math. Algarotti agreed that mathematics was needed for any scientific endeavor. However, for the purposes of this work, Algarotti declared that "lines and mathematical figures are entirely excluded as they would have given these discourses too scientific an air and appear formidable to those, who to be instructed must be pleased."[53] He then promised that if mathematics appeared, it would be explained in the simplest terms. Despite his firm resolve not to discuss mathematics, he did it regularly.

At one point he discussed the fact that there was a science, known as Algebra, which had extended its power over all the regions of natural philosophy and had become an important contrivance of special interests who used it for business and civil matters. In addition, he could not resist lifting the famous passage from Fontenelle concerning mathematics:

> Mathematicians, Madam, returned I, are thus far said to resemble lovers, that no matter how insignificant the first favor you grant them may be,

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[52]Algarotti, (1), Preface,viii.

[53]Ibid., (1), 3.

> they know so well how to take advantage of it, that they will lead you by degrees to greater lengths than you ever designed to go.[54]

Algarotti turned from a discussion of algebra and lovers to suggest an experiment. It was the *crucial experiment* of Newton but is not identified as such.

> Imagine yourself in a . . . place of visible darkness. Let a ray of sun enter in at a hole made in a window shutter, and let a glass prism be placed horizontally at this hole, to refract the ray in such a manner as to throw it upon a wall opposite to the window, so that as it is going out of the prism, it is almost horizontal and parallel to the pavement of the chamber . . . . [55]

In the second volume Newton's view of light and color are laid out in detail. "The proposition that rays which differ in colour also differ in degree of Refrangibility is the fundamental discovery upon which the System of Optics is built."[56] Violet is listed as the most refrangible, followed by indigo, blue, green, yellow, orange and red.[57]

Algarotti sets up the condition for the experiment that will demonstrate this principle. It is another restatement of the "crucial experiment" put forth by Newton.

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[54]Ibid., (1), 48. Compare this with Fontenelle: In love and mathematics people reason alike . . . Allow never so little to a Lover,—yet presently after you must grant him more; nay more and more, which will at last go a great way: In like manner, grant but a Mathematician a little Principle, he immediately draws a consequence from it, to which you must necessarily assent, and from this consequence another, till he leads you so far (whether you will or no) that you have much ado to believe him. Fontenelle, *Plurality of Worlds*, 137.

[55]Algarotti, (2), 26-27.

[56]Ibid., (2), 24.

[57]Degree or refrangibility: as light passes from one medium into another, it is refracted (the ray is bent); for any such combination of mediums, each color has a different degree of refrangibility or is bent a different amount. Cohen and Westfall, *Newton*, 425.

> Let a ray of sun enter in at a hole made in the window shutter and let a glass prism be placed horizontally at this hole, to refract the ray in such a manner as to throw it upon a wall opposite the window, so that as it is going out of the prism, it is almost horizontal and parallel to the pavement of the chamber.[58]

After a detailed explanation of how the prism will break the white light into a variety of colors, he states that when he first tried the experiment he could not make it work. In fact, Algarotti had been a central figure, with Zarotti, in disproving Rizzetti's claims against Newton's theory of color. In 1722 Rizzetti had published a detailed refutation of Newton's work. Zarotti and Algarotti had traced the problem to the prisms used. Rizzetti's Venetian prisms were too flawed to allow the experiment to work. When Zarotti and Algarotti substituted English prisms, the results mirrored Newton's findings.[59]

It is unclear why Algarotti would have suggested that his experiment failed. In *Newton for the Ladies,* he simply attributed the failure to bad tools. It was the poor quality of prisms made in Italy [60] where, as he described it, they were used only by children at play. The philosopher in the dialogue made no pretense of having

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[58]Algarotti, (2), 26.

[59]Shapiro, "Newton's Theory of Color," 126-28.

[60]This passage created a great stir in Venice and turned Venetian glass makers into vehement anti-Newtonians. Algarotti might have raised the issue merely to goad the Italians into accepting the fact that the leading Italian anti-Newtonian, Rizzetti, had been defeated by his lack of proper tools. Since Shapiro argues that this issue only came to light when Algarotti entered Voltaire's circle, it might be Algarotti's way of underscoring his place in the controversy. Ibid., 126.

contributed to the debate over the superior quality of English glass. He was more concerned about expounding Newton's views.

Algarotti returned to the discussion of the composition of light. There were two possibilities: Either light was composed of rays differently colored and differently refrangible and the prism simply separates them out, or there was an alternate explanation – the prism created the colors. In order to answer that question, Newton had added a second prism. In this case, the red fell to the lower part and the violet to the upper part of the spectrum. As Algarotti correctly reported, adding additional prisms did not change the color. He concluded this section with the comment, "As everything that Midas touched was transformed to gold, everything that Sir Isaac Newton handled became demonstrated."[61]

Algarotti and Fontenelle differed in their notion of what constituted science. A major concern in Fontenelle's famous dialogues was extraterrestrial beings. Fontenelle put forth a series of arguments about why other planets must be inhabited. Algarotti did not even consider the issue. For him, scientific inquiry had to lend itself to experimentation. Fontenelle was concerned with the telescope and what it revealed of the heavens. Algarotti favored the microscope. Fontenelle was not argumentative. Algarotti was. Both were expert at leading the discussion into a variety of byways and intellectual detours. Algarotti presented the argument offered by Dr. Halley, later

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[61]Algarotti, (2), 45.

echoed by Velikovsky,[62] that "the countries of North America were once perhaps nearer the Pole than they are at present, that a Comet by giving a shock to the earth altered their situation and by this means set them at a greater distance."[63] Fontenelle did not discuss any such implications in his work. He used his stroll in the garden to lead his pupil to an appreciation of the wonders of other worlds through the telescope. For him it was the study of the moon that held the truths of science.

For Algarotti the main focus of experimentation was the microscope. With great enthusiasm he shows how a tiny speck can be magnified so that it can be seen for study. The young lady protests that if she had her way she would forbid the use of microscopes. "They take what appears to be beautiful and reduce it to pores and holes and indentation — her hands for instance." It is this ability to turn from a discussion of a piece of scientific instrumentation to admiration of the softness of a lady's hand that made Algarotti's book so compelling.

Though simplistic, it was a remarkable vehicle for bringing the issues discussed in Newton's *Opticks* into the arena of general discourse. The examples used resonate with the average reader. They raise questions about the likelihood of a squint-eyed person seeing everything double, or a boy standing on his head seeing an inverted world,

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[62]Emmanuel Velikovsky, *Worlds in Collision, Earth in Upheaval* (Garden City, N.Y.: Doubleday, 1950). This is a highly controversial work based on the assumption that earth had experienced a near collision with a comet-like projectile from Mars and thus was thrown off course. The author uses a remarkable amalgamation of science and mythology to argue his point.

[63]Algarotti, (2), 215.

or a blind man never wishing to see at all.[64] Frivolous discussions abound, such as the suggestion that in the Turkish paradise there would need to be many telescopes and speaking trumpets in order for the Muhammadans to be able to see and converse with the diabolically great number of angels of theirs.[65] The selection of the correct dress for the opera was dependent on understanding how colors changed in candlelight, as contrasted with how they were perceived in sunlight. The color of a flower was as important an issue for scientific inquiry as was the potential of the microscope. Ordinary issues began to be treated as scientific enterprise.

As in most of the science books written in this period, *Newton for the Ladies* was full of allusions to ongoing philosophical debates and public arguments. For example, Algarotti ridicules an explanation of vision that was put forth by a Dr. Robert Green, whose views were similar to the Aristotelian theory that sparks or forces came from an object, assaulted the eye and thus created perception.[66] Other discussions depicted those with opposing views as fools and knaves. Leibniz was discussed and dismissed. While Socrates was scorned, Roger Bacon was held to be the model of the great scientist.[67] Algarotti condemned all Greek philosophy because its mode and

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[64]Ibid., (2), 145-52.

[65]Ibid., (2), 184.

[66]Ibid., (l), 141. Green also wrote a book, *Principles of Natural Philosophy* (1712), in which he denies most of the existing science and attacks mathematical reasoning as spurious. In response, there is a quote by Roger Cotes arguing that Green must be as great a genius as Newton because he is able to write an entire treatise without getting *one* thing right anywhere in his discourse.

[67]Ibid., (1), 191.

substance featured only rhetoric and ethics. He took the position that real observation of nature only starts with Galileo. It was his observations on motion that resulted in further examination of the underlying laws of nature.

Algarotti worked to bring empirical examination into the mainstream of popular culture. To this end, he directed the dialogue from the nature of color to the nature of perception, including a lengthy discussion of various lenses and the manner in which colors, light and shapes would appear in disparate light. The Marchioness interrupted the discussion of perception to tell of seeing someone light a candle with light reflected through a glass. She is assured that the same thing has been done with a piece of ice. This observation, in turn, triggered an elaborate discussion of the camera obscura. In the eighteenth century the camera obscura represented an important item for scientific instruction. It was believed that the camera obscura operated very much like the inside of the eye and, therefore, was crucial to any discussion of perception.[68] After a refutation of Descartes' view of optics, the philosopher observed that, owing to the curvature of the earth, objects will appear larger in England than they do in Italy.[69]

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[68]The discussion continues with the premise that everyone is familiar with the camera obscura. Many science books make liberal assumption about what readers know and assume they have access to a variety of scientific instruments. The literature on scientific instrumentation suggests the existence of a widespread sale of such relatively cheap pocket instruments as microscopes, telescopes and scientific gadgets. See Anthony Turner, *Early Scientific Instruments: Europe, 1400 -1800* (New York: Sotheby's Publication, 1987), and Gerard Turner, "Scientific Toys - Presidential Address, " *British Journal of History of Science* 20 (987):377-98.

[69]Algarotti, (2), 97.

Even though Algarotti's observations were not science as the nineteenth and twentieth centuries would later define it, they contained interesting descriptions of some scientific possibilities. Also, they initiated the first step in scientific enterprise — the process of description. His protagonists looked at the world in a new way; they examined elements based strictly on observation, attempting to eliminate previous bias.

The text under consideration used perception to illustrate the process of scientific inquiry. It first compared the differences between Cartesian and Newtonian empiricism. Secondly, by separating the elements of perceptions and sight, Algarotti opened the way for further inquiry. But, unexpectedly, Algarotti ignored any further analysis. He did not provide a straightforward explanation of perception; rather, he reverted to poetry and witticisms to examine questions about the nature of perception. He emphasized the Marchioness' confusion about the nature of perception and pointed out that she was unable to identify the faculties involved in perception. Was perception in the eye or in the mind? Was color in the object or in the eye? By isolating these important questions, Algarotti began the process of setting up scientific inquiry. But the Marchioness and her companion never delved beyond the questions and they carried out no experiments.

If one accepts the modern definition of the scientific method as consisting of description, explanation, experimentation and application, then Algarotti's attempt to popularize Newton represents the first stage of scientific development. Essentially a descriptive work, *Newton for the Ladies* combines poetry and science.[70] The protagonists mention problems and they describe experiments. However, they carry out no actual demonstrations and they resolve no intellectual controversies. Algarotti urges his reader to opt in favor of a particular philosopher. Algarotti intersperses discussions of color and perception with clever quotations or witty remarks, but little attempt is made to resolve questions such as the nature of color or the principles of perception. Ridicule of Descartes is sufficient to diminish his importance as a philosopher while excessive praise places Newton on a heroic pedestal.

However, Algarotti's key contribution was the insistence on experimentation as the hallmark of science. The discussion about prism quality — English versus Venetian prisms — suggests there were no definitive criteria for instrumentation. A scientific method, still mixed with metaphor and poetry, was not yet fully developed. Algarotti highlighted experimentation as the only criterion for philosophical truth. He explained the first phase of an ongoing process of scientific discovery. Once one goes beyond questioning the appearances of matter, one becomes a Newtonian, at least by Algarotti's definition. The Marchioness' quest is now complete. She has discarded Descartes and embraced Newton.

A young lady translated *Newton for the Ladies,* but was it just intended for an audience of women? There is some evidence that many men read this work and

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[70]Eileen Douglas, "Popular Science and the Representation of Women: Fontenelle and After," *Eighteen-Century Life* 18 (May 1994):7. Douglas argues that both poetry and science grapple with the underlying laws of nature. The inclusion of poetry in works of popular science stems from the fact that both are essentially describing the natural world.

considered it a worthwhile endeavor. Lord Hervey reported recommending it to his friends in government, many of whom read it in the Italian version because it had not yet been translated into English.[71] Algarotti had communicated the desire that it would convert the Italians to Newtonianism. He expressed the idea that it would be better for the Italians to contemplate Newton than to spend time fixing their curls.

The designation "for the ladies" has come to mean many things. Mary Hamer, a feminist writer and a student of art history, has argued that Algarotti addressed it "to the ladies" because of his affection for the two women at the University of Bologna who had supposedly instructed him in physics. Alberto Elena has suggested that the title is a direct compliment to Laura Bassi.[72] Hamer [73] has argued that even though it was addressed "to the Ladies" it does not mean the dialogues were aimed at an audience of limited education. On the contrary, she argues that Algarotti felt women were more receptive to the new sciences and more willing to cope with the complex issues involved.

Erica Harth, who looked at the broader issue of women and Cartesian science, sees the term "for the Ladies" as an ill-concealed message that the material had been purposely redefined to make it accessible to women, children and others ignorant of the complexities of natural philosophy. Harth argues that by the time Fontenelle wrote *Conversations on the Plurality of Worlds* the convention of using "the Ladies" to

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[71]Halsband, *Lord Hervey*, 196.

[72]Elena, "Laura Bassi," 511.

[73]Hamer, *Signs of Cleopatra*, 51.

indicate "the untutored and the ignorant" was so well established that it was self-explanatory. Since it was agreed upon that the term "the Ladies" really indicated "the untutored and the ignorant," it meant that it was not necessary to present rigorous mathematical arguments or philosophical reasoning.[74]

Authors such as Stella Tillyard have documented that both young ladies and young gentlemen would often have such books read to them at family gatherings. The books might be quite sophisticated and tedious for a child but would be regarded as part of a well-rounded education.[75] Memoirs and letters written during this period comment on the preoccupation with science, the regard in which new scientific endeavors were held in society and the pursuit of science in the home of "substantial" gentlemen.[76] The father of the Lennox sisters concerned himself with science, but his interest was primarily focused on horticulture. The fact remains that the father and mother of the family did attend scientific lectures and purchased scientific equipment. The letters used in Tillyard's book suggest that such scientific enterprise was not an unusual event in their social class. More to the point, they made this material an integral part of the family conversation and included it in the general education of the children.

Madame du Châtelet went out of her way to explain that *her* version of Newton was being written precisely to make Newton available to her thirteen-year-old son, but,

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[74] Erica Harth discusses this in detail in the section on the "Real Marquises" in *Cartesian Women* (Ithaca: Cornell University Press, 1992), 139-89.

[75]Stella Tillyard, *The Aristocrats: Caroline, Emily, Louise and Sarah Lennox 1740-1832* (New York: Farrar, Straus and Giroux, 1994).

[76]Ibid., 15.

she emphasized, her book would have mathematical rigor. This comment was assumed to be directed at Algarotti, since she had already criticized him for his lack of mathematical rigor and his failure to discuss metaphysical issues. This seems to suggest that the younger set had already discovered and were reading Algarotti's book.

Harth's position appears more valid in terms of simple logic and in relation to the historical record. There is little evidence that anyone wanting to put forth an erudite philosophical discussion would label it "for the ladies." *Newton for the Ladies* was a popularization and as such certainly aimed to reach an audience not already familiar with the new philosophy or with rigorous demonstrations of complex issues. Children could be said to constitute one such audience.

Nevertheless, one might argue that the sophisticated language makes it unsuitable for children. However, this assumes that people in the eighteenth century would have made a distinction between language appropriate for children and for adults. Little evidence exists for that viewpoint. Most books given to children at this period were written in very sophisticated language, because in the eighteenth century the recognition of childhood as a separate state did not include the recognition of linguistic differences. It is one thing to delete mathematical rigor in presenting material to the "ladies," but it is quite another to assume that a writer would modify his language to the same degree. Algarotti considered himself an intellectual, even if a bit of a gadfly, and he would never have written in a primer style even if his work were to be marketed to children.

Algarotti's book, both praised and condemned for its simplicity, is an excellent introduction to science for children. The convention of presenting scientific material as a dialogue between two or three people was a popular pattern that persisted in children's literature through the end of the century. It was much later that Maria Edgeworth abandoned this practice for a more narrative form of storytelling. The use of dialogue by Fontenelle, by Algarotti, and later by Ferguson enabled these writers to create a natural student-teacher exchange and introduce simple, unsophisticated questions. Such questions are quickly answered and ensure that only one authoritative voice is heard. Not surprisingly, it is the voice of reasonableness and maleness.

Algarotti wrote *Newton for the Ladies* to establish a popular forum for the discrediting of Descartes and for expounding the virtues of Newtonianism. While lauding Newton's genius, especially in the field of optics, Algarotti went beyond to insist on experimentation as the new criterion for truth. Algarotti was instrumental in calling into question old ideas and old systems of thought. He set forth the conditions whereby the uneducated person could begin to question the world around him in terms of the new philosophy. The hitherto untutored would now look at the colors in the rainbow in a new light.

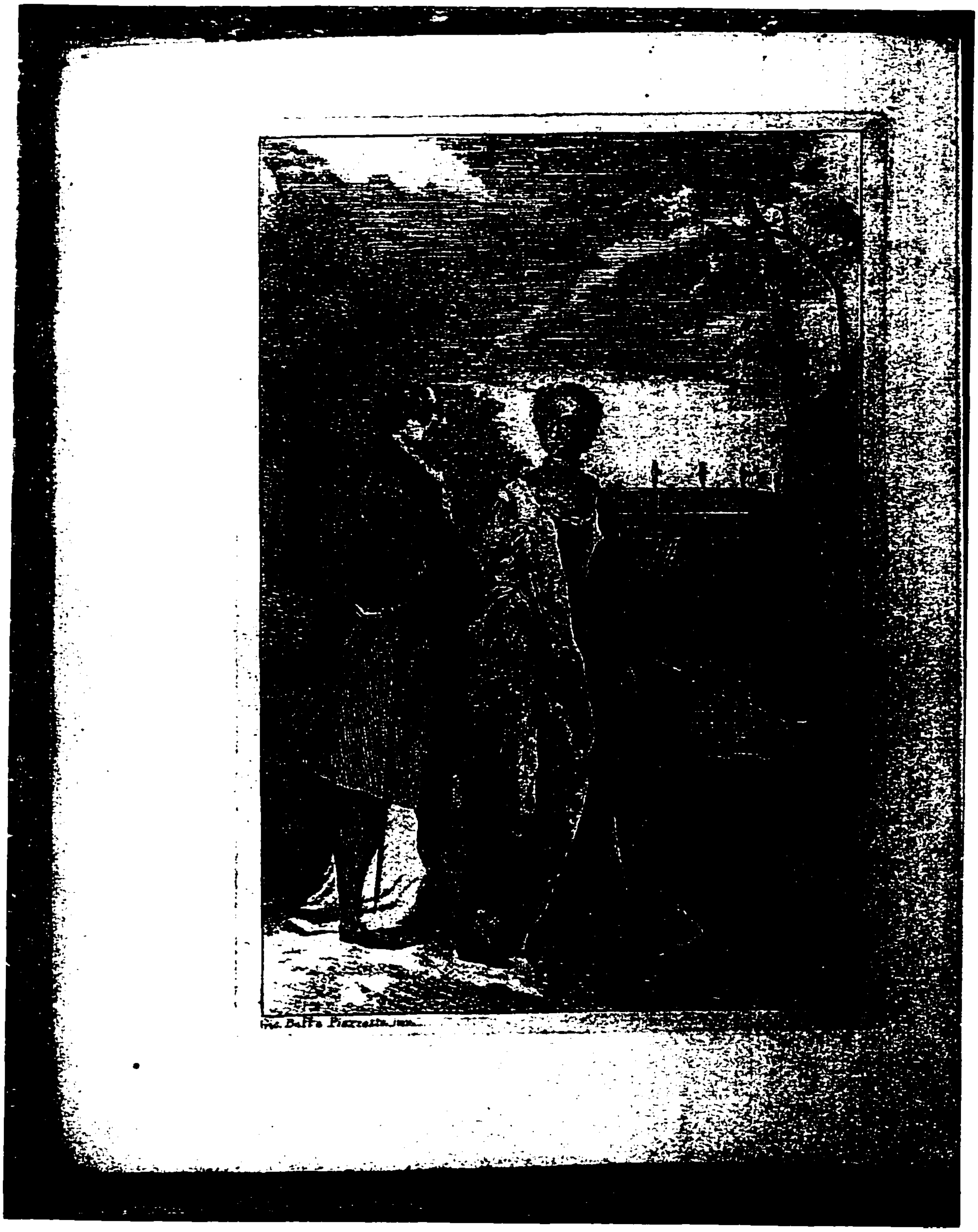

Figure I

Chapter 2

Newbery and *The Philosophy of Tops and Balls*

In 1698 John Locke, living out his last years in the home of his longtime friend Lady Masham,[1] enjoyed the company of Sir Isaac Newton.[2] The friendship, previously carried on by letter, flourished as the two old friends conversed about religious and alchemical matters. At the request of Lady Masham, Locke, with help from Newton,[3] began to compose notes from which to teach young Frank Masham natural philosophy. These notes appeared later (1719) under the title *The Elements of Natural Philosophy*. Sixty years afterward, an ingenious bookseller, John Newbery, published these notes, somewhat embellished, using the pseudonym Tom Telescope as *The Newtonian System*

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[1]Lady Masham was a theologian in her own right and the daughter of Ralph Cudworth.

[2]Maurice Cranston, *John Locke: A Biography* (New York: Oxford University Press, 1985), 357-57, 372-75 and Richard S. Westfall, *Never at Rest: A Biography of Isaac Newton* (New York: Cambridge University Press, 1980), 488-97. Both authors explore the friendship between Locke and Newton and the chronology of their relationship.

[3]Cranston refers to a diagram, obviously created by Newton, demonstrating how the planets move in ellipses. It is endorsed in Locke's hand, "Mr. Newton, March 1689." In 1855 David Brewster, a well-respected author and scientist, commented on the diagram and other parts of the *Elements:* "There can be no doubt that even in their present modified form they are beyond the capacity of Mr. Locke." Cranston, *Locke*, 337-38.

of Philosophy.[4] This work, popularly called *The Newtonian System*, or "Newton in the Nursery," published in 1761, was the first book to announce its intention to teach Newtonian natural philosophy to children.

The influence of Locke and Newton had not diminished by 1760. In fact, their combined impact in England was probably greater than at any previous period. This period, beginning in 1760 and continuing up into the early 1800s, exemplifies rapid industrial, economic and population expansion.[5] Technological improvements based on applied science began to change the face of the countryside, as enclosure and factories redefined agricultural spaces.[6] Better roads and improved conveyances increased the spread of information. New ideas of education and new formulations of family life led to a rethinking of values. Many of these changes reflect responses to the scientific contributions of Newton and the philosophical influence of Locke. At the same time, Locke's writings continued to encourage a rethinking of the nature of man and the nature of childhood.

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[4]The full title was *The Newtonian System of philosophy, adapted to the capacities of young gentlemen and ladies and familiarized and made entertaining by Objects with which they are intimately acquainted being the substance of six lectures read to the Lilliputian Society, by The Newtonian System, A.M., and collected and methodized for the benefit of the youth of these Kingdoms by their old friend Mr. Newbery* (London: Printed by F. J. Newbery at the Bible and Sun, 1761).

[5] John B. Owen, *The Eighteenth Century: 1714-1815* (New York: Norton, 1974), chapters 13 and 14, and Roy Porter, *English Society in the Eighteenth Century* (New York: Penguin Books, 1982), chapters 1 and 8.

[6] Paul Langford, *A Polite and Commercial People: England 1727-1783* (New York: Oxford University Press, 1989), chapters 4, 9, and 10, and Derek Jarrett, *England in the Age of Hogarth* (New Haven: Yale University Press, 1986), chapter 3.

Children emerged as newly defined members of society. Part of this new definition included John Locke's insights into the process of socialization, not the least of which was the movement away from perceiving the child as a miniature adult. This resulted in a reassessment of the needs of the child, especially in terms of education. The expenditures on education, private tutors, day schools and academies signaled a societal change that, in turn, created a new market within the booksellers' trade[7] and the growth of literature specifically for children.[8] For the first time, children as an audience were taken seriously by printers and booksellers. John Newbery, often credited as the father of this market, saw the necessity of publishing science books easily accessible to this younger audience. By the time Newbery published *The Newtonian System*, its ideas were at least a generation out of date and some of the scientific material had already been rethought. Nevertheless, the book did provide the young reader with definitions and concepts central to Newton's system of natural philosophy.

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[7] E. N. Williams, *Life in Georgian England* (New York: P. T. Putnam's Sons, 1962), chapter 1. The author reviews the dismal state of education and notes that a few private schools, originally intended for the education of the sons of local tradesmen, soon grew into profitable establishments that catered to the rich but failed to provide much in the way of education.

[8] Jonathan Rose, "Rereading the English Common Reader: A Preface to the History of Audiences," *Journal of the History of Ideas* 53 (1992):47-70, discusses the impact of reading on audiences and comments on the fact that books were often read by an audience other than the writer intended. Children and servants often were read adult books because they were available. Obviously, the reading of the Bible was a common household activity. All this activity served to increase the ease with which people learned to read.

This chapter will explore several aspects of "Newton in the Nursery," including the authorship of *The Newtonian System*,[9] the scientific content in the first edition and changes that occur in subsequent editions. This segment will examine the impact of Locke's thinking on the education of children, especially scientific education. Finally, because it is an important issue in *The Newtonian System*, gambling will be discussed both in its social and scientific context.

As already noted, Lady Masham enlisted Locke's aid in the education of her twelve-year-old son. In response to this request, Locke composed an elementary treatise for young Master Masham, later entitled *The Elements of Natural Philosophy*.[10] It was not a book on natural philosophy but a series of notes to stimulate discussion between Locke and young Masham. It is these notes that form the basis of *The Newtonian System*. More than merely serving as an inspiration, the notes make up over fifty percent of the actual text. Almost all the scientific principles presented in *The Newtonian System* are taken verbatim from Locke's notes to his student. The diagram of the solar system

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[9]*The Newtonian System*. All quotations will be taken from the first edition (1761) found in the Pierpont Morgan Library unless specifically mentioned otherwise. All quotations from Locke's *Elements of Natural Philosophy* are taken from John Locke's "Advice to a Young Gentleman" in *A Collection of Several Pieces of Mr John Locke never before printed or extant in his works*. Published by the author of The Life of the ever memorable Mr. John Hale and Co. (London: Printed by J. Bettenham for R. Franckler, at the Sun in Fleet Street,1719).

[10] In the preface to *A Collection of Several Pieces of Mr. John Locke never before printed or extant in his works* (London, 1719), Pierre Desmaizeaux apologizes for publishing what are essentially private papers, but he then excuses himself with the argument that there are already copies of the *Elements* circulating throughout Europe. Pierre Desmaizeaux published this work along with other unpublished materials from Locke's writings, and *The Elements of Natural Philosophy* soon became the most sought-after part of that publication and was quickly printed as a separate pamphlet.

that was published in Desmaizeaux's edition of *The Elements* is reprinted in the first edition of *The Newtonian System.*

Betty Jo Dobbs and Margaret Jacob [11] identify the authors of *The Newtonian System* as John Locke and Isaac Newton. James Axtell currently thinks that the notion of Newton's having anything to do with this book is an impossibility.[12] However, in a book published in 1968, he describes the close relationship between Locke and Newton including Newton's frequent visits with Locke at the Masham's home. In that book, Axtell argues that the first four chapters of *The Elements* reflect Newton's thinking and writing. For this reason, he sees Locke's *Elements* as an important popularization of Newton's work. In addition to the cachet of Newton's association with the work, Axtell also extols *The Elements* as a unique explication of the Newtonian cosmology [13]

As an outline of the basic ideas of natural philosophy, Locke's (or Newton's) work is sufficiently straightforward to be used for children and the untutored. Its axiomatic approach covers twelve major areas, which in *The Newtonian System* were merged into six lectures. The range of the material included in *The Newtonian System* covers all twelve of the topics in Locke's work. The chapter headings give an indication of the scope of the material: "Matter and Motion," "The Universe," "The Solar System,"

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[11]Betty Jo Teeter Dobbs and Margaret C.Jacob, *The Culture of Newtonianism* (Atlantic Highlands, N. J.: Humanities Press, 1995).

[12]In my conversations with Dr. Margaret Jacob, she remembered getting the idea from an old article by James Axtell. In a subsequent conversation with Dr. Axtell, he suggested that he had never put forth any such idea. (March 3, 1997).

[13]James Axtell, *The Educational Writings of John Locke* (New York: Cambridge University Press, 1968), chapter 4.

"Of Air and Atmosphere," "Of Meteors," "Of Springs, Rivers and Seas" and finally a discussion on the nature of man and his senses. This last discussion is quintessentially Locke, including the basic idea that data are acquired through the senses. Learning occurs as sense data about the physical world are processed in the mind. This chapter explores the place of sensation and reflection in the learning process. By ending *The Newtonian System* with a summary of Locke's major ideas about man, the author manages to underscore the link between the Newtonian system and Locke's *tabula rasa.* The reformulation of the laws of motion are linked to the rethinking of the nature of man.[14]

In the original edition of *The Newtonian System*, all the material taken from Locke was carefully italicized. Either John Newbery, the publisher, felt that the material was so well- known that it did not need attribution, or he was simply protecting himself from charges of plagiarism by setting it in special typeface.[15] A few examples will show the close parallels between the two texts. In fact,*The Newtonian System* would cease to make any sense if all the passages directly quoted from Locke were removed.[16]

Chapter One: "Matter and Motion."

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[14]There is ample literature tracing the influence of Newton on Locke's thinking, a topic outside the scope of this paper. A look at the influence of Locke is contained in Samuel F. Pickering, *John Locke and Children's Books in Eighteenth-Century England* (Knoxville: University of Tennessee Press, 1981).

[15]Over time later publishers simply dropped the italics. By the 1812 edition the quotations from Locke are simply incorporated into the text as though they were the original words of Mister Tom Telescope.

[16]Quotations taken from Locke are in boldface; quotations from *The Newtonian System* are italicized.

Matter is an extended solid substance, which being comprehended under extended surfaces makes so many distinct bodys.[17]

By matter, my dear friends, we mean the substance of all things or that of which all bodies are composed, in whatever form or manner they may present themselves to our senses: for this top, Tom Wilson's ivory ball, the hill before us, that orange on the table, and all the things you see, are made of matter differently formed.[18]

Motion is so well known by the sight and touch, that to use words to give a clearer idea of it would be in vain. Matter or body is indifferent to motion or rest. There is as much effort required to put a body, which is in motion at rest as there is to set a body, which is at rest, into motion.[19]

As to motion, I may save myself and you that trouble of explaining that; for every boy who can whip his top knows what motion is as well as his master. Matter or body, is indifferent to motion or rest. As for example, now I whip my top and it runs round, or is in motion: but when I no longer whip it, the top falls down, as you see, and is at rest. When a body is in motion, as much force is required to make it rest as was required, while it is at rest, to put it in motion [20]

This attraction is the strongest, the nearer the attracting bodies are to each other; and in different distances of the same bodies, is reciprocally in the duplicate proportion of those distances. [21]

This attraction is the strongest, the nearer the attracting bodies are to each other: and in different distances of the same bodies it decreases as the squares of the differences between these bodies increase.[22]

These examples could be endlessly multiplied to substantiate the claim of Locke as the true author of *The Newtonian System*. However, Locke did not create the

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[17]Locke, *Elements*, 179.

[18]*The Newtonian System*, 5.

[19] Locke, *Elements*, 180.

[20]*The Newtonian System*, 13.

[21]Locke, *Elements*, 182.

[22]*The Newtonian System*, 15 .

character Tom Telescope, and so the problem of authorship remains open. Most libraries list the author as Oliver Goldsmith. There seems to be little awareness of Locke's connection to the material. Because many of Newbery's works were written by Oliver Goldsmith, the assumption has been made that Newbery hired him to write *The Newtonian System*. In fact, during the period that *The Newtonian System* was published, Goldsmith was working for Newbery as a hack writer. It is interesting to compare what Goldsmith presumably wrote in 1761 with what he published under his own name in 1776. In his *Survey*, Goldsmith states emphatically that experimentation is the prerequisite for any natural philosophy worthy of the name. By contrast, the author of *The Newtonian System* uses demonstrations but no experimentation. Goldsmith's *Survey* contains rigorous mathematical demonstrations. In *The Newtonian System* there are almost no mathematical statements. Goldsmith exhibits an encyclopedic knowledge of key scientists in each area and on each continent.[23] This information is not included in the teachings of Tom Telescope.

Goldsmith qualifies as an author with a good grasp of scientific principles as well as knowledge of the scientific literature of the time. Tom Telescope made much of the inhabitants of the moon, the certainty of life on other planets and the idea of plurality of worlds. Goldsmith adamantly rejected such ideas. Nor would Goldsmith have discussed matter in terms of earth, air, fire and water, as is the case in *The Newtonian System.*

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[23]Oliver Goldsmith, *A Survey of Experimental Philosophy considered in its Present State of Improvement* vol.1 (London: Carnen and Newbery, 1776), 79.

Whoever the author, he knew to alter some of Locke's basic ideas to fit the contemporary scientific environment. For instance, in the discussion of minerals and stones, vegetables and objects that grow in the ground, Locke's work clearly states the principle of vegetation. "All stones, metals and minerals, are real vegetables; that is, grow organically from proper seeds, as well as plants." The Lilliputian lecturer is not so willing to accept this view, and so he fudges with the statement: "It should be supposed that minerals and ores grow in the ground like vegetables starting from seeds." By the middle of the 1700s, the scientific community had begun to question this principle, which is linked more to alchemy[24] than to natural philosophy. The principle of vegetation is clearly rejected in Goldsmith's work but is a part of *The Newtonian System*.

One other major figure in contention for authorship is John Newbery himself. He was a salesman, a creative bookseller and a storyteller, an astute businessman and a purveyor of patent medicine. Starting in the 1740s, he introduced children's books into his publishing firm.[25] In 1761 he published *The Newtonian System*. This marked the first attempt to integrate two major concerns of the mid-eighteenth century, Sir Isaac Newton's

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[24]The principle of vegetation is basic to the transmutation of metals. If metals were picked "unripe," then sufficient heat and pressure would ripen them into a less base metal. The belief that base metals could be transmuted to gold was linked to this concept. By the 1760s, alchemy had fallen from favor and was replaced by a more systematic chemistry that did not depend on the virtue of the experimenter, as it did in alchemy. Cohen, *Scientific Revolutions*, 514-16.

[25]Newbery quickly went beyond his first attempts, the simple alphabet books, to produce *Nurse Truelove's Christmas Box* (London, 1750), *Nurse Truelove's New Year's Gift* (London, 1750), *The Lilliputian Magazine or the Young Gentlemen and Ladies Golden Library* (London, 1751), *The Royal Primer* (London, 1756), *The Little Lottery Book* (London, 1756) and *A New History of England* (London, 1759).

laws governing the universe and John Locke's theory of education. This was not accidental. John Newbery was remarkably perceptive about the book market and the London social scene. He was cognizant of the emerging middle class and their preoccupation with upward mobility. He observed the amount of time and money being spent on children, and he noted that parents, like other members of middle-class society, were beginning to connect knowledge of science with increased social status.[26] Because Newbery did understand children, knew how to capitalize on the current market and was clever enough to be able to interweave the story line of *The Newtonian System* with the science of Locke, I believe that he should be regarded as the author of the text.[27]

Newbery regarded children's literature as a lucrative addition to his flourishing patent- medicine business and his well-established printing concern. Best known for the ever-popular *Goody Two Shoes* and *Giles Gingerbread* as well as the *Circle of Science*, Newbery did not leave any written record of what motives beyond commerce inspired his work. Often described as a rotund, red-faced, energetic and somewhat frenetic individual,[28] he enjoyed the process of producing and advertising the books that his printing shop developed. He enjoyed writing and his creative and humorous energy

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[26]Hogarth, *England*, 62-63.

[27] Newbery provided loans and monetary support to Goldsmith throughout his life. John Townsend, *John Newbery and His Books: Trade and Plumbcake for Ever, Huzza!* (Metuchen, N. J.: Scarecrow Press, 1994), 94.

[28]Elizabeth Eaton Kent, *Goldsmith and His Booksellers* (Ithaca, New York: Cornell University Press, 1933), 51-52, reports that Johnson portrayed him as an enterprising, hurrying, round-faced little man.

seems consistent with the story line of *The Newtonian System.* It was not unusual for him to write parts of children's books.

The marketing devices for *The Newtonian System* provide some insight into Newbery's direct involvement in the book. Newbery's strategies for selling books included giving a book for free but charging two shillings for the binding or supplying a ball or pincushion free with the purchase of a book. Every book contained advertisements for every other book. Other booksellers have used this form as well, but seldom with such wit. In *The Newtonian System*, the audience is advised:

> Because I cannot deliver what I am going to say, Madam, without making use of the terms of art, says he, and thus I must desire, your Ladyship, and the rest of the good company, to learn from Mr. Newbery's pocket dictionary, and some other books of that kind.[29]

At the end of every book published by Newbery was a list of other books and toys available for the education and edification of children. Embedded in most stories were references to other books from the same publisher. In many cases Mr. Newbery used the stories to advertise his patent medicine.[30] This kind of puffery is not uncommon; it can be seen in most children's books of the period, but Newbery did it better. He wrote arresting

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[29] *The Newtonian System*, 126. The copy in the Berg Collection at the New York Public Library still has the end papers and the advertisement intact. It states: "The author of the preceding sheet has in most places explained the technical terms, but in all he could not. . . mention is made of the Pocket Dictionary (Page 95) not because the terms are better defined than in any other, but because it is sold for only three shillings bound . . . and is rendered more portable and convenient for the Pocket."

[30] In "Goody Two-Shoes," little Margery's father dies because Dr. James's Fever Powder was not to be had, and he died miserably. Dr. James's fever powder was sold by Newbery. Townsend, *Trade and Plumbcake forever,* 106.

advertisements and was always on the lookout for ways of increasing the circulation of his books. With the publication of *The Newtonian System,* he was able to move in a direction that would shortly be followed by several other printers, all attempting to cash in on science for children. Books of natural history became quite popular, especially the work of Thomas Bewick, but none enjoyed the popularity of *The Newtonian System,* repeatedly reprinted from 1760 through the early 1820s. Newbery produced a story that children could relate to both as story and as science. As one review reported,

> This useful little work is written in so clear and comprehensive a style, that children not only understand its contents but find amusement in them.[31]

On a bright summer afternoon the children visiting the Marquis of Setstar argue over what activity would be most enjoyable. Because the children are having such a "warm debate" over the relative merits of hot cockles, blind-mans-buff, or threading the needle as a means of occupying themselves, Lady Twilight asks Tom Telescope to point out some diversions. He describes the entertainments that he and his friends engage in:

> We play at Sham Orations, comical disputes, measuring of Land and Houses, taking the heights and differences of Mountains, and Steeples, Solving problems and paradoxes on globes and Maps and sometimes [we play] at Natural Philosophy.[32]

The conflict is resolved by the children agreeing to begin the study of natural philosophy.

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[31] *The Juvenile Review*, 1817, as quoted in John Roscoe, *Newbery, Carnen, Power: A Provisional Checklist of Books for the Entertainment, Instruction and Education of Children and Young People, Issued under the imprint of John Newbery and His Family in the period 1742-1802* (New York: Oxford University Press, 1966), 348.

[32] *The Newtonian System*, 3.

The lectures take place in the private parlor of the Marquis of Setstar with Lady Twilight as the hostess. The cast of characters varies. The first third of the book seems to be populated only by young boys, but suddenly the lectures are being addressed to young gentlemen and ladies.[33] Whether the ladies in question are adults or children is not quite apparent. The Marquis of Setstar is a sometime participant in the lectures, but his real contribution is to make available all the scientific equipment, an observatory, microscopes and telescopes and, of course, sweets and delicacies for tea. The Duke of Galaxy is not so much a character as a prop.[34] Other figures making an appearance are Master Hal Thomspon, Master Lovelace, and Master Lang. Most of these simply appear as names, but Master Wilson has a distinct role as skeptic and clown. He brings the wrath of Tom Telescope down on his head more than once. Lady Caroline is the voice of compassion and reason. Master Blyth and Sir Harry have little to say, while the unidentified "Baron" disrupts the last lecture with boisterous behavior and ridicule. He is soon put in his place by tiny Tom Telescope, who is somewhat pompous, very knowledgeable, but easily peeved when his authority is questioned.

The first lecture deals with matter and motion. As soon as the lecture is under way, Master Wilson objects. He challenges Tom Telescope's dictum that a body in motion tends to stay in motion. As evidence, he demonstrates rolling a hoop down a

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[33]Ibid., 30.

[34]The Marquis' coach enters the driveway and bursts into flames. This provides Tom Telescope with an excellent example of one result of friction. Heat caused by the friction of the wheels on the road often resulted in such coach fires. Ibid., 62.

hill. There is great difficulty in keeping the hoop in motion; it has a tendency to fall over. Tom Telescope patiently explains the issues of friction and wind resistance to his pupil, but not before he has commanded silence and admonished Master Wilson, "Don't expose your ignorance, Tom Wilson, for the sake of a laugh." Master Wilson is not alone in questioning the little philosopher.

In the discussion of the Lisbon earthquake, both Tom Wilson and Lady Caroline doubt Tom Telescope's explanation. Tom Telescope argues that just as gunpowder is driven from a gun by the force of rarified air, so, too, the eruption of a volcano is caused by rarification of air trapped in some of the cavities of the earth and under the sea. He explains that the rarification of air is caused by fires burning under the earth. He finally clinches the argument with the statement that "a fire could burn down a mountain but not blow it up – without rarified air."[35] The author equates earthquakes and volcanoes. Tom Telescope argues that they are caused by the same process. He goes on to describe the Aetna volcano in Italy and reiterates that the center of the earth is fire. This is followed by a detailed description of the Aetna volcano reprinted from *The Philosophical Transactions*.[36]

Not only do the children ask questions and challenge Tom Telescope, but they also clamor to take part in the demonstrations. Lady Caroline shows great enthusiasm for all the activities involved. She is quite vocal, whether she is questioning God's place in

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[35]Ibid., 41.

[36]Ibid., 68.

all of this,[37] challenging the notion of fiery furnaces[38] within the earth or arguing against cruelty to animals. Tom Telescope does not take kindly to being challenged. He takes himself quite seriously most of the time. At one point, he takes umbrage at the repeated jeers coming from his audience. The children laugh at his self-righteousness and eventually he apologizes and is able to laugh at himself. He then returns to his role as philosopher and continues to demonstrate the principles of Newtonian philosophy.

Tom Telescope points out the rather obvious fact that the earth is not all water. This, he explains, is because water is lighter than earth. Lady Caroline challenges this idea. In response, he demonstrates by taking a three-pint pot of earth and a similar pot of water. He mixes them together and shows the audience how the earth falls to the bottom and the water rises. This is construed as a vindication of God's wisdom.[39] It is one of the few references to God made by the Lilliputian lecturer and seems to be a response to having earlier offended Lady Caroline's religious sensitivities.

Just as water and earth are used to demonstrate the make-up of the planet, other mundane instruments are also used to teach about science. The little philosopher not only uses the tops and balls of his audience, their hoops and wooden blocks, but also points out that Lady Caroline's fan doubles as a scientific instrument and her earrings can be used to demonstrate the qualities of stones. Harry's popgun is used to show the power

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[37]Ibid., 64. "I protest, says Lady Caroline, I think you carry the argument too far and seem to question the power of the Creator."

[38]Ibid., 67.

[39] Ibid., 65.

of concerted air, and a cricket ball serves as an excellent example of the principle that, "the quantity of the motion is measured by the swiftness of the motion, and the quantity of the matter moved, taken together."[40]

Toys are useful, but they are not the only accouterments used for demonstration. Proper scientific instruments are also available to the children. The air pump is employed to demonstrate the connection between air and respiration. The array of demonstrations using both scientific instruments and everyday objects contributes to the appeal of this little book. Allowing the children to use the equipment in the laboratory of a nobleman seems more than generous. He makes available microscopes and Leyden jars, but that is not the extent of his largess. An illustration shows the Marquis of Setstar's observatory, perched high on a hill and open to the sky.[41] The children are invited to explore the wonders of this observatory and to examine the heavens through two different types of telescopes. They study the heavens and identify the planets, chart the fixed stars, and report on the tides of the moon.

Lady Twilight questions the possibility of comets hitting the earth. She asks whether this would explain the irregularities in the earth. In the eighteenth century some people feared that Halley's comet might hit the earth and do great damage.[42] As Lady

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[40]Ibid., 64.

[41]This illustration replaced the Lilliputian lecturer as the frontispiece of subsequent British editions of *The Newtonian System.* In the American editions, the woodcut of Mt. Vesuvius was used as the frontispiece.

[42] Beliefs about comets ranged from William Winston's theory that comets had caused the Biblical deluge to Joseph LeLand's prediction that Halley's Comet heralded the end of the world. These writers reflect the eighteenth-century preoccupation with

Caroline explains, "I know, Lady Lucy and many others, in great pain when the late comet was expected."[43] The idea of a comet hitting the earth is dismissed as nonsense and Tom Telescope responds, "I am unable to answer for all the extravagant conceits and ridiculous follies of the human race, Madam."[44] Yet Tom Telescope has no trouble entertaining the idea of plant and animal life on the moon and other planets. Despite any evidence, he exhibits a great deal of enthusiasm for this idea.

From the earliest definitions of matter and motion to the more lofty conclusions on the nature of man, the text gives both information and entertainment. Some of the discussions retain ideas already abandoned by science. For instance, at one point the process of learning is related to vitalism and is explained as the process by which "some part of the blood enters the brain and is separated out into 'animal spirits' giving motion and sense to the body."[45] Tom Telescope retains the notion of matter made up of earth, air, fire and water.[46] Chemistry is treated as an alien topic, acknowledged but glossed over with some passing references to precipitation[47] and the nature of precious stones.

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comets and, in particular, Halley's comet. Donald K. Yeomans, *Comets: A Chronological History of Observations, Science, Myth, and Folklore* (New York: John Wiley and Sons, 1991), 162-67.

[43]Ibid., 66.

[44] Ibid., Edmond Halley (1656-1742) had correctly predicted the return of the comet every seventy-five or seventy-six years. It appeared in 1758-59 shortly before the publication of *The Newtonian System.*

[45]Ibid., 97.

[46]Ibid., 35-36.

[47]Ibid., 54.

Tom Telescope explains that some parts of matter are made up of globules and some of cubes. This presumptions leads to the following explanation of how matter is constructed:

> Globules of water or quicksilver easily separate because they are made up of round particles, touching only at one point. Metals are made up of square particles and adhere as magnets and [are] hard to separate.[48]

To demonstrate this principle of adherence, Tom Telescope files down two leaden balls so they each have a flat edge. He puts the two balls together, and the children discover the balls are very hard to separate. By contrast, water droplets are easily separated by passing a stick though them. This proves, for the Lilliputian lecturer at least, that the difference in matter is simply a difference in the shape of the particles. Matter is held together by magnetic force. The children attempt to produce just such magnetism.

> Master Brown took his uncle's sword and supported it with the point downward and Master Smith placed his father's amber-headed cane at about three or four feet distance where he kept rubbing the amber-head round on his waist coat. After some little time the sword began to move, tho' at that distance; and sometime after that it turned quite round . . .[49]

The children are quite impressed with the demonstration of magnetic attraction. This material is definitely not taken from Locke, but concern with magnetism increased greatly in the later half of the eighteenth century.[50]

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[48]Ibid., 12.

[49]Ibid., 13-14.

[50]Patricia Fara, *Sympathetic Attractions: Magnetic Practices, Beliefs and Symbolism in Eighteenth-Century England* (Princeton: Princeton University Press, 1996), 16.

Other assertions go unchallenged. For instance, Tom Telescope explains to his audience that one can, with the naked eye, observe the rings around Jupiter.[51] Other scientific principles take on a whimsical air. In the discussion on electrical attraction, he claims that glass, sealing wax, amber and precious stones, if rubbed till they are warm, will both repel and attract feathers, straw, hair and the like. This is offered as proof that each of these bodies has a sphere of electrical fire. As Tom Telescope describes electrical fire, "It may be drawn from the Ladies eyes, yet leaves them not less brilliant than they were before. It may be drawn from thunder-clouds, and is probably the same species of fire with the lightning. . . "[52] Tom then goes on to explain how electrical fire is harvested. An example is made of Dr. Richmann of Hamburg, a German gentleman who harvested too much electricity and died of shock.[53] The comments on electricity are somewhat limited, although later editions expanded on the material.

Some of the later editions of *The Newtonian System* underwent drastic changes as new information and new discoveries demanded alterations. However, all the editions retained a comprehensive explanation of the basic issues in natural philosophy, using the same examples and the same cast of characters.[54] The 1794 edition was "revised and

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[51]*The Newtonian System,* 37.

[52]Ibid., 14.

[53]Ibid.

[54]S. Roscoe, *John Newbery and His Successors: 1740-1814: A bibliography* (Wormsley, England: Five Owls Press, 1973), 252-53, lists eight English editions of *The Newtonian System* up through 1794. The price of 1 shilling seems to remain constant during the period from 1761 to 1784 when it was raised to 1s 6d.

enriched by an account of the late new Philosophical Discoveries by William Magnet. F.L.S."[55] This edition incorporated material reflective of the popular issues of the day. One such topic was the amazing feat of Mr. Blanchar and Dr. Jefferies crossing the English Channel from Dover to France in a hot-air balloon.[56] Both an introduction to the electrical machine and a discussion of the nature of electricity lead to the conclusion that "all the phenomena called Electrical, are supposed to be effected by an invisible subtle fluid existing in all bodies of the earth." [57] An extended discussion of the electrical machine includes the manner in which it extracts this subtle fluid from the earth and how this is related to the use of the Leyden jar, electrical kites and lightning rods. The author then gives credit to the up-and-coming hero who invented these rods, "the ingenious Dr. Franklin of America."[58]

In 1808 there was yet another edition, this time in America. The book was edited by Robert Patterson, professor of mathematics at the University of Pennsylvania.[59] In this

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[55]*The Newtonian System,* 1794, frontispiece.

[56]Ibid., 56. This amazing feat will be discussed in detail later, since the same material is presented in greater depth in Maria Edgeworth's final volume of science for children.

[57]Ibid., 64.

[58]This material will also be covered in greater depth in the Maria Edgeworth chapter.

[59]Tom Telescope, *The Newtonian system of philosophy explained by familiar objects, in an entertaining manner, for the use of young ladies & gentlemen*, Illus. with copper plates and cuts. 2d Philadelphia ed.: with notes and alterations, by Robert Patterson. Professor of Mathematics, in the University of Pennsylvania, Lydia R. Railey (sic) for Johnson & Warner, 1808. The publisher was believed to be among the first women publishers in America. Leona M. Hudakl, *Early American Women Printers and*

edition, the changes are mostly in terms of the social relationships and there are more exact diagrams. The labeling of instruments is more detailed in the case of the refracting telescope and the microscope. Early on in this version, embedded in the discussion on air, is a analysis of the problems and dangers of mining. In the first edition, the discussion of the necessity of air for breathing, referred to prisoners dying in India. The American version omits the "Black Hole of Calcutta" and explores instead the fate of coal miners and the terrible conditions under which they are forced to work and deplores their suffering ("[they] die in agony for seven pence a day")[60]

Several alterations to the text suggest changing social mores. The American editor democratizes "Lady Caroline" to "Miss Caroline" and changes the Marquis of Setstar to Mr. Setstar. A new character has been added: the children are now under the tutelage of a Mrs. Mentor, a rather stern, unbending, humorless lady. This edition defines the audience as children rather than a mixture of adults and children. The setting is no longer an English mansion but an American classroom. Mrs. Mentor brings in an adult, Tom Telescope, to instruct the children. Perhaps the most significant change is that the activities do not grow out of the curiosity of the children but are now imposed because Mrs. Mentor feels it will be informative. Everything is more structured and stilted. The work has moved away from Locke's idea of entertainment leading to curiosity and thus to new knowledge. In this edition, the storybook has clearly become a textbook.

Publishers:1639-1820 (Metuchen, N. J.: Scarecrow Press, 1978), 613.

[60]*The Newtonian System*, 1808, 95.

Other modifications appearing in later editions primarily reflect scientific changes. For example, the chapter on the universe contains several additions. The reflecting telescope and the refracting telescope are discussed with extensive diagrams. A more lengthy discussion on the fixed stars accompanies a more detailed diagram of the orrery. The diagram showing the planets in relation to the sun features two important additions: the orbital of a comet and the piace of the Georgian Planet. (This latest planet discovered by Dr. Herschel is called the Georgium Sidus, or Georgian Planet.[61]) Most of the other changes involve popular scientific notions, not any modification of the Newtonian system.

In the eighteenth century, a belief in a plurality of worlds was still alive and well. The 1808 American edition of *The Newtonian System* still retains a vital part of the material, but other, more scientific data are revised. The principle of vegetation is dropped without comment. How metals are formed in the ground does not appear – just the comment that they are always found in mountainous regions. Other differences include changes for various distances from the planets to the sun and some footnotes correcting data on magnets and how they work, but the overall material on the latter is relatively unchanged.

In the chapter on Springs and Mountains, Professor Patterson reports on the skeleton of an elephant recently discovered in upstate New York. A footnote reports that it can now be seen at Peale's Museum in Philadelphia.[62] These and other changes give

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[61]Ibid., 24.

[62]Ibid., 78.

the book a more local flavor. The distinctions between the Locke text and *The Newtonian System* are gone. There is no separation of the italicized text of Locke and the Newbery material. In a discussion on chemistry, this editor points out that *modern* chemists now recognize not less than twenty-two different metals, and the term semi-precious (as it refers to metals) is at present generally "exploded."[63] (Yet, there is no discussion why that is so or even why it might be worthy of note.[64])

For all the editions, the science presented in *The Newtonian System* varies in accuracy, depth of detail and range of topics, but it still accomplishes the goal of presenting Newtonian science to the untutored. Therefore, it contributes to the popularization of science taking place in England in the middle of the eighteenth century, becoming one element in the larger scientific movement that defines observation and demonstration as appropriate means of gaining knowledge.

Few children's books have received much attention from historians, but one historian of science, James Secord,[65] has made a strong case for looking at this and other texts intended to teach children science. Secord has discussed in detail the wit and wisdom of *The Newtonian System,* analyzing the changes that took place throughout the

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[63]Ibid, 95.

[64]Tom Telescope, *The Newtonian System of Philosophy: explained by familiar objects in an entertaining manner, for the use of young persons,* A new edition, illustrated with copper plates and cuts (London, 1812). The copy in the New York Public Library was a presentation copy for an excellent student at the Palmer School. By the time a book is given as a school prize, it is usually considered a classic. The fact that it is still intact may suggest that it was more prized than read.

[65]James Secord, "Newton in the Nursery: *The Newtonian Systemand The Philosophy of Tops and Balls:*1761-1838," *History of Science,* 23 (1985): 127-51.

various editions, as well as looking at the scientific and social material in the text. He shows how this assembly reflects the public lectures that were popular at that time. Certainly what is presented in this book is not significantly different from what would have been heard in the local lecture hall when Benjamin Martin or James Ferguson came to town to deliver lectures on the new natural philosophy.[66]

Secord comments on the way in which religious issues are sidestepped. There are general references to God's grandeur but no direct references to the Bible or any particular dogmatic issues. In the discussion of the way in which nature forms rivers, mountains and seas, Tom Telescope is overcome with the glory of it all. He is awestruck by the goodness of God, but his God is nonsectarian. His is not identified as the God of the deists or the Scotians but rather the author of all grandeur. Tom Telescope discusses the beauties of nature and remarks that volcanoes and earthquakes show the majesty of God. There is no discussion of how these natural disasters might be punishment for sin or part of a plan of retribution. There are no admonitions that God demands to be worshiped in a special way or that His majesty is linked to any concern with human behavior.

Secord's work on this book has led many historians of science to acknowledge the existence of a scientific literature for children in the eighteenth century. Secord looks at some of the ways that Locke's teaching have influenced the text, but he does not look

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[66] Larry Stewart, "Public Lectures and Private Patronage in Newtonian England," *ISIS* 77 (1986):47-58, and John Millburn, "The London Evening Courses of Benjamin Martin and James Ferguson, Eighteenth-Century Lecturers on Experimental Philosophy," *Annals of Science* 40 (1983): 437-55.

at the close correlation between Locke's *Elements of Natural Philosophy* and *The Newtonian System.* He comments on the fact that the very first issue discussed in the book is the social evil of gambling, but he does not elaborate on why this issue might be important.

J. H. Plumb[67] also looked at *The Newtonian System* in his discussion of the impact of commercialization on children. He calls it the quintessential children's book both for its historical significance as the first attempt to teach Newtonian science to children and as a vehicle to educate both children and adults. He argues that Newbery was fully aware that the book would be purchased by parents, read by parents, and enjoyed by children. Plumb makes a strong case that *The Newtonian System* gives a novel insight into how ideas were being disseminated during this period in England.[68] He would agree with Mary Jackson, who argues:

> In a very real sense, the Enlightenment percolated through English Society from opposite directions: from the top down through the writings of philosophers, scientists and their popularizers; and from the bottom up through a variety of humble, popular books, including that upstart, children's literature.[69]

This means that the book had to be written at a level of sophistication to appeal to parents while at the same time remaining understandable to children. This was a remarkably successful attempt if, as Plumb argues, no less than 30,000 copies of the book

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[67]J. H. Plumb, "New World of Children"in *The Birth of a Consumer Society* (London: Europa Publications Limited, 1982), 301-03.

[68]Ibid., 302.

[69]Mary V. Jackson, *Engines of Instruction, Mischief and Magic* (Lincoln: University of Nebraska Press, 1989), 11.

were produced between 1760 and 1800. In the same article, Plumb makes it clear that this is not the only book that attempted to explain volcanoes, earthquakes and the solar system, but it is the first book to proclaim itself as promoting Newtonian science.

Shifts in the economic status of a nation almost always include shifts in the values of the populace. For the middle class in the eighteenth century, the new definitions of childhood encouraged behaviors that altered the family's economic patterns. Increasingly, discretionary capital was spent on books and education for the children of these upwardly mobile families. A visual reminder of the changes in family life can be seen in the way families are depicted from the seventeenth to the eighteenth century. Prior to 1730, family portrait poses are stiff and formal, looking like an assortment of strangers. After 1730[70] an increasing number of paintings show families in more relaxed settings, children reading, playing, and fishing.[71] This is the view of family life that parents were willing to pay to have recorded. Reading, relaxing and playing together had become an inherent part of family life. Later in the century, Joseph Wright of Derby painted An Experiment with the Air Pump showing a family around a table watching a scientific experiment.[72] The societal changes reflected in paintings can also be traced in

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[70]This date is somewhat arbitrary but corresponds to the increased wealth of the "middlin class" approximately two generations after the Glorious Revolution. Langford, *A Polite and Commercial People*, 61-66.

[71]Plumb, *Birth of a Consumer Society*, 288. In Tillyard's work on the Lennox sisters, much is made of the frequency of portraits, the desire to have children portrayed in a variety of poses, and the practice of going to the artist's studio to pick the correct accompanying icons and pose that would define both the child and the family.

[72]National Gallery in London. As a member of the Lunar society, Joseph Wright had a vested interest in showing the family involved in scientific endeavors.

similar fashion to the toys and equipment provided for young children. In memoirs of the day, mention is made of the scientific equipment, the science books and the interest in experiments that necessitated buying equipment and finding specimens to catalogue or to experiment with.[73]

The frontispiece of the original edition shows Tom Telescope as a tiny boy standing on a table to deliver his lectures to a roomful of adults and children.[74] The assumption is that both will learn Newtonian physics at the same time. This means that the lectures have to be explicit enough to be understandable to young children and yet sophisticated enough to hold the attention of adults, who are expected to read this book to their offspring. Part of Newbery's genius was his insight that if a book could not hold the adult audience, it would also probably not hold his younger readers.[75] As a reviewer in 1844 commented:

> The real secret of a child's book consists not merely in its being less dry and less difficult, but more rich in interest . . . such being the case, the best of juvenile reading will be found in Libraries belonging to their elders,

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[73]Tillyard, *The Aristocrats,* 175-76.

[74]On page 102 is the picture showing the coach on fire due to friction. This is taken from the first edition, courtesy of the Pierpont Morgan library.

[75]The idea that books for children must also appeal to adults continues to be the rule of thumb in children's literature. The recent popularity of two children's books from Japan hinges on the fact that both children and parents are eager to buy and read them. (*New York Times*, 16 July 1997, B1). These books have such eye-catching titles as *Everyone Poops* and *The Gas We Pass.* These are basic science books about the body and seem to engage both parents and children.

> while the best of juvenile writing will not fail to delight those who are no longer children.[76]

Samuel E. Pickering and others have credited Locke with the new form and content of children's literature in the eighteenth century. Gillian Avery makes the point that many educators prior to Locke had called for more respect for children, more pleasure attached to learning and greater attention to the needs of the child. Roger Ascham wrote *The Training up of Children* about 1593, in which he argued for learning to be made more delightful for children. Laughter was important for children and "the more children laugh for exercise, the more lightsome they be."[77] Other writers have argued that Locke's ideas on childhood socialization were voiced earlier by such men as Sir William Petty and Comenius. Sir William Petty certainly anticipated the work of the Edgeworths by his emphasis on trade and industry and his concern that children should acquire manual skills. What Locke added to the equation was the concept of the individuality of the child and the notion that curiosity should be prized more than obedience and rote learning.

Locke's thoughts on education came out of his correspondence with his friend and cousin, Edward Clark. At the birth of his son, Clark sought Locke's advice on child rearing. In a series of letters from 1684 to 1691, Locke advised the Clarks on every

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[76]"Children's Books," from the *Quarterly Review*, June 1844, reprinted in Marjorie Moon, *John Harris' Books for Youths 1801-1843* (London: Five Owls Press Limited, 1976), 156.

[77]Quoted in Gillian Avery's "The Beginning of Children's Readings to 1700,"in *Children's Literature: an Illustrated History*, ed. Peter Hunt (New York: Oxford University Press, 1995), 11.

aspect of child rearing from toilet training[78] to science education. These letters later became the basis for Locke's *Some Thoughts concerning Education.*

Locke's view of education started with very early training embracing the idea that "Children owe honor not obedience."[79] The notion that children were not obliged to strict obedience constitutes a revolution in the perception of the parent-child relationship. The parent was moved from the position of dictator to counselor. More engrossing was the Lockean suggestion that pain was a good thing. With learning linked to pain, early training should prepare the child to suffer minor discomforts in order to be better placed in society. Locke encouraged the use of thin shoes so that the child would be acclimated to cold feet and thus build up resistance to colds and bad humors. He recognized the importance of pain as well as pleasure in the learning process, and he set down in detail his plan of education, which combined both rewards and punishments to lead the child to a better understanding of both classical and scientific material.

The correspondence between Locke and his cousin Clark gives additional insight into the evolving views of child rearing that were to dominate the eighteenth century. Locke encouraged Clark to have his son learn a trade as well as be educated. One craft that Locke highly recommended was that of stone polisher, so that young Master Clark

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[78]His dictates on toilet training included this bit of wisdom: "People with loose bowels have seldom strong thoughts." Nathan Tarcov, *Locke's Education for Liberty* (Chicago: University of Chicago Press, 1984), 85.

[79]Ibid., 74.

might be positioned to become a jeweler.[80] This advice is given almost three-quarters of a century before many in England would begin to see that knowledge of a trade might position one to advance in commerce. Locke saw that it was the child who should be schooled in "natural philosophy, chemistry, or. . . anatomy"[81] before he was faced with the duties of adulthood. For adults he recommended the study of those areas that they needed to fulfill their social obligations: "the art of speaking well, ethics, politics, the history and Law of England, chronology, geography, travel literature, and the knowledge of human nature."[82]

More unusual is Locke's advice to "manage children by appealing to their own inclinations, individuality is crucial."[83] Locke attracted a great deal of support among the so-called "educationalist." The idea that the child's personality[84] as well as his intellect could be molded by the parent and teacher was a more optimistic view of human nature than the early deterministic models. Much has been made of Locke's concept of individualism,[85] but it probably is not as important as his insistence that learning occurs

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[80] "Locke to Clark: Feb. 6, 1688, " *The Correspondence of John Locke and Edward Clark* (Cambridge: Harvard University Press, 1927), 238.

[81] Ibid.

[82] Axtell, *Educational Writings of John Locke,* 82-83.

[83] Quoted in Tarcov, *Education for Liberty,* 81.

[84] Note that the tabula rasa applies only to knowledge and not to temperament, abilities and desires. Tarcov, *Education for Liberty,* 109.

[85] Tarcov observes that Locke's view of individualism is a long way from the "worshipful enrapture of the supposed creativity and individuality of children." Ibid., 108.

through habituation, not exhortation or happenstance. One aspect of developing this individuality was the selection of the correct people to instruct the child. As home schooling became more common, the search for a good tutor became almost an obsession for many families. The Clarks sought advice on the exact criteria to use in finding such a person. Locke assured them that tutors should have not only good learning but also good breeding, knowledge of the world, and virtue. "If God had selected a better tutor – Adam and Eve would still be in paradise."[86] If the tutor was an important asset in the household, the servant was the most threatening to child rearing. Because the child often ran to the cook to be comforted, Locke saw the servant as undermining the work of both the parent and the tutor.[87]

Education was a matter of great concern by the middle of the eighteenth century. Many educational establishments were in total disarray, especially those for young gentlemen. There were few establishments where any science was being taught.[88] The few people advocating experimental science as proper subject matter for the education of youth were usually not well accepted. The more popular view was to continue the long-

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[86]Quoted in Tarcov, 126.

[87]Pickering discusses Locke's view on this in detail. Maria Edgeworth later reiterated the same idea in *Parent's Assistant,* which will be discussed later.

[88]See Michael Brande, *The Georgian Gentleman* (Farnborough, Harts, England: Saxon House, 1973). E. N. Williams reports that in 1764 Richard Watson, who became professor of chemistry at Cambridge, had never read a syllable on the subject or ever seen a single experiment. *Life in Georgian England* (New York: P. T. Putnam's Sons, 1962), 38. An alternate view is presented in Elisabeth Leedham-Green, *A Concise History of the University of Cambridge* (New York: Cambridge University Press, 1996), 113-17. Her attempts to explain the status of science at Cambridge during that period do little to persuade the reader that much was actually happening.

established practice of rote learning of traditional material with little consideration of application.[89] Locke's contribution to learning theory is encapsulated in the concept of *tabula rasa.*[90] Because it is assumed that all learning takes place through the senses and concrete experiences, Locke regarded education as similar to the hunt. If the pursuit is more enjoyable than the kill, then, likewise, it is the process of acquiring information that brings the greatest delight. Tom Telescope encapsulates Lockean thought: as a teacher, he leads the children from common examples and playthings to more complex ideas. For example, Master Wilson scoffs at Tom's explanation of matter and motion, because he knows from experience how difficult it is to keep the hoop rolling along. Tom Telescope's response includes a discussion of friction, the atmosphere and similar issues involved in matter and motion. When Tom Wilson understands both the principle of motion and the role of friction in the laws of motion, he then acquiesces to the little philosopher and eventually becomes quite vocal in his enthusiasm for natural philosophy.

Locke saw the process of education as leading the child to greater self-esteem. As the child has his questions answered and his thoughts seriously considered by the adults around him, he begins to shape a positive self-image. This process is illustrated in the

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[89]The one major exception to this was the dissenting academies. They, however, suffered from instability since they often only remained open due to the diligence of a particular headmaster or teacher. Once the person died or retired, the school often disappeared. Langford, *A Commercial People,* 84-86.

[90]Tarcov, 104. This instructional theory is based on a series of assumptions: the child is neither inherently good nor evil, all learning takes place through the senses, the child can learn that which is presented in concrete form, abstraction is not immediately available to children, learning is a result of moving from the familiar to the unfamiliar and the child should be led to learning through entertainment.

interaction of the children in *The Newtonian System.* The children seem to settle into the process of learning and express triumph in each new discovery or demonstration. As they make the connection between the air pump and the pop gun, they begin to swagger over their new-found expertise.

The Newtonian System is a model for the teaching of science to the untutored. It utilizes exhortation, examples, clever demonstrations and some scientific principles expressed in simple terms. For instance, Tom tells his audience to look at the carriage wheel as it moves down the drive. This will enable them to visualize the movement in the solar system. The popgun one of the boys has been playing with turns into a scientific instrument to demonstrate the way in which canons work. The fan in Lady Caroline's hand is a piece of scientific apparatus in the discussion of the importance of air and its movement. All of these examples point up the way in which Locke's ideas of learning and Newton's system of philosophy may be joined in a reasonable presentation for children.

Two areas of social change commented on in almost all children's books are sensitivity to animal rights and the danger to children of gambling. Kindness to animals and respect for the animal world were certainly not new, but the emphasis on these ideas during this period was. The eighteenth century has been characterized as a time of greater optimism, greater sensitivity and greater freedom than previously. As Keith Thomas points out, the less anthropocentric the world became, the more man began to look at his connections to other species.[91] Thomas has looked at a variety of books on natural history and argues that their very presence increased the sentiment for animal rights. In *The Newtonian System*, Lady Caroline objects to an animal being put in a closed chamber to demonstrate the result of airlessness. She is upset about the animal's death, but she agrees to a compromise in which a rat that has already been caught in a trap will be used; if he survives, however, he will be released.[92] The children discuss the need for animals to be respected and condemn those who crave special foods that are only available through the suffering of other animals. The Ambassador becomes incensed at the notion of boiling a lobster alive, a custom that he sees as barbaric.[93] Earlier, Locke had written: "Children should be taught not to destroy any being unless it be for the preservation and advantage of some other that is nobler."[94]

Tom Telescope continues this line of reasoning. He rails against the Squire, who worries about his horse being mistreated but ignores the starving children at his gate. The Aristocrat who takes care of his livestock, but invests his money in the slave trade also comes in for his share of criticism as a supposed "Christian." The book attempts to demonstrate the need for children to be aware of their natural world as they endeavor to

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[91]Keith Thomas, *Man in the Natural World: Changing Attitudes in England, 1500 -1800* (New York: Oxford University Press, 1983),chapter 6.

[92]*The Newtonian System,* 44.

[93]Ibid., 113.

[94]"Locke to Clark: 15 Sept .1685," *Locke-Clark Correspondence.*

understand the rules that govern it; but they are also encouraged to observe their social world and to see the inconsistencies in adult behavior.

The new philosophy forced a corresponding cognitive shift that has been characterized as the movement from magic to science. The new philosophy represented a movement away from superstition and magical thinking. As Kuhn[95] has established, old paradigms give way to new thought processes and many components of the older paradigm are abandoned. Just as the new philosophy railed against the static quality of scholastic thought, the eighteenth-century philosophers were adamant about the evil influence of magical thinking, whether it was in alchemy or in the economy. A particularly virulent form of magical thinking is embodied in the practice of gambling. The superstitious thought processes in gambling can be juxtaposed to the requirements of the new science. The new science espouses curiosity, hard work, thrift and thoughtfulness. Gambling implies greed, lack of control and magical thinking.

In the opening chapter, Tom Telescope begins with a condemnation of the pastime of gambling. He is adamant that there is no greater danger to young people than the habit of playing cards. Moreover, this pastime is connected to the downfall of good families. This concern with gambling in the eighteenth century is mentioned repeatedly in social histories, in literature and in almost all moral tracts and educational treatises. Gambling is seen by the merchant class as a threat to their position. Their newly acquired wealth can be quickly decimated by an heir who engages in excessive card playing. But

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[95]Thomas Kuhn, *The Essential Tension* (Chicago: University of Chicago Press, 1977).

why would a book on Newtonian science open with a diatribe against gambling? Many parts of the problem have to be considered to arrive at an answer.

From a historical point of view, the sheer popularity of the practice needs to be explained. John Dunkley[96] makes the point that the gambling phase of the eighteenth century really began with the court of Louis XIV. With the nobility stripped of its ability to compete in any real world issues, they turned their competitive skills to games, gambling, sport and intrigue. While this issue was not germane to England, it did have its parallels. In England the aristocracy were still important politically, but they were not, for the most part, heavily involved in the new economic endeavors that were making fortunes for the emerging middle class. The aristocracy still maintained their country houses, their London season and their autumn hunt, but many of them were running out of money. The educated class and the virtuosi were touting science as the new basis for judging religion, politics and business. The two classes most likely to lack this scientific expertise were the aristocracy, who were not educated to the new philosophy, and the lower orders, who were not educated to much at all. Both of these classes could make up for their deficiencies by supporting competitive sports with the financial incentive of wagering.

Porter[97] indicates that many of the peerage exchanged tens of thousands of pounds in the gambling binges of the 1770s. Later in the century, the enormous popularity of cricket was essentially because, as a spectator sport, it could be gambled on.

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[96]John Dunkley, *Gambling: A Social and Moral Problem in France 1685-1792* (Oxford: The Voltaire Foundation at the Taylor Institute, 1985).

[97]Porter, *English Life*, 59.

Supposedly, Horace Mann staked £1000 on a match. Bookies were not banned from the House of Lords until 1825.[98] Boxing was equally popular as a betting sport. Horse racing moved outside Ascot, the personal estate of Queen Anne, to the villages and towns. Porter reports that gambling went from the nobs to the mobs. Gambling followed the masses. As early as 1738 the Gaming Act had outlawed dicing games as well as the card games ace of hearts, faro, and basset.[99] Needless to say, other games were immediately invented to circumvent the law. These laws were passed because of the enormous amount of wealth changing hands, and its movement threatened the upper echelons of society.[100]

Tom Telescope laments social scenes like the one he had seen at Bath, a fashionable resort where gaming was prevalent. There, a young child was seen at his mother's knee, the child betting on cards while the mother looked on with amusement. Tom Telescope is outraged that the better element in society was engaging in such debilitating behavior and involving young children at the same time. Lady Twilight writes about his reaction:

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[98]Ibid., 236-38.

[99]James A. Inciardi and Charles E. Faupel, eds. *History and Crime, Implications for Criminal Justice Policy* (Beverly Hills: Sage Publications, 1980), 174-75.

[100]Tillyard, *Aristocrats*, 263-65. Stories abounded about the wagers at Almacks, Whites and Boodles, the elite London clubs where members of the aristocracy wagered and lost large amounts, like Charles James Fox, who had lost £140000 by the time he was twenty-five. Eventually, he and his brother dissipated the entire fortune acquired by a very wealthy father. Their father, Lord Holland, attempted to settle his sons' debts by selling off his holdings but had a stroke while signing the papers. He died a few years later.

> Playing at cards for many, says he, is so nearly allied to covetous and cheating, that I abhor it; and have often wondered, when I was at Bath with my papa, how people, seemingly of years of discretion, could so far mistake themselves and abandon common sense, as to lead a young urchin just breeched, or a little doodle-my-lady in hanging sleeves, up to a gaming table, to play and bet for shillings, crowns, and perhaps guineas, among a circle of sharpers. Parents, continued he, might almost as well teach their children to thieve as to game; for they are kindred employments, and generally terminate in the ruin of both fortune and character.[101]

The author is obviously addressing parents more than children. He describes the difference between those who are excited by the new philosophy juxtaposed with the moribund and tedious pursuits of those who engage in less worthy pastimes based on greed and cruelty to animals. Often the behavior results in harm to one's fellow men by gossip and libel. Frederick, Prince of Wales, gambled immoderately, but he was not alone.

> But these were common habits among young men of his age and class in the period in which he lived. . . . Similarly gaming for high stakes was a pastime that gripped highly respected statesmen, professional men, their sons and their wives.[102]

Mary Wollstonecraft devotes an entire chapter to the evils of gambling when addressing the education of women.[103] She finds it especially reprehensible for women

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[101]*The Newtonian System*, 2.

[102]John Walters, *The Royal Griffin: Frederick, Prince of Wales, 1707-1751* (New York: Stein and Day, 1972), 63-64.

[103]Women playing cards, losing great amounts of money and swearing like sailors seem to be part of the changing image of women at this time. As greater freedom for women came into vogue in the middle of the eighteenth century, there was a lessening of the restraints on both language and behavior. The admonition against unwomanly behavior is a common theme, as is the admonition against gambling. Once a young lady

to be wasting their time at card playing because it not only arouses the passions but also ruins one's ability to cope with the tedium of life.[104] John Dunkley denies the destructive nature of gambling, even though there is much evidence against his claim. He has looked at the problem in France during the eighteenth century and come up with some interesting observations. While it has always been assumed that gambling was potentially destructive to the individual and ruinous to family and social relationships as well as ruinous to economic viability, his research suggests otherwise. Gambling is a persistent activity precisely because it offers incentives that are not otherwise available. It enables the individual with no skills to break economic barriers and to attain new status. As people engaged in applied science began to reap the benefits, some outside these pursuits looked to acquire wealth through gambling.[105]

Geoffrey Gorer, an anthropologist, analyzed the football pools in England and observed that while the assumption that a man betting a pound a week on football lost

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has experienced the card room she will not be content with the mundane duties of her station. There are many issues involved in gambling as a pastime: greed, excitement, too much pleasure, superstition, luck and high risk. It is the issue of excitement that seems to play an important part in the actual appeal of gambling. Women could rely on their husbands to pay their gambling debts so it was usually not issues of greed or attempts to recoup losses. It seems that with little productive work at their command, they turned to an activity that produced some new outlet for their energies

[104]Tillyard, in looking at the lives of the Lennox sisters, saw Caroline devoted to her husband's position in politics, Emily devoted to spending money and having children (twenty-two of them), Sarah devoted to sexual liaisons and gambling, and Louise devoted to her country house and its constant remodeling. Tillyard's study shows an interesting cross section of upper-class female occupations.

[105]An amazingly similar parallel can be related to the current growth of gambling by blue-collar workers as they see the computer-linked profits of the white-collar class creating instant millionaires.

over £52 a year, in fact, since the football odds are about five to one, the bettor is simply recycling the same six pounds during the course of the year. This is essentially what Dunkley has suggested, although he does not go into the mathematical discussion. Rather, he focuses on the changes in the moral, ethical evaluation of the practice. Dunkley argues that increased individualism and dependency on rationalism replaced religious dictates that had condemned gambling. In an age of reason, there was a general belief that bettors would not go beyond what was reasonable, given their resources and the odds of the cards or dice. This assumption that gambling is a rational activity fails to consider the very factor that Wollstonecraft had pinpointed. The gambler is driven more by the excitement of the moment than the rational outcome of the statistical odds.

Tom Telescope saw gambling as debilitating because it seduced young people from the study of a rational subject. Dunkley uses modern psychological studies to indicate why, for certain people, gambling may be a rational pursuit. For Dunkley, the classic example of the gambler who keeps on going when he has lost almost everything is rational. If he continues playing he has some chance of recouping his losses. If he walks away, there is no hope. Likewise, if an individual lacks the skills to join a particular economic revolution, then the only avenue open is chance or luck. It is not surprising that gambling increases in times of great change in the economic distribution of wealth. As the eighteenth century progressed, there was more discretionary capital in every family. A rational use of such capital might be to try one's luck at the cards and change a small margin into a windfall.

Gamblers accept the possibility of changing one's life chances with one stroke of good luck. Several children's stories deal with the theme of easy money, but always with a disastrous outcome. Maria Edgeworth presents a contented family driven to destitution because of the old aunt's insistence that they play the lottery. [106] The family wins the lottery but eventually loses everything, because the father of the family refuses to work once he has tasted "easy money."

A salient aspect of gambling centers on the excitement it generates. The gambler is totally absorbed in the process and can spend untold hours of pleasure and excitement in this endeavor. Many argued that pleasure should only be for a short time and the bulk of one's life should be devoted to work. In England this devotion to the work ethic precluded allotting excessive amounts of time outside work and social obligations.

The scientist of the eighteenth century created hypotheses based on the assumption of a rational, nonchaotic world. The scientist looked at an ordered world with predictable events. These hypotheses cannot hold if one returns to a cognitive world-map in which chance and luck explain natural events. Gambling and luck, or the belief in fate, undermine both the world of science and the world of industry where there is expected to be a clear causal relationship between hard work and material success. Dependency on an external locus of control is anathema to a society attempting to develop a class of entrepreneurs and mechanical specialists. It is not accidental that children's books rail against gambling. It is the one vice that is inconsistent with material

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[106]Maria Edgeworth, "The Lottery," *Edgeworth's Popular Tales* (London: George Routledge and Sons, [c. 1866]).

success based on hard work. William Hogarth graphically illustrates the horrors of gambling as he depicts the downfall of the Rake as he sits at the gambling table at White's Chocolate House signing away his fortune to cover his debts. In the final scene, the Rake has even gambled away his sanity.[107]

In summary, it can be seen that *Philosophy of Tops and Balls* gave an additional impetus to the spread of Newtonianism. Using mostly demonstrations and descriptions, the work introduced the child to the various elements of science, an understandings of matter and motion, and an appreciation of basic scientific principles. At the same time, children are induced to look at the way science is modifying the larger society. The desire for sensitivity to all sensate life spills over into concern for one's fellow man whether he is starving at the gate, crushed in the mines, or languishing in the Black Hole of Calcutta. The demands of a society based on industry mean that one must avoid the lure of luck and fate and take control of one's life. In addition to this social agenda, *The Newtonian System* also encouraged the child to observe the world in a precise and orderly manner. Such were the lessons that Newton, Locke and Newbery left as their legacy to the young eighteenth-century children curious about science.

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[107]Platé IV from *The Complete Works of William Hogarth in a series of One Hundred and Fifty Steel Engravings* (London: The London Printing and Publishing Company, n.d.) 98.

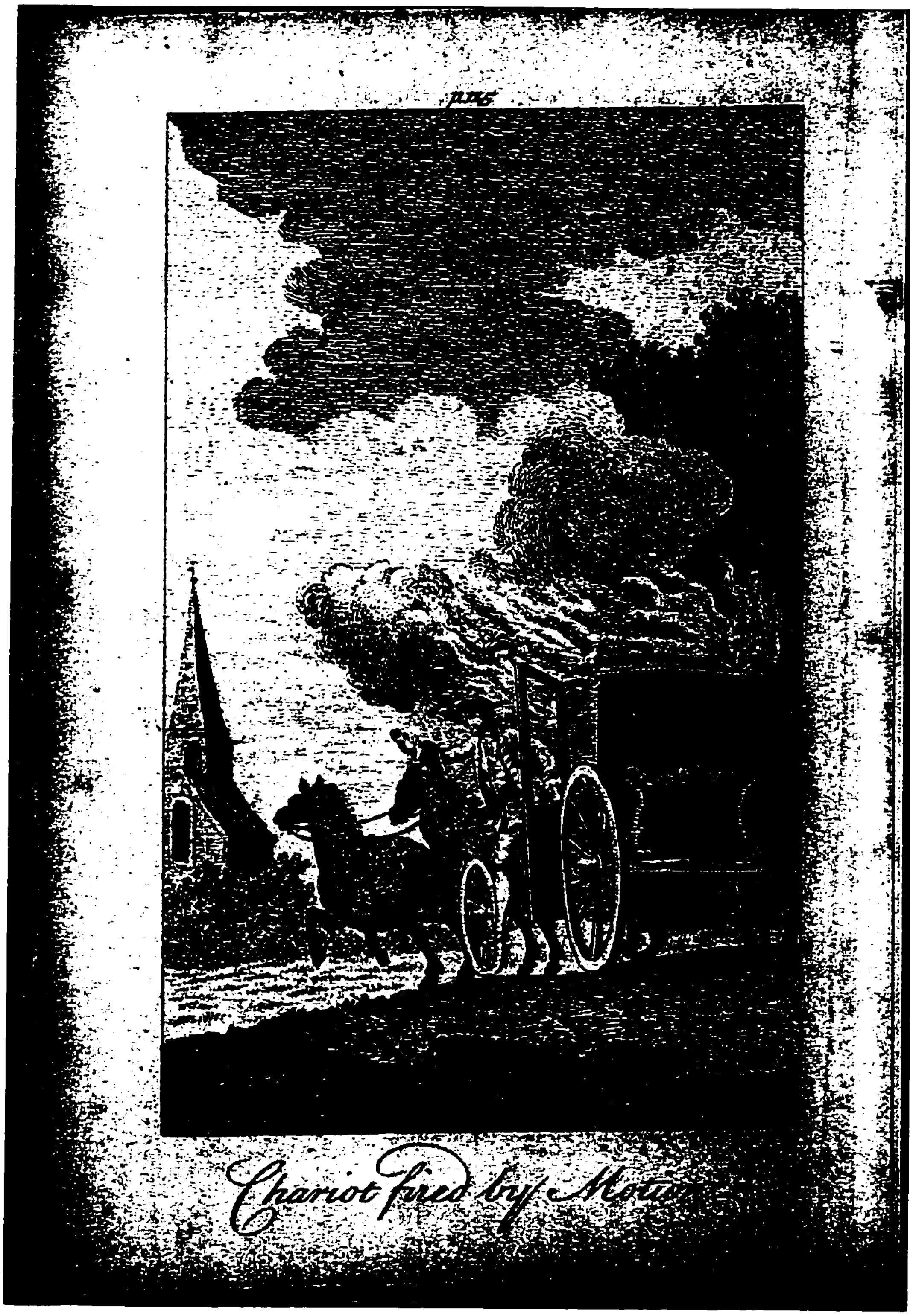

Figure II

Chapter 3

Ferguson and *The Young Gentleman and Lady's Astronomy*

Early in 1767, Anne Emblyn, a pretty and personable adolescent, arrived at No. 4 Bolt Court in London, the residence of an itinerant lecturer, James Ferguson. She requested to be instructed in the wonders of astronomy. Several events may have stimulated Anne's interest in astronomy. The eighteenth-century quest for a reliable means of determining longitude had involved scientific competition and political conflict.[1] The return of Halley's Comet had brought both fear and fascination.[2] The recent mapping of the transit of Venus had offered an additional way to measure the distances of other planets from the sun and earth. In addition, Anne, a frequent visitor to court, would have been aware of King George III's interest in astronomy and may have

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[1]Dava Sobel, *Longitude, the True Story of the Lone Genius Who Solved the Greatest Scientific Problem of His Time* (New York: Penguin Books, 1995) presents a popular account of this political conflict and its resolution. For a more erudite discussion of the same problem, see William Andrewes, *The Quest for Longitude: the proceedings of the Longitude Symposium, Harvard University, Cambridge Massachusetts, November 4-6, 1993* (Cambridge: Harvard University Press, 1996).

[2]Donald K. Yeomans, *Comets: A Chronological History of Observation, Science, Myth and Folklore* (New York: John Wiley and Sons), chapters 6 and 7.

visited the royal observatory. Against such a background, it is understandable that Anne sought out an instructor who was able and willing to tailor the material of astronomy to the mind of a youngster. The notes produced by James Ferguson for her were rewritten as *The Young Gentleman and Lady's Astronomy*.[3]

Anne's selection of a tutor suggests that James Ferguson (1710-1776), a Scottish philosopher, portrait painter, lecturer, instrument maker and author, was already known for his ability to explain science in a clear and concise manner. He had made several contributions to the popularization of science, including his insistence that prediction was the end product of science. He also linked his love of astronomy with his belief in life on other planets. However, it is the clarity with which he presents astronomy for children that makes his work unique.

The son of a poor Scottish farmer, Ferguson eventually became one of the key players in the popularization of science in England in the middle of the eighteenth century. As a boy watching his father lift the roof of their cottage with the help of a lever, he became intrigued with mechanical devices. Later, sent to work as a shepherd, Ferguson studied the heavens and began to devise mechanisms to explain the movement of the planets. Although he only attended three months of formal schooling, he was extremely well read. Reportedly, he learned most of his mathematics from a butler,

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[3]James Ferguson, *The Young Gentleman and Lady's Astronomy Familarily explained in Ten Dialogues between Neander and Eudosia* (London: printed for A. Millar and T. Cadill in the Strand, 1768).

Alexander Cantley[4], under whom he served in his youth. Ferguson tried his hand at a variety of trades, including portrait painting and needlepoint design.

In 1743 he arrived in London with his young wife. Over time his marital relationship deteriorated. In fact, his family life was as dismal as his scientific endeavors were brilliant. One of the strangest stories about Ferguson has to do with his eighteen-year-old daughter, Agnes. As they walked along the strand, he was so engrossed in contemplating a scientific problem that he did not notice when she disappeared from his side. He never saw her again. The mystery of her disappearance includes reports of her abduction by an Italian count, a career on stage and, finally, a miserable death in a London garret. The story is based on the evidence of a doctor who treated a woman who claimed to be Agnes Ferguson and who left a short history of her life, scribbled on the flyleaf of a book still found in the British Library.[5]

His wife was most famous for streaking into one of his lectures, screaming at the top of her lungs, and destroying all the equipment that he had laid out for his demonstration. His only remark was, "Ladies and gentlemen, I have the misfortune to be married to this woman." John Millburn quotes an ad circulated on 25 January 1773:

> Whereas Isabelle my Wife and I are parted by mutual consent, and I have agreed to allow her what is amply sufficient (according to my Situation

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[4]In his autobiography, Ferguson describes Cantley as a self-taught individual who knew Greek, Latin, French, all levels of mathematics and who also had a grasp of philosophy and science. James Ferguson, "A Short Account of the Life of Ferguson Written by Himself," *Autobiography 6* (London, 1826).

[5]There are several versions of this tale; see Ebenezer Henderson, *Life of James Ferguson, F.R.S. in a brief Autobiographical Account and further Extended Memoir.* (London, 1867), 284-285.

> and Circumstance) for her separate Maintenance, as appears by written Articles legally drawn up, and signed by both her and me: This is to caution all Persons whatever from trusting her on my Account, for I will pay no Debt or Debts that she shall contract after the date hereof.[6]

She died eight months later in September 1773. His only child at home was the fourteen-year-old son, John who also died in early adulthood.

Having arrived in London under the protection of Sir Stephen Poyntz, Ferguson earned his living painting miniature portraits. Even though this was his basic source of income for about twenty years, his first love was science. He had the rare talent of being able to produce exact models of any machine that was explained to him, including a watch with a wooden mechanism.[7] This ability to solve a problem by creating a mechanical model enabled him to construct numerous pieces of scientific equipment. In 1755 the globe plates and tools of the late John Senex came on the market. Ferguson purchased them and set up shop as a globe maker. As a skilled designer and artist, he was ideally suited to enter into the scientific equipment business. He manufactured and sold a wide variety of scientific instruments[8] and pocket gadgets.

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[6]John R. Millburn, "The London Evening Courses of Benjamin Martin and James Ferguson, Eighteenth-Century Lecturers on Experimental Philosophy," *Annals of Science* 40 (1983), 450.

[7]The wooden mechanism for a clock had been perfected by John Harrison in 1713. Sobel, *Longitude*, 64.

[8]Ferguson also created optical cards that he felt would be useful for teaching children about optics. Anthony Turner, *Early Scientific Instruments* (London: Sotheby's Publications, 1987), 200, contains pictures of Fergusons's pocket celestial and terrestrial globe, made after 1748.

According to Anthony Turner, a scholar studying early instruments, the cabinets of philosophical instruments gradually became a part of both academic and bourgeois settings, not just the purview of the aristocracy.[9] The availability of such instruments and the fact that instrument making became a lucrative trade, attest to the genius of the instrument makers, but it also suggests a new shift in middle-class priorities in England.[10] The emerging middle class began to emulate the aristocrats in the acquisition of scientific equipment just as they sought other information about the new philosophy. The demand for scientific equipment provided a major source of income for itinerant lecturers who were also instrument makers. People attending public lectures, money permitting, could collect their scientific gadgets. Microscopes and telescopes were common instruments in many homes. King George III aspired to own one of each demonstration model and scientific apparatus produced in Europe.[11]

Two of the models made by Ferguson are part of the King George Collection. Ferguson's list of scientific equipment includes small models of working cranes, a compound engine, a pyrometer, a double cone that seemingly rolls uphill by itself while it

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[9]Ibid., 199.

[10]M. A. Crawforth, "Evidence From Trade Cards for the Scientific Instrument Industry," *Annals of Science* 42 (1985): 453-554.

[11] George III was particularly interested in astronomy. He had his own observatory. William Herschel had came to England to study music and to pursue astronomy. He was ordered by George III to bring his telescope to Windsor, where the king was studying astronomy. Later, Herschel was commissioned to build an enormous telescope for the king, who in return, gave Herschel a pension of £200 a year. Thus it is not surprising that Herschel and his sister, Caroline, named the planet they discovered, "The Georgian Planet." John Brooke, *King George III* (London: Constable, 1973), 302-305. His collection is now stored in London at The Science Museum.

is actually descending, a model of a handmill for grinding corn, machines for demonstrating the hydrostatical paradox, a wind-gun and seven types of sun dials. In addition he also produced small orreries, a tidal dial and a "whirling table" for demonstrating the action of central forces, numerous agronomical clocks and stellar and lunar rotulas.

In 1744 Ferguson convinced Martin Folkes, president of the Royal Society, to allow him to demonstrate an instrument that he had devised for plotting the true path of the moon in space. This instrument was used to demonstrate the mathematical rule by which the moon outlined a concave path in relation to the sun. Ferguson was not discouraged to find that the watchmaker John Ellicott had devised a similar instrument twenty years earlier. Rather, the two men joined forces and worked to create additional scientific devices that were later incorporated into Ferguson's lectures.

In 1746 Ferguson again appeared before the Royal Society to demonstrate his orrery, an accurate model of the solar system. From 1746 to 1763 he made several additional appearances before the Royal Society.[12] Despite these frequent appearances before this learned body, it took almost twenty years for him to gain acceptance as a fellow. It was a matter of great humiliation to him that he was rejected for a clerkship in the Royal Society. But he persisted, and in 1763 (some feel out of pity), he was entered

[12] DNB, CD ROM (Oxford University Press, 1995) identifies the eclipsareon as an instrument showing the time, duration, and quantity of solar eclipses in all parts of the earth. Ferguson described it before the Royal Society on 21 Feb. 1754; a new hygrometer was presented on 8 Nov. 1764, and his universal dialing cylinder was unveiled before the society on 2 July 1767.

on the books as a Fellow of the Royal Society. His fees were waved and he was at last part of the inner circle, at least on paper.

The Royal Society was an important resource for this driven, ambitious and inexperienced genius. Almost everyone Ferguson mentions in his writings was also a member of the Royal Society. He read their work in *The Philosophical Transactions*, listened to their lectures, and incorporated many of their ideas into his own lectures. From 1743 on, he acquired additional instruments for demonstration, and by 1749 he was making a living traveling from town to town, giving demonstrations of the new science. In his lifetime, he was referred to as "the Peasant Philosopher"; however, no biographer has explained how a self-educated shepherd became a major lecturer on natural philosophy and a recognized expert on astronomy. Certainly one reason for this accomplishment, in addition to the lectures he heard at the Royal Society, could have been the ever-present public lectures. Desaguliers[13] had begun the tradition of delivering learned lectures to general audiences. Several public lecturers had already made a name for themselves by the time Ferguson arrived in London.

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[13] Lectures by Desaguliers, given at his London house, were widely attended and were made attractive by demonstrations. About 1730 his lectures in Holland interested men like Boerhaave. In February 1741-2, he received the Copley gold medal from the Royal Society in recognition of his successful experiments. Desaguliers tied his public performances to the wants and needs of the Royal Society. He ultimately served as a scientific ambassador to Europe. By all accounts, Desaguliers was more than a lecturer; he was also a poet, the person picked to espouse Newton in the face of the threat of Liebniz's entering England. The popularizer of Newton's crucial prism experiments, he incorporated them into his lectures, stressing the methodology of science. Paul Langford, *A Polite and Commercial People, England 1727-1783* (New York: Oxford University Press, 1989), 11. Larry Stewart, *The Rise of Public Science* (New York: Cambridge University Press, 1992),119-133..

Having profited by Desaguliers' writings and lectures, Ferguson entered the lecture circuit early in 1747. He advertised his lectures whenever and however he could. Included in the back of his texts are a series of announcements about his lectures. Near London, a group of no fewer than thirty could hear his lecture for one guinea. Farther outside London, Ferguson had to be assured of an audience of at least fifty people. He was able to draw sufficiently large crowds, as is evidenced by the fact that he traveled to the "hinterlands" several days a month.[14] Instrument makers and itinerant lecturers also had another agenda. It was their place, originally outlined by Desaguliers, to prevent the new science from being used by charlatans and cheats. Many schemes for perpetual-motion machines and unrealistic labor-saving devices had already appeared: bogus contrivances guaranteed to reduce the cost of labor threatened to turn would-be industrialists against the scientific endeavor.[15] To instruct a gullible society in the principles of science, to give guidelines as to the "art of the doable" and to teach basic ideas upon which sound judgments could be made became the ideal of the science lecturer. In a sense, the lecturer saw his job as predicting what machinery was realistic to devise and what designs could not work. Ferguson's aim was to teach what he termed "dabblers and tinkers" the astronomy and physics of Newtonian science.

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[14]John R. Millburn, "The London Evening Courses of Benjamin Martin and James Ferguson, Eighteenth-Century Lecturers on Experimental Philosophy" *Annals of Science* 40 (1983): 445-448.

[15]Alan Q. Morton, "Concepts of Power: Natural Philosophy and the Uses of Machines in mid-eighteenth-century London," *British Journal of the History of Science* 28 (1995): 63-78, 65.

At the end of his life, when he listed other individuals involved in public lecture series, he named "Dr. John Keill, Mr. Hauksbee, Dr. Desaguliers, Mr. Whiston, Mr. Cotes, Mr. Whiteside, Dr. Bradley, and Dr. Bliss."[16] The omission of Benjamin Martin's name is reflective of their fierce rivalry. Their lectures were practically interchangeable as far as the scientific content was concerned. Martin used more poetry and classical references, while Ferguson was more likely to include religious sentiment.[17] Their advertisements often appeared side by side. More frequently, Martin would pay for a large announcement, and Ferguson would place a smaller ad directly underneath it, indicating that the same material was available at Ferguson's address.

Ferguson's initial success in the provincial towns encouraged him to become a regular on the London lecture circuit. The clearer one's demonstrations and explanations, the more likely one's audiences would return. Several authorities comment on Ferguson's ability to make complex issues remarkably clear without recourse to

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[16]James Ferguson, *Lectures on Select Subjects in Mechanics, Hydraulics, Hydrostatics, Pneumatics and Optics with The Use of Globes, The Art of Drawing and the Calculations of the Mean Times of New and Full Moons and Eclipses* (London: 1976, Fifth edition), Preface.

[17]Aileen Douglas, "Popular Science and the Representation of Women: Fontenelle and after,"*Eighteenth-Century Life,* 18 (May 1994),7.

mathematical concepts.[18] Not only were his lectures well attended, but there also seemed to be a healthy market for all his various texts and handbooks.

His first major work, *Astronomy Explained upon Sir Isaac Newton's Principles,* was published by subscription and was quite well received. When the second edition appeared the following year, he decided that it was time to abandon the globe-making business and turn to writing and lecturing to support himself. His second major work, *Lectures on Select Subjects in Mechanics,* established him as a writer of popular science. Each of these works went through more than twenty editions. When he entered the field of children's literature, he was equally successful. Mme. de Genlis, author of *Adalaide and Thomas,* said of his *Astronomy made easy,* ". . . even a ten year old can understand it."[19]

The Art of drawing in Perspective made easy for those who have no previous knowledge of Mathematics grew out of his own ability to draft remarkable diagrams. In his lectures on astronomy, he often used such diagrams to illustrate points of mechanics and to make clear various activities of heavenly bodies. He possessed a peculiar kind of intelligence that made formal mathematics difficult for him but which enabled him to produce a model of any machine that could be verbally explained to him. The list of his

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[18]Dr. Houston of Liverpool called Mr. Ferguson the "head of Astronomy and mechanics in this nation of philosophers;" Sir David Brewster regarded him as the first elementary writer on Natural Philosophy; and Capel Lofft regarded him as "heaven-sent and heaven-taught." All quoted in the appendix of E. Henderson, LL.D., ed., *Life of James Ferguson, F.R.S. in a brief autobiographical account and further extended memoir* (London: A Fullerton & Co., 1867), 462-464.

[19]DNB, CD-Rom: Ferguson, James.

various works and their multiple editions runs to some twenty-seven pages in Millburn's bibliography.[20]

The New York Public Library[21] owns a collection of Ferguson's work. It contains several of his drawings, some of his tables and his pocket calculator for the tides on the Thames. There is also evidence of his own caustic temper.[22] The same collection also contains an explanation of the tides, the arithmetic triangle, a probabilities table and some exquisite drawings. There is a pocket toy that consists of a series of movable circles serving as the Tide Dial for London Bridges — the movable parts still function. Much of his writing remains, although a great number of the scientific instruments are only known from descriptions. Ferguson began to publish his lectures so that he could increase his revenues and attract more people to his lectures. But although he became famous, he remained poor.

James Ferguson represents a unique example of scientific intuition. As an instrument maker, a lecturer and a tutor, he used his remarkable talents to illustrate the

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[20] John R. Millburn, *A Bibliography of James Ferguson, F.R.S. (1710-1776) Astronomical and Philosophical Lecturer* (Aylesbury, Bucks: John M. Millbury, 1983).

[21] New York Public Library, Manuscripts and Archives Section: *James Ferguson's (1710-1776) Papers.* The material in this collection was assembled by the bookseller and printer, Richard Cameron, in 1868.

[22] "Letter to Mr. Kennedy, September 7, 1775." Cameron Collection. There seems to have been a series of letters exchanged between Ferguson and the Reverend Mr. Kennedy. Ferguson was trying to correct the scientific errors in Kennedy's sermons. In this letter Ferguson points out, yet again, the mistakes in a theological dispute. Finally, in disgust, he declares: "Remember that I shall *not* answer any written letters of yours after this date - it is neither worth my while nor have I time to throw away to so little purpose. . . . " He signed the letter, "Your well wisher though *not* your humble servant."

basic tenets of the rational mechanics. *The Young Gentleman and Lady's Astronomy* (1768) enabled him to profit from the newly burgeoning book market for juveniles.[23] The friendship with Anne Emblyn, for whom it was written, lasted all his life. Ferguson apparently had a better relationship with Anne than with most of his own family. According to Anne's daughter,

> Anne went as a pupil to study astronomy under Mr. Ferguson, Bold Court, Fleet Street, London when she was young in her teens, about 1767 and often stayed with him. She was then in all her youth and beauty, and George III used to call her the Flower of Windsor. Her ardent taste for astronomy astounded her younger sister and parents.[24]

Anne's daughter remembered her mother talking about Ferguson, who had given her many of his instruments and his tables. By the time Henderson attempted to locate this material in the late nineteenth century, the Emblyn family had lost or destroyed most of the instruments and had little useful information.[25]

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[23] Millburn has listed 17 English editions of *The Young gentlemen and Lady' s Astronomy Familiarly explained in ten dialogues*. This title was changed to *An Easy Introduction to Astronomy for young gentlemen and ladies* after the first London edition, for all issues except the Eighth London edition, 1815. It retained the original name in the Irish editions. This name change was probably made in order to avoid confusion with Benjamin Martin's *Philosophy for young Gentlemen and Ladies.* In addition to the eight editions in England, there followed the Brewster edition in 1823. In the meantime, there were seven editions in Ireland, five in America (all based on the 7th edition in London) and three translations: one in French in 1827, one in German in 1771, and one in Bengali in 1833.

[24] Ebenezer Henderson, *Life of Ferguson, F.R.S. in a brief Autobiographical Account and further Extended Memoir* (London, 1867), 284-285.

[25] Ibid., 13.

Ferguson wrote *Astronomy* in 1768. If Anne was born in 1753, she could not have been more than twelve or thirteen when she was under Ferguson's tutelage. When published, the book was a series of dialogues between Eudosia and Neander. In *Astronomy* the young girl worries that she will not remember all that she has been taught. Her teacher assures her that he intends to publish these conversations so that many can learn. "If you do, Sir, I must insist upon your not mentioning my name." Her teacher responds, "Your desire will be complied with: And in concealing your real name, I shall also conceal my own."[26] In later years, Anne's husband decided that he should identify Eudosia. In 1781 her husband, Capel Lofft, made sure the world would know that Anne Emblin and Eudosia were one and the same. He published the poem "Eudosia" and dedicated it to his wife. This poem lauds Ferguson as the greatest of the astronomers and ranks him with the likes of Isaac Newton and Robert Boyle. It also presents an overview, in elaborate rhyme, of most of the key ideas in natural philosophy.

Ferguson had elected to use a series of dialogues much in the same tradition as Algarotti and Fontenelle. Theirs were full of wit and charm; they took place in a garden, near a fountain, or in a parlor. Their scenes come alive for the reader. Not so with Ferguson. Whereas Algarotti presents a series of dialogues between a young man and his aristocratic lady, Ferguson's protagonists are a young girl and her brother. Ferguson may have chosen the brother-sister dyad rather than a romantic couple to underscore the importance of education within the family, a common theme at this period. It is the same

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[26]Ferguson, *Astronomy,* 56.

format that Benjamin Martin[27] used earlier with some success. Such an approach may also represent national differences. The French and Italian writers serve up science in a romantic interlude; the English bury it in advertisements and self-promoting dialogues.[28] In Ferguson's work, there are no descriptions of beautiful gardens or starry nights but, rather, stilted conversations featuring the brother as teacher and the sister as a devoted student. Eudosia is presented as a novice in the study of astronomy, but she appears to grasp major scientific principles rapidly. Ferguson uses the format of Algarotti and Fontenelle, but his goal is different. He does not intend to entertain or tease people into an acceptance of a new viewpoint. For him, the beauty of astronomy is compelling enough.

Neander and Eudosia live comfortably. The daughter spends a great amount of time as the guest of the Goodals, obviously a family in similar economic circumstances. This selection of a family in an unspecified social position serves to widen the appeal of the book. Both the emerging middle-class reader and the more genteel clientele could relate to it.

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[27]Benjamin Martin, "*General Magazine of the Arts and Sciences*," Six Parts, including *The Young Man's and Lady's Philosophy in a continued Survey of the Works of Nature and Art: by way of Dialogue. Illustrated with Copper Plates by Benjamin Martin* (London: Printed and sold by W. Owen, near Temple-Bar, and by the author, at his house, in Fleet Street, 1763).

[28]Aileen Douglas, "Popular Science," argues that the non-romantic nature of these dialogues used by both Benjamin Martin and James Ferguson indicates the English concern with the market economy. She writes, "Flirtation was replaced by advertisements." She argues that this is further proof that the popularization of science in England was directly related to the birth of the consumer society.

One of the problems immediately addressed is the issue of women and science. This was a key issue in the popularization of science in the eighteenth century. Were women to be spectators or participants? Eudosia's role establishes the eighteenth century's expectation of women and science. In the opening chapter Eudosia is hesitant to ask for her brother's tutoring.

> What I want to learn of you cannot be done, I believe without taking up a great deal of your time; and perhaps you may think me too vain, in wanting to know what the bulk of mankind thinks our sex have no business with.[29]

After Neander reassures her that he will be delighted to teach her astronomy, she is only slightly mollified: ". . . but shall I not be laughed at for attempting to learn what men say is fit only for *men* to know?" Her brother informs her that it would be better if women learned science rather than filling their heads with gossip and spending time in useless endeavors.

Changing economic times redefined women as well as children. But there seemed to be confusion as to the exact role women were to play. Roy Porter, a social historian, argues that as mothering and domesticity came into vogue, the cult of family created a new place, some might say prison, for women. "Women became ornamental, flirtatious, delicate and helpless."[30] Eudosia is aware that women must know their

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[29] All quotations are from first edition in the Morgan Library. Ferguson, James F.R.S. *The Young Gentleman and Lady's Astronomy Familarily explained in Ten Dialogues between Neander and Eudosia* (London: printed for A. Millar and T. Cadill in the Strand, 1768), 2.

[30] Roy Porter, *English Society*, 30.

position. She worries that a knowledge of science would detract from her role as a woman.[31]

Both brother and sister talk about their place in the intellectual milieu. He has completed his education at Cambridge and is about to depart on the Grand Tour. The normal pattern of the period was for the young man to have a series of tutors and then travel in Europe. The universities of this period were reportedly in a rather dismal state. According to Porter, many liberal families mistrusted the universities and "its diet of birch, boorishness, buggery and the bottle."[32] The universities mainly prepared young men for the Church. Neander claims that he is well versed in astronomy because of the lectures he attended at the university. He, of course, credits one particular professor at Cambridge. He makes a very strong point that he learned both science and the Christian religion, as "proved in the lectures which I have constantly attended."[33] Given the curriculum of the universities of the period, this declaration sets him apart from the typical student who tended not to learn much science at the university and rarely bothered attending lectures.[34]

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[31]Peggy Aldrich Kidwell, in "Women Astronomers in Britain, 1780-1930" *ISIS* 75 (1984):534-546, argues that twenty years later women were able to make it in the world of astronomy, the most famous being Caroline Herschel and Mary Somerville.

[32]Porter, *English Society,* 163.

[33]Ferguson, *Astronomy,* 2.

[34]Elizabeth Leedham-Green, *History of Cambridge* (New York: Cambridge University Press, 1996), 111-114, argues against the prevailing view that little education was taking place at Cambridge at this time. She insists that educational choices were present even though tutors might not have encouraged their students to attend lectures that were not immediately applicable for certain academic disciplines.

Theological issues are addressed early in the *Astronomy*.[35] Is the idea of the movement of the earth consistent with Biblical view of the world? With great patience, the young man expresses arguments, similar to those Galileo had earlier given to the Grand Duchess in the seventeenth century.[36] Neander, in his defense of science, suggests that the Bible must be read with a different understanding. "You know that we can not take everything in the literal sense. If we did, we should believe that Our Savior was actually a vine at one time, a door at another, and at a third time a lamb." [37]

To consider whether the sun or the earth moves, Neander uses the example of a bird being roasted over the spit. The bird is easier to rotate than the spit; therefore, the sun must stand still and the earth must move, it being the smaller body. In this deliberation, the proof depends on the axiom that God would not offer an unreasonable solution to a practical problem. Therefore, for the protagonists, it would be blasphemy to assume that the earth stands still and the sun moves. The religious belief is more compelling than scientific reasoning.

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[35]Brewster's Preface to his edition of *Ferguson's Lectures on Select Subjects* as reprinted in Henderson's Biography of Ferguson, 463. Brewster, in his discussion of Ferguson, makes the point that religious sentiment was always an ingredient in his public lectures, so it is only slightly surprising to find this text liberally sprinkled with such references.

[36]Galileo Galilei, *Discoveries and Opinions of Galileo: Including the Starry Messenger (1610 Letter to the Grand Duchess Christina),* Stillman Drake, trans. (New York: Anchor, 1957)

[37] Ferguson, *Astronomy,* 4.

The brother and sister discuss the possibility of the destruction of the world by a comet.[38] At this point, Neander consoles his sister. The world cannot end, he says, because everyone has not been converted to Christianity. He posits the following "truth" as though it were common knowledge:

> You know the world must be converted to Christianity before it be burned; which we can hardly believe will be within the time that you and I live, according to the course of nature.[39]

This religious pursuit of the end of the world comes not only from the preoccupation with comets but also with concern about alien cultures. Many writers in the eighteenth century linked aliens from outer space and the alien savages in the New World. There were theological problems as to the status of both the alien and the *savage*.[40] Is it possible for these aliens to have been saved by Christ's redemption? If not, there is now a new impediment to the Second Coming of Christ.[41] Eudosia believes

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[38]Comets were quite frequent in the eighteenth century. As indicated earlier, this resulted in a general fear of comets hitting the earth and doing great damage. Yeomans, *Comets*, chapter 7.

[39]Ferguson, *Astronomy*, 51.

[40] In "Outer Space and the New World Imagination of Eighteenth-Century Europeans," *Eighteenth-Century Life* 19 (February 1995):70-83, John Adams refers to a novel by Ralph Morris entitled *A Narrative of the Life and Astonishing Adventures of John Daniel* (1751), which represented moon people as the cliff dwellers of the deserts of New Spain.

[41]Luther had worried that the Jews and their lack of conversion would delay the Second Coming. For the eighteenth-century millenarians, the aliens from both worlds were problematic. John W. Wilks, "The Transformation of Dissent: A Review of the change from the Seventeenth to the Eighteenth Century" in Michael Moody and Robert Cole, eds., *The Dissenting Tradition* (Athens, Oh: Ohio University Press, 1975), 108-122.

that all should be converted. Ferguson seems to be echoing some of the concerns of the dissenting sects.

Eudosia sees a link between this millennial prophecy and certain current events.[42] She is moved by the plight of the American Indians. She speculates that the English are not doing much to convert the Indians, since they treat them so terribly. Lamenting the injustices perpetuated on the American Indian by "supposed" Christians, she assumes the Indians will never change. Because of the barbarian-like atrocities visited upon the Indians, there is no likelihood they will convert to the Christian religion. It seem unlikely that the whole world will ever be converted to Christianity. In fact, she is not at all surprised to hear that the Indians often rise up and attack these "so-called Christians." Neander then remarks that the Indians return "good for good and evil for evil" since they have a natural sense of morality. This question of morality and its source ends with a condemnation of atheism:

> Tis said there are atheists; but they must all be stupid fools — The Almighty has laid the great book of nature open to our view; so that, every one that runs may read . . . .[43]

Eudosia goes on to conclude that, even if matter is eternal, it would still be impossible for it to assemble itself into the series of logs, beams and stones needed to build a house. How, she demands, could something as complicated as the solar system

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[42]Eudosia seems to link the salvation of the world, the plight of the Indians and inhabitants of other worlds together. Adams, in "Outer space and the New World," argues that the aliens of other planets and the newly discovered populations, especially in the Americas, were all lumped together and became part of a greater theological discussion of salvation.

[43]Ferguson, *Astronomy*, 59.

come into play without a guiding intellect? She again reiterates the unreasonableness of an atheistic stance.

Once the questions of gender roles and religious conflict have been put to rest, the course in astronomy commences. The chapters are concerned with the motion and dimensions of the earth, the balance of nature and the solar system, the nature of gravity and light, the transit of Venus, the moon's motion around the earth and the sun and the nature of eclipses. These topics are followed by discussions of the ebb and flow of the sea, and the nature of the fixed stars. Ferguson outlines solar and sydereal time and explains the projection of solar eclipses. The book concludes with a chapter concerned with "Answers to some astronomical Questions." Chapters four and five are devoted to the key astronomical issues of the mid-eighteenth century: the measuring of the transit of Venus and the search for an accurate means of determining longitude. The dialogues between the two young people eventually cover all these topics.

Having established that a consideration of astronomy is in no way detrimental to religious belief, Eudosia demands to know how it can be ascertained that the world revolves and not the sun. In just a few short pages the basic idea of Newtonian inertia is laid out. Ferguson uses the analogy of a river trip. A person is traveling by boat. When the boat stops, the traveler continues forward. The idea is quickly grasped by Eudosia. She remembers her experience when she stood up before the boat docked and was knocked over:

> I once had the experience thereof; and very painful it was. For, crossing our river in the boat, I stood up when it was half way over; and as its motion was uniform by the men pulling the rope, I was quite insensible both of its motion and

> my own. But when it stopt suddenly against the bank of the river, I fell forward on my knees . . . [44]

She elaborates on the fact that had she persevered in the motion given by the boat, she would not have fallen and scraped her knees.

After Ferguson has explained the notion of force and gravity, he turns his attention to the standard questions posed by a moving earth: why ships do not fall off the surface, why we do not feel ourselves standing upside down on the surface of the earth, and how birds are able to fly. There follows an exposition of the force of attraction. In the explanation of day and night, Neander describes the natural process as, " a turning that still leaves all people standing upright even though the earth has turned halfway around."[45] A further discussion of the movement of a ship illustrates the inability to detect whether the ship is moving from the land or the land is moving from the ship. Neander uses the example of a ball tossed back and forth between two ships to demonstrate that while on the ship the ball appears to be going in a straight line, to a person on the shore the ball appears to veer to one side. Ferguson used both verbal examples and scientific instruments for demonstration purposes in his lectures, and he did not significantly change his tutorial approach for his young pupil. He combined verbal descriptions with graphic illustrations to ensure the understanding of basic physics.

Chapter two presents an extensive discussion of the characteristics of gravity and the way in which the sun and the planets are held in place in the solar system. True to his

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[44]Ibid., 16.

[45]Ibid., 18.

promise, Ferguson has not yet introduced any mathematical concepts into the discussion. He does, however, introduce the concepts of centrifugal force and attractive force, using the pebble in a sling as an appropriate example. Having made the observation about force, the brother produces diagrams to expedite his explanation of forces and orbits.[46] This deliberation leads to a discussion of the length of a year for each planet.

Many books written for juveniles include a list of facts that are considered imperative for the child to know. One chart that is frequently presented is the distances between the sun and the earth or between the sun and the other planets. Charts like this are listed in *Telescope Tom,* and in Martin's *Philosophy for Young Ladies and Gentlemen,*[47] as well as in Daniel Fenning's *Young Man's Book of Knowledge.*[48] In the case of Ferguson, of course, the discussion of the various distances was an important way of introducing the tracking of the transit of Venus on June 6, 1761.

> The method of finding these distances by the transit is purely geometrical; which, as you have not yet learned anything of geometry, I cannot at present make you understand.[49]

One of the great scientific endeavors of the eighteenth-century was the observation of the transit of Venus, from which an *accurate* measure of the distance from

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[46]Ibid., 38-40.

[47]Martin, *General Magazine of the Arts and Sciences.*

[48]Daniel Fenning, *The Young man's book of Knowledge: being a proper supplement to the Young man's companion* (London: Printed for S. Crowder, in Pater Noster Row, and B Collins in Salisbury, 1764).

[49]Ferguson, *Astronomy*, 47.

the Earth to the Sun might be obtained, and, consequently, the proposed scale of the whole solar system.[50]

The fourth dialogue is devoted completely to a discussion of the transit of Venus. It was a matter of great personal pride to Ferguson that he stood atop the British Museum as one of the crew of scientists measuring the transit of Venus. In 1679 this event had been identified by Edmond Halley as a means of measuring the earth's distance to the sun.

In *Astronomy* Neander and Eudosia study Plate III, which explains the infrequency of the transit of Venus. In having them discuss this diagram, Ferguson uses their dialogue to express his disappointment in the quality of the measurements.[51] Several sites had been selected to measure the transit of Venus. Observations had been gained from such diverse points as Stockholm, Torneo in Lapland, Paris, Tobolsk in Siberia, Bologna, Calcutta, and the Cape of Good Hope.

> Eudosia: Did you find, that all the observations (as you got accounts of them) agreed with one another; as to give all the same conclusion?
>
> Neander: I cannot say they did, so nearly as we could wish: which might have been owing to two causes. First that the differences of longitude (as it is called) between many places where those observations were made, are not yet well ascertained: and secondly, that all the observers did not use telescopes of an equal

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[50]John L. McKnight, review of "Scientists and Instrument Makers of the eighteenth Century: The Organization of a Profession," *Eighteenth-Century Life* 14(2) 1990: 108-115.

[51]Ferguson, 100. The Royal Society had underwritten several expeditions to be sure that the exact information could be obtained.

> magnifying power, which they should have agreed upon before hand. [52]

The measurements taken in 1761 enabled scientists to compute the size of the planets and their distances from the sun: Mercury's distance from the sun was 36,841,468 English miles, Venus was 68,891,486 miles, Earth was 95,173,00 miles, and so forth. These measurements were quickly incorporated into scientific texts. More importantly, it was hoped that these measurements might contribute to better ways of determining longitude.[53]

Ferguson's *Astronomy* is a prototype of other eighteenth-century juvenile books that equate scientific enterprise with measurement. Measurement leads to precision, which, in turn, enables one to predict outcomes. Repeated measurements and predictable outcomes produce a reliable product. Neander expresses the hope that the next measurement of the transit – which, he says, will take place on the 3rd of June 1769 – will yield better data because there will be more control.[54] Since this is the last transit for the next 150, years it is easy to understand the concern of the astronomer.

Chapter five focuses on the ingenious work of John Harrison, whose clocks made it possible to calculate longitude. In 1714 the English Parliament offered a reward (equal to millions of dollars in today's currency) to the person able to establish a

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[52]Ibid.

[53]Sorbel, *Longitude,* 114-115.

[54]The transit of Venus was first recorded in 1639. Usually, two transits occur within eight years of each other; then, after a lapse of 105 years or 122 years, another two transits occur within eight years.

foolproof way of accurately measuring longitude. The success of Britain on the seas was at stake: the wealth of the nation floated on the seas. A riveting race developed among astronomers, who hoped to map the heavens and thus give a foolproof guide to sailors and instrument makers. Several instruments were created, but all required a standard timepiece to make them work. Working alone, and with no formal instruction, John Harrison produced several amazing timepieces, not the least of which was the first clock with a totally wooden mechanism. He created five different clocks, all capable of keeping time on board ship. Eventually, his clocks proved most trustworthy for establishing the measurement of longitude because they could keep time on the open seas. Due to political considerations and the determination of the astronomers that the solution would be linked to star charts and not a mechanical device, the prize was not immediately awarded to him. Only after appealing to King George III did Harrison and his sons finally receive part of the prize. Ferguson obviously sided with the watchmaker and championed his cause in his book. In fact, Ferguson expounds on "the great Mr. Harrison" in several places in the book.[55] Nevil Maskelyne, a rather aggressive individual, whose method of finding longitude by mapping the stars was more in line with the interests of astronomers, goes unmentioned.[56] In this case, then, Ferguson allied himself with the instrument maker rather than with the astronomers.[57]

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[55]Ferguson, *Astronomy,* 107, 113, 127-129.

[56]Sobel, *Longitude,* 112-116.

[57]In 1757 Harrison and Ferguson were finalists in a contest sponsored by the Society for the Encouragement of Arts, Manufacture and Commerce. A fifty-pound reward was offered for a plan to produce a mill inexpensive enough to be used by poor

Ferguson manages to present all the measurements in the book without any direct reference to geometry. Primarily because of his diagrams, he is able to make himself understood. However, Eudosia does exhibit some computational ability:

> Very Well - - And the moons's mean distance from the earth's center is 240000 miles—now I divide 240000 by 40, and the quotient is 6000; which I think must be the distance of the common center of gravity between the Earth and the Moon, from the Earth's center: and, that the said common center of gravity must always be in a right line between the centers of the Earth and Moon; because both these bodies move round it. —Am I right, brother? [58]

A machine called The Whirling Table provides a graphic image of how the planets interact. It is described as four planets placed so that the distance of the second from the sun is two times as great as the distance of the first; the distance of the third, three times as great; and the distance of the fourth, four times as great. Ferguson could use it to discuss the attraction between planets, thus avoiding mathematical calculations while demonstrating, by mechanical representation, a geometrical relationship. This is only one of the ways in which he accomplishes the goal expressed in the Preface:

> The design of the following treatise is to shew, the Young Gentlemen and Ladies may acquire a competent knowledge of Astronomy without any previous knowledge of Geometry or Mathematics. How far the Author has succeeded in this, is left to the judgment and decision of his impartial Readers: to whom, if his

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people to grind their own corn. Millers often forced the poor to exchange their good corn for an inferior or adulterated meal. Neither Ferguson nor Harrison were winners. William Andrewes, *The Quest for Longitude*, 220-221.

[58]Ferguson, 194.

> labors be agreeable and instructive, the purpose for which he wrote will be fully answered.[59]

Nevertheless, Eudosia finally masters both astronomy and its basic geometry. At the end of the book her brother promises her:

> I will send to Mr. Bennett, in Crown Court near St. Ann's Church, Soho, for a complete set of mathematical instruments; and will make a present of it, and instruct you how to use them before I leave this place.[60]

Eudosia is provided with mathematical instruments but not a telescope. Despite the fact that the telescope is associated with the study of the heavens, Ferguson makes only two references to the telescope in *Astronomy*.[61] Although one might assume that an instrument maker and an astronomer would emphasize this piece of equipment, Ferguson has only one reference to the telescope, for viewing the moons of Jupiter.[62]

The microscope is given more attention than the telescope. Ferguson makes an analogy to a drop of blood seen through a microscope and the size of a star seen in the distance. Algarotti had used a similar comparison to show a variety of infinitely complex worlds. Ferguson's discussion of the microscope reflects this same idea of complexity and why a drop of blood under a microscope looks like a mountain. Even though this particle measures less than a tenth part of an inch, it can be made to appear

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[59]Ibid., Preface.

[60]Ibid., 237.

[61]Ibid., 55, 78.

[62]Ibid., 78.

enormous by magnification In a similar manner, the solar system seems to be relatively large but even that is deceptively simple and misleading. This section might well be subtitled "Worlds within Worlds."

Other than the microscope and the telescope, only the whirling table and the quadrant are mentioned in the text. However, in the advertisements appended to the text, Ferguson promotes the astronomical rotula as well as forty-four other mechanical devices linked to his lecture series. There is no doubt the major impetus for publishing *Young Gentleman and Lady's Astronomy Familarily explained in Ten Dialogues between Neander and Eudosia* was to further advertise his lectures.

Ferguson is a good teacher. He does not just produce a picture book to teach science. He is intensely interested in astronomy and eager to pass on information. This book is much more complex than either *Newton for the Ladies* or *The Newtonian Philosophy* by Newbery. If one follows the closely reasoned text and studies the diagrams, a great amount of astronomy may be absorbed. The care taken in both the text and the copper plates indicates an interest in teaching that goes beyond just providing public exposure. His passion for the material shines through Ferguson's writings. He argues the mechanics of astronomy in a way that has neither poetry nor charm, but it does show mastery. There is no playfulness in his presentations and no shortcuts to the data. He works hard to give the student a real understanding of astronomy.

Ferguson had himself been led to the wonders of the natural philosophy through his early study of the heavens. In addition to the intrinsic elegance of the heavens, astronomy deals with a predictable system. Algarotti and Newbery had presented science that was part description and part explanation, but neither worried about the reliability of his data. Ferguson's astronomy is based on accurate outcomes. If Halley predicts the time and place of a comet, his skill as an astronomer is on the line. If one has a correct theory, then one ought to be able to predict the outcome of some future event. Such is the beauty of astronomy. If one is predicting the appearance of a comet or an ecllipse, one certainly cannot be accused of achieving it with magnets under the table, a secret compartment in the machine, or some other sleight of hand. By naming a time and place for an event, the astronomer puts his scientific knowledge up front to be judged publicly. The predictions attached to the transit of Venus, both as foretold by Halley and as he projected for the second transit in 1769, were crucial to Ferguson's work as an astronomer. The measurement of the transit makes it possible to compute other astronomical data and to predict subsequent events in the heavens. He was part of a growing group of scientists who measured the accuracy of experiments by correctness in prediction.

Ferguson's artistic talent is evidenced in the seven plates used in *Astronomy.*[63] These plates are essential to the text and remain unchanged through all the editions. The first plate shows "The World tilted on its Axis, The Meridian of London, the Equator and the North and South Poles." Plate II shows "The Rays of the Sun, The Distance that determine the size of a shadow, and The Phases of the Moon." It is Plate III that depicts

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[63]One point is crucial: the seven copper-plated diagrams that accompany the text are of primary importance in making the material understandable. Because of the expertise of Ferguson in this area, the diagrams are not only informative in terms of the presentation but they could also stand alone as works of art. The seven diagrams linked to the text have remained intact in all of the editions.

"The Transit of Venus" and demonstrates why this enables one to measure the distance to the sun. This idea is extended by using the figures in both Plates II and III. Plates IV, V and VI show the relationships between the earth and the moon, the earth and the sun, the moon and the sun.[64] Each of these diagrams is complete with elaborate angles and geometrical applications. (They seem to contradict the earlier promises that Ferguson made about not using mathematics in his explanations.) The last, Plate VII, is "A Projection of the Sun's Eclipse observed at London, July 14, 1748 Old Stile." This plate may have been copied from an advertisement that appeared in 1746, *The Use of a new orrery.*[65] Each plate is well labeled and, if one follows the arguments in the text, very informative. The drawings are clear, detailed and beautifully executed.

I. B.Cohen, Richard Westfall, Thomas Hankins and other writers,[66] focusing on the Newtonian revolution, all point to the change from a qualitative Aristotelian universe to a quantitative Newtonian universe. Galileo argued that the language of the world was geometry; the insistence on that same point by Kepler and the demonstrability of that

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[64]See pp.140-141 for diagrams III and V, provided courtesy of the Pierpont Morgan Library.

[65]Millburn, *Bibliography,* 4.

[66]See I. B. Cohen, *The Newtonian Revolution* (New York: Cambridge University Press:1980): Thomas L Hankins, *Science and the Enlightenment* (New York: Cambridge University Press, 1985): Michael Hunter, *Science and Society in Restoration England* (New York: Cambridge University Press, 1981): Larry Stewart, *The Rise of Public Science, Rhetoric, Technology and Natural Philosophy in Newtonian Britain, 1660-1750* (New York: Cambridge University Press, 1992): and Richard Westfall, *Never at Rest, the Life of Isaac Newton* (New York: Cambridge University Press, 1980).

truth by Newton serve to demonstrate the importance of mathematics in any scientific endeavor.

However, in the eighteenth century in England, mathematics appears to have been viewed as tremendously difficult. Innumerable references are made to the difficulty of learning math and of understanding mathematical applications. Ferguson promised, "Astronomy without math." What is perplexing, however, is the level of mathematical sophistication expected of the reader if she is to understand this densely reasoned book. The descriptions of astronomy are not in any sense "without math." Astronomy does not rely on algebra for its arguments, nor does it imply any knowledge of calculus. What is does demonstrate repeatedly is the need to understand geometric relationships. There seem to be quite divergent views of Ferguson's own mathematical ability. There is some indication that he found even basic geometry difficult. While Ferguson was lecturing at Newcastle-on-Tyne in 1770, he was visited by Dr. Charles Hutton, who later reported in amazement that Ferguson was not only ignorant of geometry, but that he could not even follow a geometrical demonstration:

> His general mathematical knowledge, however, was little or nothing. Of algebra he understood but little more than the notation; and he has often told me he could never demonstrate one proposition in Euclid's elements; his constant method being to satisfy himself, as to the truth of any problem, with a measurement of scale and compass.[67]

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[67]Charles Hutton, *Mathematical and Philosophical Dictionary* (Hildeshim, N. Y.: G. Olms Verlag, 1973), *Tracts* iii, 379.

The diagrams and the discussions in the text make one wonder if Hutton took Ferguson's claim about mathematical illiteracy too literally. It is difficult to imagine a person with no knowledge of geometry producing the complex drawings that are keyed to the text. Eudosia demonstrates her grasp of arithmetic by spouting the list of numerical facts that she has learned, such as the various distances of the planets, the time of the tides and similar calculations that can be learned from any number of tables available at that time. However, it is impossible to ignore the fact that mathematics must be part of the new education of the emerging merchant class.[68] It is therefore not unreasonable to assume that one way to lead children to this subject is to present it in picture books, to bury it in silly stories and neat rhymes and to establish easy methods for the appreciation of mathematics.

Ferguson was one of the last of the scientific writers of children's literature to involve himself in a rather esoteric issue: the doctrine of plurality of worlds. He was a devoutly religious man and wrote several works investigating astronomical references in the Bible.[69] Consequently, when he introduced theological arguments into the scientific discourse they seemed believable. It is not possible to trace all influences that moved

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[68]One piece of evidence of this concern is the sheer volume of books to teach mathematics that reside in libraries housing early literature for children. The Free Library in Philadelphia has a collection of some 250 books on the topic. The popularity of *vade mecum* books for tradesmen shows the need for mathematical formulae and other tidbits of information for trade. One of the most popular was Daniel Fenning, *The Young man's book of Knowledge: being a proper supplement to the Young man's companion* (London : Printed for S. Crowder, in Pater Noster Row, and B Collins in Salisbury, 1764).

[69]One example is James Ferguson, *A brief description of the Solar System.& . . . an astronomical account of the year of our Savior's crucifixion* (Norwich: W. Chase, 1753).

Ferguson into this controversy, but several members of the Royal Society shared his concern. Michael J. Crowe [70] credits Ferguson with being a major influence on William Herschel, Thomas Paine[71] and David Brewster, encouraging their belief in extraterrestrial beings. Several founders of the Church of the Latter Day Saints, including Joseph Smith and Joseph Bates, credited Ferguson with influencing their views of other worlds.[72]

This concern with extraterrestrial life is found in many scientific writings in the eighteenth century. Fontenelle has suggested:

> Aristotle knew the fixed stars represented other worlds but he never told Alexander because he knew Alexander would go mad with despair that he could not conquer these worlds.[73]

There is some evidence that Newton was convinced that such life existed but his belief was not based on any scientific evidence but, rather, on his notion of the goodness of God and thus the possibility of life on other planets. It is not clear what compelled Ferguson to believe so strongly in the doctrine of plurality of worlds. His arguments are not unique, since they mirror many of the same arguments given by Fontenelle and earlier writers: similarity of the other planets to earth, the fecundity and magnificence of nature,

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[70]Michael J. Crowe, *The Extraterrestrial Debate: 1750 - 1900, The idea of the Plurality of worlds from Kant to Lowell* (New York: Cambridge University Press, 1986), 59-61, 160-163.

[71]Ibid., 162-163. Ferguson's influence on Paine is mentioned by Crowe who seems to be relying on a 1936 paper by Marjorie Nicolson showing that Paine's *Age of Reason* directly ties into the notion of plurality of worlds. In that paper, she documents that Paine attended Ferguson's lectures and discussed this concept with him.

[72]Ibid., 239, 245.

[73]Fontenelle, *Plurality of Worlds,* 128.

the argument from plentitude and the assumption that more perfect creatures than man must populate other planets in order to complete the chain of being.[74]

Eudosia insists that the very existence of the planets makes it a foregone conclusion that there is life on those other worlds. In an interesting mixture of Fontenelle and Bruno,[75] she argues:

> . . . to what purpose could the sun shine upon lifeless lumps of matter, if there were no rational creatures upon them to enjoy the benefit of his light and heat?[76]

At a later point, Eudosia declares, yet again, the belief that there must be life on other planets:

> For I cannot imagine that the inhabitants of our earth to be better than those of the other planets. On the contrary, I would fain hope they have not acted so absurdly with respect to Him, as we have done.[77]

Algarotti modeled his work after Fontenelle's dialogues, but for Fontenelle the focus was on the nature of the inhabitants of other planets, especially those on the moon. Initially, the conversations in Ferguson appear to mirror much that Fontenelle had already

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[74]Alexandre Koyré, *From the Closed World to the Infinite Universe* (Baltimore: John Hopkins University Press, 1957), chapter 2.

[75]Sidney Greenberg, *The Infinite in Giordano Bruno with a Translation of his Dialogue, Concerning the Cause, Principle and One* (New York: Columbia University Press, 1950), and Frances A. Yates, *Giordano Bruno and the Hermetic Tradition* (Chicago: Chicago University Press, 1964).

[76]Ferguson, *Astronomy*, 42.

[77]Ibid., 69.

argued in *The Plurality of Worlds*. Certainly, the sense of certitude is similar. When discussing the five planets Eudosia offers the argument:

> To me, this is positive proof of their being inhabited; and is enough to make us think, that we are but a small part of the creation, or of the favorites of heaven: and that all the regards of Providence are not attached to our diminutive concerns.[78]

This comment is followed by a resounding declaration of the omnipresence and omniscience of God. Later, when the discussion turns to the fact that Saturn's ring would require a rotation around the sun of about thirty years, Eudosia concludes that the inhabitants of the ring must be very different from us and that the Deity has accommodated their days and nights to them.[79]

The presentation in the text would suggest that Ferguson recognized the issue of plurality of worlds as more a religious matter than a scientific issue.[80] Crowe and others who argue that Ferguson was a major influence in the "plurality of worlds" controversy do not suggest he ever changed his views over the course of his lifetime. Ferguson seems to be one of the last of the popular science writers to give extended coverage to this issue.

Ferguson's lectures in Birmingham on January 17, 1763, attracted the attention of two enterprising individuals, James Boulton and Erasmus Darwin. Schofield sees a

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[78]Ibid., 42.

[79]Ibid., 54.

[80]Brewster, in his introduction to Ferguson's *Works*, argues that Ferguson was a devoutly religious man and included religious material in all his lectures. This would seem to jibe with what we see in the arguments that Eudosia puts forth.

connection among Ferguson, Erasmus Darwin and Richard Lovell Edgeworth,[81] although he does not place Ferguson in the Lunar Society as a member. Ferguson was tangentially connected to the Lunar Society through his lectures and his collaboration with Benjamin Franklin on the improvement of the Franklin clock. He also shared that society's interest in applied science as an advertisement placed in the *Daily Advertiser* of Tuesday, November 17, 1772, attests:

> MR. FERGUSON, at No. 4, the uppermost House on the Right Hand in Bolt-Court, will begin a Lecture at Seven o"Clock this Evening, on Wheel Carriages, loading of Waggons, and the best Method of constructing Mills for grinding Corn and sawing Timber. . . Each person is to pay 1s. A Lecture, and no Gold to be changed nor bad silver taken.[82]

To the degree these relationships existed, they point up one of the major areas of influence in the eighteenth century. The scientific world of the period was small, influential and intermingled with both scientific and social issues. The interests of industry and the concerns of science were beginning to forge new alliances and encourage cooperation. Groups like the Lunar Society and the Society for the Study of Arts and Philosophy were more in tune with applied science than was the Royal Society. Ferguson's children's book based on the science of astronomy demonstrates clearly that prediction was an important component of science in all its implications. For her part, Anne Emblyn's curiosity about astronomy had assured that several generations of young people would see the heavens in a new way.

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[81]Schofield, *The Lunar Society,* 31, 106.

[82]John R. Millburn, "The London Evening Courses of Benjamin Martin and James Ferguson, 445-448.

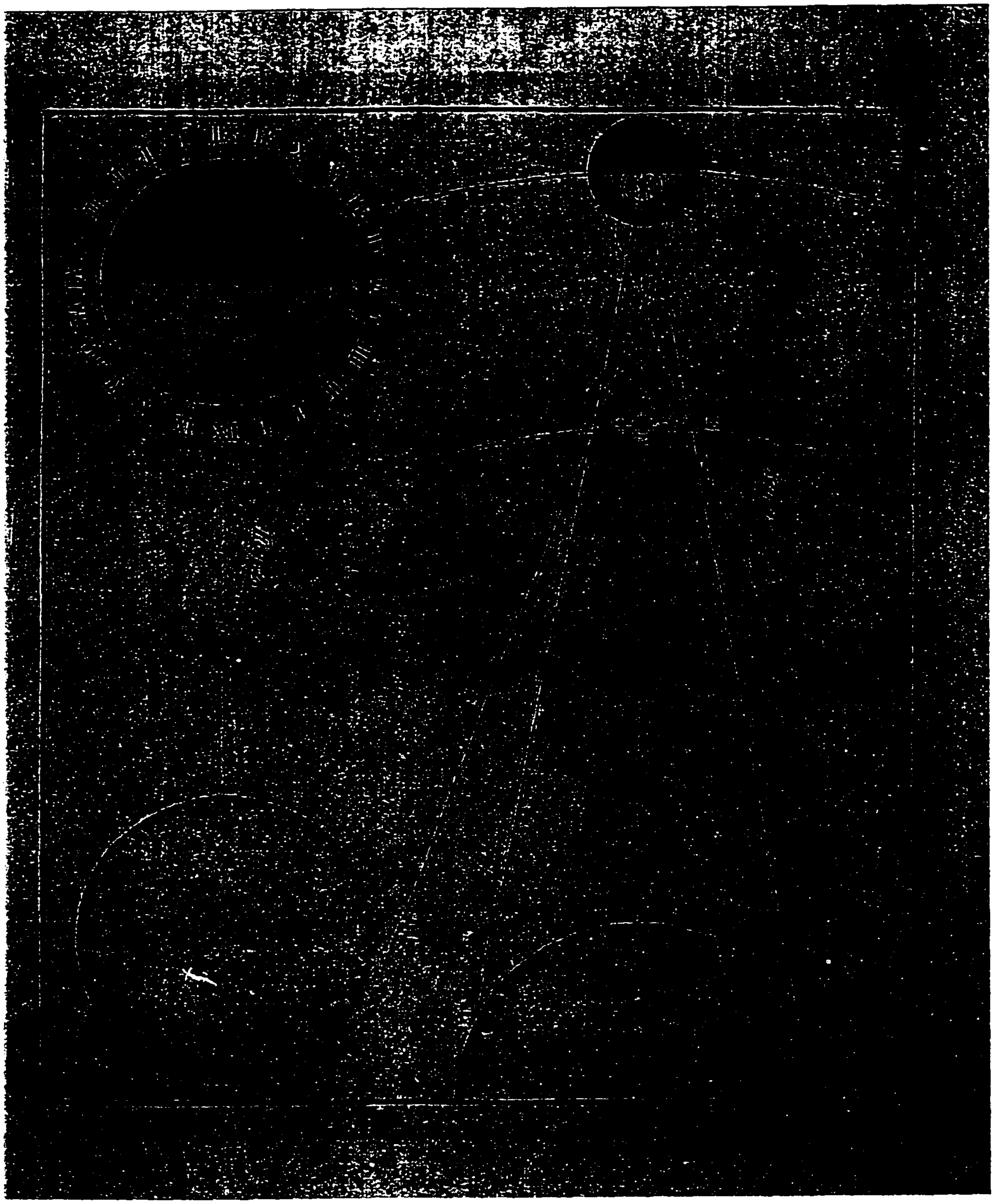

Plate IV

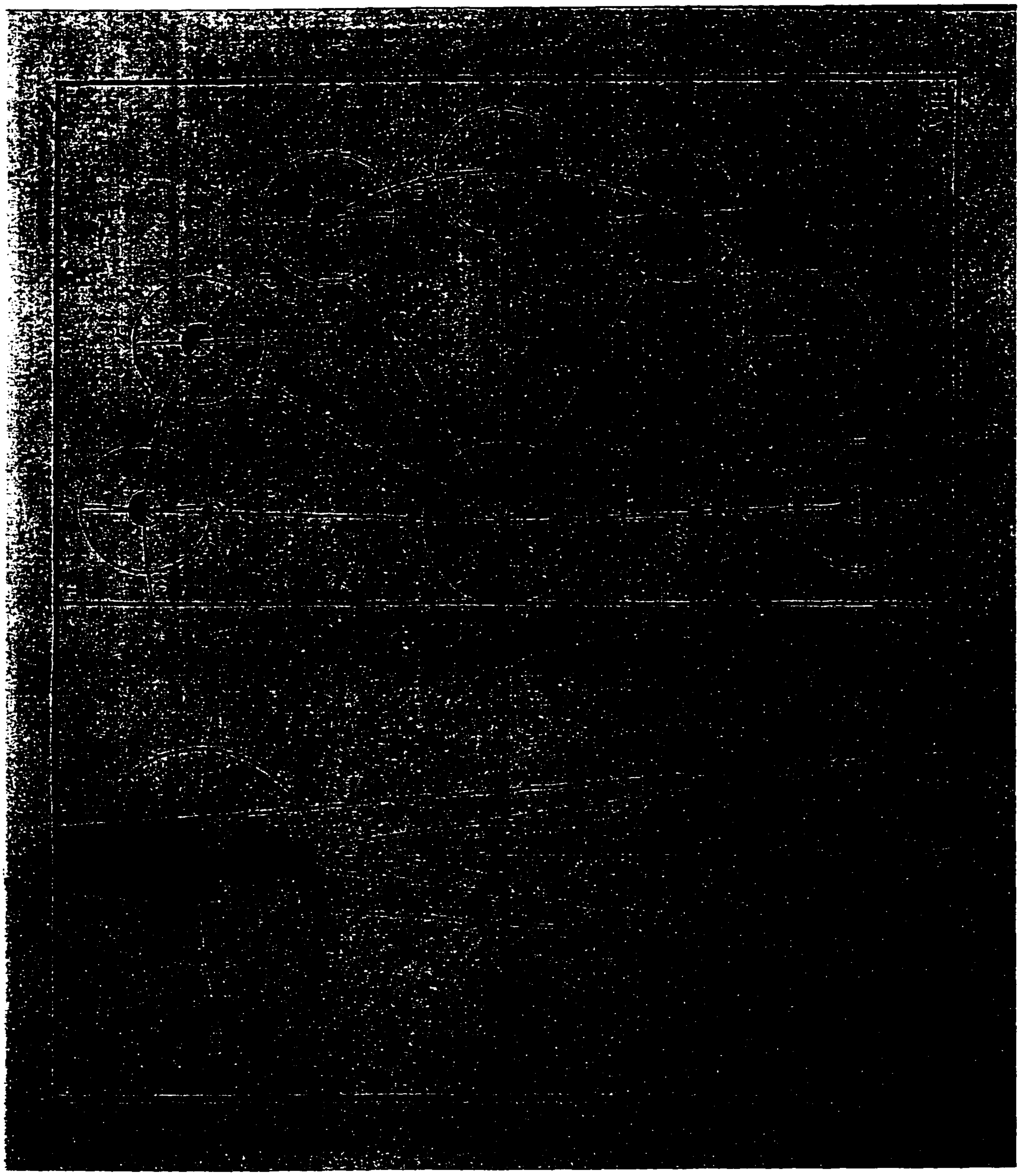

Plate III

Chapter 4

The Lunar Society, Thomas Day and *Sandford and Merton*

This chapter is not primarily about science for children, rather it focuses on issues having an impact on children's science: the goals of the Lunar Society, the relative importance of Locke and Rousseau in children's literature, and the view of natural history and animal behavior as part of applied science.

In the early 1760s, among the students attending Corpus Christi college, Oxford, were two young men, remarkably different in background and temperament, but destined to became close friends, engaging in social experimentation, proposing radical political solutions and collaborating on works of literature. Thomas Day and Richard Lovell Edgeworth, pursued a life-long friendship, first at Litchfield, then during a sojourn in France and later visiting each other in Ireland and England. They both joined the Lunar Society and collaborated on writing for children.

Day and Edgeworth, like other educated individuals[1] of that period, were cognizant of the relationship between applied science, industry and wealth. Many men, interested in both the new philosophy and the applied sciences, began to form local

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[1]Larry Stewart, *The Rise of Public Science* (New York: Cambridge University Press, 1992), especially the discussion "The Culture of Enterprise," chapter 8.

scientific societies. One such society, the Lunar Society, dominated the intellectual life of Birmingham and flourished from the 1760s to its apogee in the 1780s. This relatively small society inspired numerous other local scientific societies. The Lunar Society met at the home of Erasmus Darwin for an early dinner on the first evening of the full moon[2] to discuss the latest in scientific discoveries, the newest industrial inventions and the future changes the new technology would bring. The society was noted for its varied membership: philosophers, poets, inventors and manufacturers.[3] As science and scientific enterprise spread from London into Birmingham, many world travelers made their way to the Lunar dinners. Among the guests invited by Erasmus Darwin to attend the dinners held at his home were Sir Joseph Banks, Benjamin Franklin, Sir William Herschel, Carolus Linnaeus and Antoine Lavoisier. Jean Jacques Rousseau met several of the members including Edgeworth and Darwin. Many who never attended any of its functions knew of the society and corresponded with its members. There are various opinions as to whether Day was actually considered a member of the Lunar Society. Robert E. Schofield lists him as a member because he supported the goals of the members even when he disagreed with the ideas they expressed. Day had considered becoming a doctor but felt the field lacked exactness. However, he enjoyed discussing medicine with

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[2]The Lunar Society got its name from the fact that they met in the afternoon of the first full moon of the month so that they could find their way home after a late dinner. Dr. Dauben has pointed out that highwaymen were less likely to attack under these conditions, so traveling was less dangerous.

[3]Paul Langford, *A Polite and Commercial People: England 1727-1783* (New York: Oxford University Press, 1989), 260-262, discusses the Lunar Society as unique both for its free-wheeling, informal structure and its concern with the nexus of philosophy and industry.

Darwin. Day enjoyed debating ideas about the natural world. Though somewhat of a recluse, he proved to be a good friend and benefactor to many of the members but he was rarely present at the actual dinners.[4]

Day was an eccentric, but his extreme positions on the place of women, the issue of abolition, and his political radicalism are indicative of the societal changes present in the latter part of the eighteenth century. He espoused the cause of the American Revolution and sympathized with the French. His view of women was extreme, if not farcical. Viewing himself as an authority on education, he tenaciously clung to the beliefs of Rousseau, presented a bizarre view of animal behavior and taught a type of "survival science" for children. In contrast to Edgeworth and other members of the Lunar Society, Day's ideologies serve as a counter example, showing his unique responses to social and scientific disputes of the period.

Improvement and industry were bywords of the Lunar Society, with innovators such as Edgeworth and Darwin constantly attempting to improve roads, canals, and coaches to expedite local and long-distance travel. When Edgeworth met Darwin, the latter had just completed a carriage that could turn in a very small circumference, had an elaborate detailed interior and was a more comfortable conveyance than any that then existed.[5] After their meeting, Edgeworth immediately set himself the task of building an

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[4]Robert E. Schofield, *The Lunar Society of Birmingham: A Social History of Provincial Society and Industry in Eighteenth-Century England* (New York: Oxford University Press, 1963), 52-53. Schofield attributes Erasmus Darwin's hesitancy in inviting Day to join the group for dinner to Day's atrocious table manners.

[5]Richard and Maria Edgeworth, *Memoirs of Richard Lovell Edgeworth, ESQ Begun by Himself and Concluded by His Daughter Maria Edgeworth,* 2 vols. (London: Baldwin, Cradock and Joy, 1820).

even better coach. Not only did he build several coaches, he went on to invent a telegraph system, a turnip digging machine and several labor-saving devices. This competitive spirit drove the members of the Lunar Society to share and challenge ideas, and to seek ways of improving older inventions and promoting new technologies. The members of the Lunar Society wished to participate in the social reorganization necessitated by the changing technological advances.

As part of that social reorganization, the Lunar Society targeted education as a major area of concern. They were especially cognizant of the need to incorporate science into the curriculum of any viable educational system. Many of the members were religious dissenters, and several had been involved in setting up dissenting academies. Joseph Priestley was the one most involved in education, having taught at Warrington, one of the premier dissenting academies. He also published extensive treatises on educational subjects, including *A Course of Lectures on the Theory of Language and Universal Grammar.*[6] Erasmus Darwin, concerned with the fate of his two natural daughters, set up a school for them to run and wrote the guidelines for such an establishment. His book *A Plea for the conduct of Female Education in Boarding Schools* listed in detail the appropriate curriculum for women.[7] The book reflects the concerns of many eighteenth-century parents who struggled with the problems of

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[6]Joseph Priestley, *A Course of Lectures on the Theory of Language and Universal Grammar* (London, 1762).

[7]Erasmus Darwin, *A Plea for the conduct of Female Education in Boarding Schools* (Derby: J. John, 1797), includes prohibitions against dancing and recommendations for more science and philosophy. Darwin urged women not to become too "accomplished" at art and music, because it made them appear empty-headed.

education. Some middle-class parents still utilized the public schools, others hired tutors and a small group set out to educate their children at home. It was the home-school enterprise that intrigued Edgeworth and Day. And, like many other reformers of that period, they attempted to reconcile the educational theory of Locke[8] with the psychological assumptions of Rousseau.[9]

Both Rousseau and Locke believed in the importance of early-childhood education, but Locke's plan was less systematic than Rousseau's. Locke, building on earlier comments of John Evelyn and Sir William Petty, generated a series of principles on which child rearing ought to be based. With a refreshing view of man and a great deal of common sense, Locke hypothesized the concept of *tabula rasa*. This concept assumes that all learning comes through the senses. This idea, in turn, leaves the child at the mercy of his environment. The child must be trained in the habits one wishes to instill. This training is best conditioned by a combination of reward and punishment. Locke's view that punishment was not as successful as rewards, that the child should enjoy the process of learning, and that learning could be fun were concepts that the dissenters were more than willing to incorporate into their view of education.

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[8]Margaret Ezell, "John Locke's Images of Childhood," *Eighteenth-Century Studies* 17(Winter 1983/84):139-156, looks at the impact of Locke's "educationalist's" viewpoint which resulted in the firm belief that early minds were infinitely malleable.

[9]Paul Langford, "Thomas Day and the Politics of Sentiment," *Journal of Imperial and Commonwealth History,* 12 (January 1984) 2:57-79, and W. A. C. Stewart, *Progressives and Radicals in English Education: 1750-1970* (New Jersey: Augustus Kelly Publishers, 1972). Langford and Stewart both discuss the impact of Rousseau's *Émile* on eighteenth-century ideas of education, including the outbreak of Rousseau mania between the 1760s and 1790s. The celebration of the natural child and the repudiation of dogmatic child rearing were major components of the educational theory. Obviously, this view also held political implications.

By contrast Rousseau formulated a comprehensive developmental scheme, attempting to describe a system of education according to nature.[10] Rousseau ushered in the "Age of Sentiment" with his idealized "natural child."[11] He argued that being innately good, the child left to his own devices would develop a sense of justice, morality and independence. Rousseau outlined four stages in this process. Beginning with infancy, during which the child acquires speech and mobility, it is imperative, according to this philosopher, to leave the infant free of unnatural restraint (referring to the practice of "lead strings," which essentially tied the child to the mother or caretaker).

The second period, childhood, spans the ages from two to twelve. This stage is the crucial one in terms of its implications for educational theory. The child should be supervised but not controlled; he should be allowed to run free and to explore as his spirit dictates. He ought not to be taught in any systematic manner nor be constricted by rules of obedience or social constraints. His education should be from the natural environment, and his punishment from the logical consequences of his actions.

The third period of life, ages twelve to fifteen, which is marked by the acquisition of formal knowledge, begins the initiation into systems of knowledge and especially into systems of natural philosophy. Since the previous years have whetted the child's curiosity through experimentation, imagination and exploration, his mind is now ready to accept science, geography and handicrafts. It is in the final stage, from fifteen to

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[10]Marilyn Butler, *Maria Edgeworth: A Literary Biography* (Oxford: Clarendon Press, 1972), 61. She comments that Rousseau had declared that one should educate for mankind, not for a profession; the English liberals, at once more pragmatic and less revolutionary, wanted to do the reverse.

[11]Langford, *Polite and Commercial People*, 473-477.

manhood, that the child's moral and social character development is enhanced by the study of history, metaphysics, religion, sex education and physical training.

Rousseau's view of the natural man, often labeled the "Sentimental Revolution,"[12] was quite attractive to many of the radical reformers. An open and robust expression of one's feelings was seen to be replacing a more staid and socially prescribed interaction. Unobstructed conversation would replace the more stilted exchanges that characterized many social interactions. Rousseau argued that human feeling was superior to conventional morality.

Both Locke and Rousseau started with the same premise, that man is born free, Rousseau, however, saw him as everywhere shackled by oppressive authoritarian dictates. Locke was more aware of, and in sympathy with, the dictates of social norms and the obligations of social class. Both philosophers called into question conventional child rearing and proposed radical changes, but the details of incorporating these ideas into child rearing in general, and children's literature in particular, presented several problems, not the least of which was the rather impractical nature of Rousseau's writings. Nevertheless, his perspective dominated much of the literature for children in the last half of the eighteenth century.

Despite his perceived popularity, there is ample evidence to indicate that Rousseau was admired but often not emulated. The Lennox sisters were great granddaughters of Charles II, daughters of a cabinet minister and wives of politicians. They represented an interesting cross-section of the English eighteenth-century social

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[12] Langford, "Politics of Sentiment," 58-59.

scene. They read Rousseau but considered him completely impractical, but, as they said, "a pretty read."[13] Because their letters are so candid and they are so much in the mainstream of English society, one suspects their evaluation of Rousseau was more typical than Day's.

Most of the members of the Lunar Society encouraged the practice of home education, wishing to incorporate both Locke and Rousseau into a reasonable theory of education. The schools provided by the dissenters were the only viable alternative. However, such schools often passed out of existence at the death of a headmaster or key teacher. In view of that instability, men like Darwin and Priestley favored home schooling. They felt parents were the only ones capable of bringing about this change. However, serious problems arose in the practical application of such a proposal. Edgeworth and Day spent endless hours discussing the implications of these ideas for educating the young child and implanting what they referred to as " heroic virtues."[14]

When Edgeworth's first child was born, he and Day put together a scheme for educating the boy. Against the advice of his friends and the protests of relatives, Edgeworth pursued his goal of following Rousseau's dictates. He assumed this necessitated giving the child total freedom. There were to be no restrictions; the child did not wear conventional clothes but, rather, loose-fitting breeches and open shirts; he was

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[13] Stella Tillyard, *The Aristocrats: Caroline, Emily, Louisa and Sarah Lennox 1740-1832* (New York: Farrar Straus and Giroux, 1994), 217. This engaging book, based on extensive letters written by four aristocratic sisters, provides insight into the private world of eighteenth-century aristocracy.

[14]Scott, *Day,* 35. Friends and relatives disparaged the idea and ridiculed their endeavor, but it was an optimistic age, and Day and Edgeworth were confident that man had the ability to control his circumstances, if not his destiny.

not taught to read but allowed to learn from nature. The end result was unusual. In addition to having a violent temper, young Richard would only obey his father; he would not listen to anyone else. He scorned structured learning. Several writers, especially Scott, delight in recounting the disastrous meeting between Rousseau and the young Richard Edgeworth. Rousseau's Émile had arrived at the age of twelve; free, open, creative, and healthy, unfettered by books and learning. Not so young Edgeworth; the boy was rude, impudent and completely out of control.[15]

For Rousseau, the supreme good was freedom, not authority. Edgeworth, however, found it difficult to cope with a son who listened only to his father and, then, only sporadically. This encounter between the boy and Rousseau gave Edgeworth second thoughts about his educational theory.[16] Edgeworth began to view the boy as incorrigible and eventually he disinherited his son. However, his more immediate response was to rethink the whole notion of Rousseau's "noble savage" and to return to a closer reading of Locke. This influence is apparent in his daughter's writings, for Maria is more closely allied to Locke than to Rousseau. Thomas Day, however, was never convinced. Day remained a devoted follower of Rousseau and was interested in applying his ideas to revamping society.

Day considered himself, first and foremost, a political writer. He wrote on the need for open trade, and the necessity of ending the slave trade, and he urged England to

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[15] Summerfield, *Fantasy and Reason,* 118, and Scott, *Day,* 91.

[16]In his *Memoirs*, 272-279, Edgeworth laments the effects of the "wrong" principles of Rousseau, especially the practices that have allowed young Richard's temper to rage out of control.

establish better relationships with the colonies.[17] His anti-slavery writings might have had some minimal impact on the cause, but even that is dubious. In 1773 he wrote a poem called "The Dying Negro" about the suicide of a black man. The man had been refused the right to wed his white lover. This poem was used to further the cause of the abolitionist movement in England. Wedgwood manufactured a famous medallion[18] commemorating the poem, and the fashionable ladies of London created a fad by adding diamonds and jewels to it. Later, Wedgwood sent many copies of the medallion to Benjamin Franklin to use in the cause of the abolitionists. Scott points out one problem with the timing. In 1772 Lord Mansfield, an abolitionist, worked to have legislation passed against slave holding in England. It declared than any slave became a free man the minute his foot touched English soil. The young man in question would no longer have been a slave, in England, by the time the incident occurred.

Day joined the Rochingham Whigs, a group dedicated to independence for America and a diminution of the king's power. It was the party of Edmund Burke. Day supported their ideas of universal suffrage, equal representation and annual parliaments. He was active in the Society for Promoting Constitution Information.[19] His encouragement and support of the American Revolution was consistent with the position taken by many of the other members of the Lunar Society. Even though his treatises have

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[17] Langford, "Politics of Sentiment,"67-68.

[18] In *Harry and Lucy*, Lucy is given a copy of the medallion complete with the inscription, "Am I not a brother and a human?"

[19] This organization was founded by Capel Lofft, who was also the husband of Anne Emblym, the inspiration for Eudosia in Ferguson's *Astronomy*. Scott, *Day*, 134.

not had any long-range impact on political thought, Day attracted a significant following in England through his writings, especially in radical political circles.

Neither Rousseau nor Day ever attempted to rear children of their own, but both considered themselves authorities on the subject. Rousseau, of course, solved the problem of educating his five children by placing them in a foundling home at birth.[20] Day had no children, but he did spend time and attention on other people's children. Some children of his friends came to stay at his farm and mastered the austere way of life he practiced. He raised his nephew, Thomas Lowndes, who turned out to be something of a prig. He became convinced that Day owed him a living and relied on him for the rest of his life. Day schooled Erasmus Darwin Jr. for a while, and he nursed Maria Edgeworth in 1781, when, at age fourteen, she was sent home from boarding school with the announcement she would probably go blind. Later, he allowed Richard Edgeworth to stay with him after he had been disinherited by his father.[21]

He attached himself to unpopular causes and was a loyal friend to many of the dissenters, especially James Kier, the chemist.[22] Their only area of serious disagreement

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[20]Jean-Jacques Rousseau, *Émile.* trans. Barbara Foxley (Rutland, Vt: Charles Tuttle, 1993), I.

[21]George Warren Gignilliat, *The Author of Sandford and Merton; A Life of Thomas Day, Esq.* (New York: Columbia University Press, 1932), 251. Scott acknowledges that most of his material is taken from this source. However, Scott errs in giving too much credit to some of the more outrageous stories about Day. A more balanced view of Day's political activities is contained in Langford, *Commercial People,* 626-627.

[22]At Day's death both Edgeworth and Kier vied to write Day's life story. Edgeworth, on hearing of Kier's intent withdrew and allowed Kier to memorialize their mutual friend. This book, *An account of the Life and Unity of Thomas Day, Esq.* (London: Printed for J. Stockdale, 1791), together with Edgeworth's *Memoirs,* is the

was Kier's contention that Rousseau's education theory was impractical. Despite his unconventional ideas, Day exerted enormous influence over his friends and enjoyed a certain respect in intellectual circles.

Day was vehement in his opposition to women writers. When Maria Edgeworth was about to have some of her work published, Day opposed the idea.[23] Despite having encouraged her writing, her father refused to have her work published until six years after Day's death. In general, Day had great difficulty with independent women.[24] For Day the ideal woman should adhere to the dictates of her husband and, even if educated, ought not to show it. He generally viewed women as empty-headed and illogical. There were several humiliating episodes in which he courted and proposed to six different women, all of whom refused to marry him. Usually the refusal followed very closely on their being presented with a list of non-negotiable demands concerning the future wife's conduct. The list included a promise to pursue science and education and prohibitions against dancing and gossiping, as well as playing cards and listening to music.[25]

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source of much that was later published about Thomas Day.

[23]Maria had translated Mme de Genlis' *Adele et Theodore*. When Day heard that she was going into print, he immediately sent a letter of strong objection to Edgeworth. Later he sent a sardonic letter congratulating him for suppressing the novel and included what Edgeworth termed "an eloquent philippic against female authorship." Butler, *Maria Edgeworth*, 149.

[24]Only one, Elizabeth Syned, responded with her own list of conditions, all of which demanded significant changes in Day's behavior. Butler, *Maria Edgeworth,* 40-45.

[25]Ibid., I:149.

Day ventured into the Litchfield social scene which included the Darwins, the Syneds and the Edgeworths. The men tolerated his rather casual disregard for social convention, but the ladies were not as open-minded. His first rejection was at the hands of Elizabeth Edgeworth, his best friend's sister. Next, he turned to Elizabeth Syned. This relationship appeared to have some chance, but she was ashamed of his lack of style and grace. Determined to rectify that situation, he made a bold attempt to win the favor of the lady and become more "civilized." During a self-imposed "season" in France, Day learned fencing, dancing, horseback riding and some degree of courtliness. He contrived to improve his posture by having boards strapped to his legs.[26] He purchased more fashionable clothes and acquired a wig. Convinced that he now had achieved the demeanor of a "gentleman," he returned home to pursue his love affair with Elizabeth Syned. When she saw his foppish wig, his unlikely fashionable clothes and his newly acquired veneer of respectability, she laughed and ran from the room.[27] This incident might explain both his negative view of women and his distaste for the trappings of society.

He continued to struggle to find a wife. Having been rejected by Edgeworth's sister, Margaret; two of the Syned sisters, Honora and Elizabeth; and Mme. Panckcoucke, who was a Parisian beauty and wit, he turned elsewhere. He hit upon the idea of adopting two young orphan girls. He and Edgeworth mapped out an educational

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[26] Ibid., I:261. M. Huise proposed to fix Day's bowlegged condition by strapping boards to his legs and forcing him to walk that way several hours a day. It had no discernible effect.

[27]Scott, *Day,* 53-55.

program for the girls. Day's goal was to produce a perfect wife for himself. The girls—one dark, named Lucretia, the other, fair Sabina— were reared as directed. Lucretia was not too bright and Sabrina tended to exhibit an uncomfortable degree of independence. Despite the latter's shortcomings, Day finally chose Sabrina to be his wife. However, the match could not have been more ill-considered. She offended him in many ways, but particularly because she refused to learn science and clung, in Day's eyes at least, to the weakness of her sex. She failed several tests Day devised to test her fortitude. When he dropped hot wax on her hands and fired buckshot into her skirt, her response was less stoic than Day had hoped. He was also displeased by her desire to have fine clothes and was incensed to learn that she had visited a milliner. Finally, she defied him by wearing too short a sleeve. He refused to marry her and the experiment was abandoned.[28]

After his many failures, his friend and mentor Dr. William Small,[29] in 1778, introduced him to Miss Esther Milens of Wakefield. At first Day was reluctant to meet her, needing assurance that she did, indeed, have "large and white arms" (Sabrina had skinny arms) and, in addition to wearing sufficiently long petticoats, was also docile — that is, a shy and retiring woman who would follow his dictates. Despite the fact that she

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[28] She did later marry Bicknell and seemed not to have been too badly harmed by the entire experience. Bicknell was a friend of Day's and part of the team that planned the education of the two foundlings. Bicknell and his wife lived off Day for the remainder of Day's life. He also left them money in his will. Langford, *Sentiments*, 58.

[29]Dr. William Small, a member of the Lunar society, had also been a professor at William and Mary College in Virginia, where he had instructed his star pupil, Thomas Jefferson. Small always remained a friend of Day's and tolerated him despite his uncouth and harsh ways. Edgeworth, *Memoirs*, 1:342.

did not meet his requirement of being "tall and robust," he finally agreed to the meeting, fell in love and proposed. He had finally found "some female wiser than the rest of her sex, who would feel for him the most romantic and everlasting attachment."[30] With his new bride, he moved to a ramshackle farm in Stapelford. The house had only one habitable room. Day was determined to rebuild the structure, but his reading of *Ware's Architecture* was not sufficient to prepare him for the task. In disgust, he moved to a remote farm near Anningsley, in Surrey.

Here, he attempted his experiments in new methods of cultivation and animal husbandry. He was not particularly successful at either,[31] nor was he well received by the neighboring farmers, especially the poorer ones. They suspected he was a miser because he hired no servants and did not sport a fine carriage or beautiful horses. The gentry disliked him because he insisted on paying farm laborers throughout the winter, even when there were no chores for them to do.[32] Eventually the farmers gave him grudging respect because of his willingness to assist them with grain and equipment. But the farmers never knew what to make of this rich eccentric.[33]

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[30]Scott, *Day,* 40.

[31] In a letter to Edgeworth, Day talked about losing money on the farm but felt it was a worthwhile endeavor because it enabled him to help the local poor. Edgeworth, *Memoirs,* 2: 78.

[32]Day rightly assumed that the poor had to eat, even in the winter. The terrible state of their living quarters, and their lack of adequate heat and food— these were real concerns to Day. He lamented the plight of the poor but was often unsure how to be really helpful. Langford, "Politics of Sentiment."

[33]Edgeworth, *Memoirs,* 2:73. He "talks like a book" was the judgment of a neighboring farmer.

His wife was quite devoted and seemed not to mind the imposed austerity of a cold house, meager food and no entertainment. Esther and Day ceased to visit friends, particularly the Edgeworths. Day feared that his new wife would be contaminated by the music, entertainment and exuberance of the Edgeworth household with its many children and assorted pets and projects that filled their lives. Esther was never allowed to visit her family, and it seems that she accepted such dictates with equanimity. Day had achieved his dream, and he was not going to have it disturbed.

In 1782 Edgeworth and Honora, his second wife, had begun to plot out the first *Harry and Lucy*[34] series. Day agreed to write a story to be embedded in the series. However, he got carried away and wrote a three-volume set. The second part was written in 1786 and the third part in 1789. He obviously intended to write more but met an untimely death.[35]

Sandford and Merton[36] may be one of the most popular children's books written in the eighteenth century. It has been reviewed and analyzed repeatedly,[37] primarily because

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[34]It was the hope of the Edgeworths that the members of the Lunar Society would join them in a project to create textbooks for young children and subsequently reform education, especially in the area of science and particularly in the area of applied science. Butler, *Maria Edgeworth*, 135-137.

[35]Even that event was directly a result of his own philosophy. Believing that animals were only wild because no one had been kind to them, he refused to have his horse broken before he attempted to take it on the road. The horse, untrained, shied at a branch,and threw Day, who died of head injuries.

[36]Thomas Day, *The History of Sandford and Merton* (London: Printed for J. Stockdale, 1783-1789). PML 46526-8.

[37]Arguing that Day lifted huge parts of this work from Henry Brooke's *The Fool of Quality* (1765-70), Mona Scheuermann in "More than 'a few passages"*Durham University Journal* 75 2 (1983),:55-59, claims that not only passages but the structure,

it presents a view of life consistent with the philosophy of Rousseau. Its disdain for the aristocracy, its sympathy for the poor and downtrodden combined with an extensive retelling of classic tales, made it a popular children's book.[38] The first edition of the book, housed in the Pierpont Morgan Library, has no illustrations other than the frontispieces in the second and third volumes. There are seventeen different editions at the Morgan, dated from 1783 to 1877. Later editions have more elaborate illustrations: some simple line drawings; others extensive and beautifully colored illustrations.[39] An 1875 abridged edition was published as *Sandford and Merton in Words of One Syllable.*[40] Often *Sandford and Merton* was abridged into a single volume.

The narrative opens with the introduction of Tommy Merton, a young man raised on an estate in Jamaica with servants and slaves. He has just returned to England and is

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plot and social perspectives are all lifted from Brooke. Having examined both books carefully, I find it difficult to agree with Ms. Scheuermann. The structure bears some similarity, but the perspective on the aristocracy is the exact opposite and the "plot" in each is almost nonexistent since both consist of a series of stories strung together to incorporate older, classical stories. This is not a style unique to either Brooke or Day.

[38]Thomas Day, *The History of Sandford and Merton* (New York: Ward, Lock and Co. [NUC 1879?]). This abridged version was given as a Prize for a Resident Pupil at the G. and E. School in Bathurst, Mass. 1892. A comparison of this text with the original first edition does not indicate substantial differences in content. For the purpose of convenience the later version was used.

[39]The 1879 edition has the frontispiece of Hamet, the Grateful Turk, a slave who is by befriended by a young boy. Later as a free man, he is able to save the young man from a fire. These engravings are attributed to the Brothers Dalziel. An 1874 English edition has the frontispiece as Tommy feeding a little bird. However, most of the early editions use the initial meeting between Henry and Tommy and the snake as the frontispiece.

[40]Mary Godolphin, *Sandford and Merton in Words of One Syllable* (New York: A. L. Burt, 1895). In keeping with the dictates of the premise, the boys are now Hal and Tom.

playing in the field. Suddenly, he is attacked by a snake. A young farm boy comes to his rescue. Immediately, the differences between the two boys are drawn in sharp contrast. Tommy Merton is overindulged, wimpy and peevish; he can neither read[41], write nor do ciphers. Needless to say, Harry Sandford is not only competent in all these matters, but he is also interested in becoming a farmer and learning science. He already possesses virtues beyond his years, especially his generosity to the poor. When the grateful Mertons insist that Harry come to their lavish home for dinner, they are surprised that he is unimpressed by the heavy drapes and beautiful silver. Harry, of course, immediately reminds them that these trappings are unnecessary for the good life. The Mertons vow to have their beloved Tommy schooled by the same local clergyman, Mr. Barlow, who has been instrumental in teaching Harry so much.[42] It is agreed that both Harry and Tommy will live under the tutelage of Mr. Barlow.

Not only do the stories in *Sandford and Merton* place great emphasis on competence, they also confront a variety of ethical issues. Philanthropy and generosity are of major importance, and several different stories highlight these issues. Barlow, like Day, is a man of strong morals, and he intends to impart them to the young.[43] The author

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[41]Immediately after figuring out how to work for his dinner, Tommy asks to be taught to read. It seems to be an inordinately slow process. *Sandford and Merton,* 52. This is at odds with several autobiographies that report learning to read in a matter of weeks rather than months. Many of these are discussed by Margaret Spufford, *Small books and pleasant histories: popular fiction and its readership in seventeenth-century England* (London: Metheun, 1981).

[42] Mr. Barlow is undoubtedly Day himself in both his intellectual and philanthropic mode.

[43]Day had several opportunities to cash in on knowledge of certain stocks that were sure to increase in value because of secret negotiations to which he was privy.

adapts the ancient Roman toga story for an eighteenth-century audience. One boy in the playground is wearing a coat much too small; another boy is wearing an oversized coat. The schoolmaster urges the boys to change coats so that each will be more comfortable. Barlow condemns this behavior. The coats were not the property of the schoolmaster and so they were not his to give and take. Likewise, when Tommy sees a hungry man, he runs to Mr. Barlow's house and gets the poor man a loaf of bread. Tommy is severely reprimanded for giving away bread that is not his to offer. Day insisted on strong moral lessons for Sandford and Tommy, but he presented these moral lessons with greater finesse than is later found in the religious-scientific works of Sarah Trimmer or Mrs. Barbauld.[44]

Day was not religious and made no attempt to impose any religious belief on his young audiences. He firmly espoused the idea that a well-educated man would be able to survive in any environment. When Mr. Barlow begins teaching, he sets up the first premise of all instruction as he sees it: Education should make one self-sufficient. Viewing survival as the ultimate human goal, he teaches his young charges to appreciate the skills that make man capable of dealing with the elements. He downplays the benefits of position and power. The education of the two young boys begins with an introduction to horticulture; they learn to hoe, plant and till the soil. They must use basic scientific principles, build and produce.

Rather, he kept his money under floorboards in his house so that he would not be involved in any shady dealings. Edgeworth wrote that Day was the most ethical man he had ever met. Edgeworth, *Memoirs,* 1:182.

[44]Both women were famous writers of children's books. Their attempts to teach science to children were overshadowed by their main focus, which was religious.

The initial step in the education of the boys is to insist they provide for their own dinner. Tommy is predictably outraged at such a suggestion, because a gentleman need not work with his hands, certainly not by tilling the land. After missing several meals, Tommy succumbs to the view that hard work is really not beneath him.

Interspersed between bouts of labor, the boys listen to stories that encourage better behavior. Animals are discussed in great detail. One of the persistent themes in the book is the relationship between man and animals, specifically, why animals suffer and why they should not be mistreated. In the story "The Ants and The Flies," the boys learn how the flies play all summer while the ants work. When winter comes the flies must dies but the ants have provided for their future, so they are safe. The children learn not only the habits of other animals but also the applications of certain lessons to their own life.

Day's view of animal psychology is anthropomorphic, with an insistence that animals have the same feelings as humans. At one point, Tommy is so taken with this idea that he tries to befriend a pig, only to end up in the mud. Mr. Barlow rightly points out that while the pig had feelings, it could not read the good intentions of the person who grabbed it and intended to feed it. This discussion on animal behavior is bizarre precisely because it attributes the wildness of animals solely to the fact that people have not been nice to them. "There is scarcely any animal that will do harm without it is attacked or wants food."[45]

In another instance Tommy has adopted a wild bird. The cat finds the bird and kills it. The death of the bird is Tommy's fault because he "did not teach the cat to

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[45]*Sandford and Merton,* 127.

overcome its instinct."[46] Apparently, Day was unfamiliar with the concept of domesticated and nondomesticated animals. In another instance, the boys are with Mr. Barlow when a circus bear escapes. Mr. Barlow walks over to the bear and speaks kindly to it and then strikes it on the head. He tells the boys that wild animals recognize a lack of fear and respond accordingly. Later, Tommy subdues a monkey by using a similar strategy.[47]

Interspersed among the various lessons on farming and animal husbandry are stories based on classical tales and ancient history. In most of the stories, the hero is a poor man and the villain is a rich man. Often, the characters find themselves in changed circumstances and the roles are reversed. The poor man is able to survive because he has some "marketable skill," such as weaving, candle-making or animal husbandry.

Mr. Barlow continues with a range of stories from Pizzarro's failure in the New World to the plight of shipwrecked Russian sailors. In every story, it is the person who takes the more humble route, who can exact food and clothing from the environment, who wins out over the haughty individual looking for easy money and great recognition. The wit and cleverness of the hero is contrasted with the slothfulness of the rich man, who is seen as a drain on society.

Mr. Barlow tells the story of Androcles and the lion and uses the narration to quiz Tommy about the injustice of slavery. Since Tommy's father held slaves in Jamaica, it is a

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[46]Ibid., 2:7.

[47]The story was told that Day's mother had subdued a bull by simply staring it down. This may be apocryphal but it was a major factor in Day's view of the ability to control animal behavior. Scott, *Day,* 20.

perfect foil for Mr. Barlow to suggest that he sell Tommy to some farmer so that the farmer can enjoy cheap labor. Tommy's initial reaction is outrage but, in the end, leaves the conversation convinced that slavery is wrong. The assumption is that he will grow up to redress the wrongs of his father.[48] At least he agrees to quit kicking and pinching his slave, William.

Like other books written in this period, there is a constant emphasis on concrete economic situations. Children are not shielded from the reality of everyday life, whether it be crooked lawyers, evil servants, arrogant members of the aristocracy or crushing poverty brought on by disaster and debt. A couple are about to forfeit their house and furnishings because the husband co-signed a loan for his brother-in-law, who has gone to sea and cannot be held accountable for the debt. This recurring scenario in the books of this period suggests a fairly common economic reality. Tommy Merton approaches his parents requesting permission to use his spending money any way he wishes. They not only agree but remain silent when they are urged not to ask why he makes the request. The parents agree to withhold the sum of forty pounds from his allowance for an unspecified period of time. This amount suffices to keep the bailiff content and to allow the poor family to remain in their home. Tommy is beginning to appreciate the joys of philanthropy.

It is in the second book of the series that the boys begin to investigate the natural philosophy that defines their world. The boys get lost in the snow. This leads them to a comprehension of the nature of an avalanche and how it works. A fantastic story is told

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[48]*Sandford and Merton*, 35.

of a family, trapped by an avalanche, that lives all winter in a barn but is able to survive by eating the animals and the hay in the barn.[49] Later, the boys are lost on the moor and see the legendary jack o'lantern, a phenomenon caused by mist rising on the moor. It often misleads travelers, who believe the eerie light to be a lantern held by someone beckoning them home. In this case, the boys are smart enough to use the North Star to guide them home. This episode results in an astronomy lesson and the boys begin to learn to read the heavens.

Tommy becomes so intrigued with astronomy that he learns the names and locations of the constellations, including Andromeda, Cepheus, Cassiopeia's Chair and Orion. One night, he comments on the fact the stars continuously move around the earth. Mr. Barlow challenges his observation and demands to know how Tommy arrived at this conclusion. Tommy is then led through all the arguments that have become standard for children's literature. Have you ever been in a coach? How can you tell which is moving, the coach or the world outside? Have you ever been in a boat? How do you know whether the boat or the shore is moving? Tommy ponders these questions and concedes that it is possible the earth, not the sun, is moving.

The following day Mr. Barlow takes Tommy for a walk to the sea. He points to a speck on the horizon and asks Tommy to identify it. First, he identifies it as a small fishing boat, then as a vessel with one mast, then finally as a frigate. Mr. Barlow uses this experience to show Tommy that apparent size is a function of distance. He asks Tommy

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[49]This event is reported to have actually happened on March 19, 1755, and the wife and children were stuck under the snow until the 24th of April. *Sandford and Merton*, 85-92.

if he traveled from the earth to the sun, which would look larger as he approached the sun. Tommy agrees that the sun would begin to look larger as he moved farther away from the earth.[50]

After Tommy masters some basic astronomy, the text turns to fundamental principles of mechanics. Tommy and Harry attempt to move a huge snowball. It is impossibl. Tommy is ready to give up until Harry tells him to take two long sticks and to place them strategically; then they are able to move the snowball with great ease. Likewise, they watch some workmen trying to dislodge a huge stump. It is only when Harry uses the wedge and a hammer that the stump disintegrates and the men can move it. After this informative lesson on the lever and the wedge, Tommy is taken into the barn and told to lift a huge sack of wheat into the top of the barn. When he declares it cannot be done, he is introduced to the wheel and axle combination that allows a pulley to lift large weights. Tommy is duly impressed with all of this. He makes the observation that knowledge not only improves the mind but also increases the strength of one's body as well. He is then told that there are many such contrivances but understanding them requires a certain type of knowledge. He stops short when Mr. Barlow suggests that he learn arithmetic. "What is arithmetic, Sir?"[51]

Mr. Barlow admits that arithmetic is not easy to explain, but he tries to make it real by asking Tommy to count grains of wheat. When Tommy cannot do the simple sums of fourteen grains plus twenty-five grains, he is chagrined to discover that Harry

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[50]Ibid., 202.

[51]Ibid., 184.

can both add and subtract. In the next breath, Mr. Barlow explains basic arithmetic in this manner:

> A bushel of corn weighs about fifty pounds; this sack contains four bushels; so that there are just two hundred pounds' weight in all. Now every pound contains sixteen ounces , and sixteen times two hundred makes thirty-two hundred ounces. So that you have nothing to do but to count the number of grains in a single ounce, and there will be thirty-two hundred times that number in the sack.[52]

This is followed by an even more complex problem. A man who knew and loved horses is presented with a horse that is wonderful beyond his fondest dreams. However, when he hears the price of two hundred guineas, he absolutely refuses to pay such an outlandish sum for any horse. As they are about to part, the owner of the horse proposes a substitute payment: "Will you give me a farthing for the first nail the horse has in his shoe, two farthings for the second, four farthings for the third and so on, doubling each time for all twenty four nails in the shoes?"[53] Certainly, responds the gentleman, obviously not having been taught to beware of horse traders. The gentleman asks his steward to sit down and calculate the sum. Later, the steward returns to ask, "Where is the estate that you are buying . . . for the sum you asked me to calculate comes to seventeen thousand, four hundred and seventy six pounds?"[54] Embarrassed, the gentleman renegotiates for the original two hundred guineas. Tommy is quite impressed with this lesson and decides to learn arithmetic so as not to be in a position where he

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[52]Ibid.

[53]Ibid., 185-186.

[54]Ibid., 186.

might be so embarrassed. And so that winter Tommy spends his evenings studying the heavens and learning computational skills.

Because Tommy has been so dedicated in his study of the heavens, Mr. Barlow introduces him to the wonders of the telescope, enabling him to study the heavens. However, Mr. Barlow tells of a unique use for this instrument. A general in Africa had maneuvered to avert a war by having the natives look through the telescope the wrong way; convinced that the enemy is still far away, they do not arm themselves. The extra time enabled the military man to work out a compromise between the two tribes.[55]

Mr. Barlow shows Tommy an instrument this is useful for demonstrating perception. Of all the instruments that are discussed, this is the only one described as "too difficult to explain." The magic lantern is explained as some "bits and pieces of glass."[56] By the late 1780s, when Day was writing, the magic lantern was already considered an excellent instrument for teaching children the nature of light, and the processes of refraction and reflection, as well as the notion of perception. Of course, these issues had already been popularized by Algarotti and were, certainly by this time, part of the general vocabulary of anyone interested in the new philosophy. Benjamin

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[55]Ibid., 199-204.

[56]Karen Patricia Smith, *The Fabulous Realm: A Literary-Historical Approach to British Fantasy, 1780-1990* (Metuchen, N. J.: Scarecrow, 1993),102, places the invention of the magic lantern around 1843 and credits August La Pierre as its creator. However, a detailed description of a magic lantern is already in place in 1763. Benjamin Martin, *Philosophy for Young Ladies and Gentlemen* (London, 1763), 1:2, not only describes and explains this instrument but also gives a detailed diagram of it. Although an interesting topic, the detailed description of the various instruments mentioned in these stories is outside the scope of this dissertation. An inquiry with the Science Museum of London indicates that the King George collection may have such lanterns. See Alan Morton and Jane Weiss, *Public and Private Science* (Oxford, Oxford University Press, 1993).

Martin had presented a detailed diagram of one version of the magic lantern in his publication for young people.

While traveling through the town with Mr. Barlow, the boys observe a crowd gathering for a demonstration. First, card tricks are performed; then the conjurer brings forth a swan floating in a basin of water. When the man whistles, the wooden swan swims to take the piece of bread the magician offers. Since this is not a living thing, everyone is astounded as the swan swims to its master. Several other people attempt the same whistle and offer bread, but the animal ignores them. Tommy is bewildered. A few days later, Harry explains the trick to him, and they begin the study of magnets, the lodestone and the relationships that exists between a few well-placed needles and iron filings. Because magnets were often used by conjurers and magicians, some educators frowned on teaching about magnetism except in the context of its utility in navigation.[57] Mr. Barlow turns the discussion to shipping. He discusses the discovery of the role of magnetism and its uses in guiding ships. The talk of shipping leads to a discussion of various expeditions and the children are led to consider the lifestyles of other nations.

An examination of the flora and fauna of Greenland leads to another anthropology lesson characteristic of much of Day's work. This time, however, it is not the people but the dogs who are the subject of study. Day shows how the dogs' abilities, the demands of the Greenland's weather, and the needs of the humans come together to overcome some of the harshnes of their environment. He explains that the use of the dogs for pulling sleds is not cruel, since the dogs' efforts are needed for humans to survive. He represents

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[57]Patricia Fara, *Sympathetic Attractions: Magnetic Practices, Beliefs, and Symbolism in Eighteenth Century England* (Princeton: Princeton University Press, 1996).

this special case of harsh treatment not as unkindness to the animals but as a necessary component to survival based on the rigors of the difficult environment. It is important for the boys to understand that the conditions are such that humans also suffer greatly. Man trains the dogs to pull sleds through the snow. Because life is so harsh there, man does not have much choice if he is to survive. The lesson that man's existence is often dependent on other animals is reiterated yet again. Iceland serves as another example of the harsh environments that people have acclimated to with the help of animals. Tommy declares that if he were in Iceland he would not succumb to such rough treatment. Mr. Barlow asks how he would prove his superiority. Tommy replies, "I would tell them I am a well-brought-up boy."

This answer would suggest that Tommy has not lost his rather self-satisfied demeanor. This is further demonstrated when Harry is invited by Tommy to visit his father's estate. The entire episode is a disaster. Tommy joins his old friends in ridiculing Harry for his country ways. At a party, the young girls single Harry out for further humiliation. He is outraged at the rudeness of the gentry at the theater, where the boys throw oranges and disrupt the performance. Their waste of time and money, their insipid conversations and their disregard for the rest of society repel him. Finally, he beats up several of the boys and returns home with an ode to the simple life:

> The fields looked all so pleasant, and the cattle, that were feeding in them, so happy; and then every step I took I met with somebody or other I knew, or some boy I used to play with. . . and the very cattle, when I went to see them, seemed all glad that I was home again.[58]

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[58] *Sandford and Merton,* 2:101-102.

What is an unusual and a trifle surprising outcome for a children's book is that the boys, who have been learning together for well over a year, do not remain friends but go their separate ways, neither apparently having learned much of anything from the other. There is an attempt at the end of the book to have them declare some mutual admiration but it is quite unconvincing. Day's handling of the boys' relationship is more than a trifle autobiographical, reflecting his own stormy relationships.

Sandford and Merton represents a hiatus between the elaborate dialogues characteristic of much of the early scientific writing for children and the narrative and delightful stories that Maria Edgeworth later provided for the sheer fun of storytelling. Day's most valuable contribution, promoting understanding of distant cultures and varied lifestyles, was different from many other writers who presented all the inhabitants of the new world as "savages." Day shifted the focus of storytelling toward more positive awareness of other cultures. He encouraged philanthropy in his writings and he highlighted the injustices of slavery. Day is important because of his connections to the Lunar Society, the Edgeworths and his unique reading of Rousseau. Day's literary offspring, Sandford and Merton, learned the importance of natural history and applied science, within a setting far removed from the industrial world being envisioned by the rest of the Lunar Society. But they do learn to survive.

Chapter 5

Maria Edgeworth and *Harry and Lucy Concluded*

In 1767, Maria Edgeworth was born into a family already disrupted by the antics of her older brother, Richard. Her mother was not well and died when Maria was six years old. Maria spent her early childhood shuttled among relatives. After her mother's death, Maria proved to be a difficult child. Maria's disruptive behavior, rudeness at tea time, and a tendency to break tea cups were viewed with alarm. When Maria smashed all the glass panes intended for the new greenhouse, the decision was made to send her away to boarding school. There, a lonely little girl, she found friends who were enthralled by her storytelling ability.

Maria soon learned that her one entrée into the social world was her ability to spin an engaging tale. From this early experience, Maria developed into a more than competent storyteller. Eventually, she became one of the first women novelists. As part of the family's educational endeavor, her tales also became the vehicle for an extensive course of instruction in science for children. Many aspects of Maria Edgeworth's works have been studied, but little or no attention has been paid to her contribution to science education for children.[1]

Maria was a child raised in a constant maelstrom of emotion. Her early years were spent in her father's ancestral home in Ireland. Because of her mother's death and her father's desire to travel on the continent, she was transported to an aunt's house, where she was left in the care of servants. Even after her father remarried, she was largely ignored while he was totally absorbed with his new wife, Honora.

Maria was the second oldest of a family that ultimately saw a household of twenty-two children.[2] In boarding school she entertained her friends with ghoulish stories. Because her letters were so boring, her father encouraged her to write stories rather than attempting to send letters home. Her stories were to grow out of her own imagination, since her father had forbidden her to read novels. Far from family, and reportedly very lonely, she was generally left to her own devices. She entertained herself by constructing stories and story lines for both children and adults.

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[1]B. G. McCarthy, *The Female Pen, Women Writers and Novelists* (New York: New York University Press, 1994), has characterized her as the greatest of the didactic moralists. Elizabeth Kowalski-Wallace, *Their Fathers' Daughters, Hannah More, Maria Edgeworth and Patriarchal Complicity* (New York: Oxford University Press, 1991), deconstructs Locke and Freud in the trashing of the paternal instinct that drove daughters to produce works that were not truly their own. While Wallace alludes to the stories for children, she makes no mention of Maria's writings on science. Marilyn Butler, *Maria Edgeworth* (Oxford: Clarendon Press, 1972), in her extensive work on the Edgeworths, acknowledges the scientific contribution of Maria Edgeworth, especially as it relates to children's literature.

[2]Her brother Richard had been raised by Day and Edgeworth in an unsuccessful experiment that saw the brother exiled to the Day household by the time he was 17.

When Honora died, Edgeworth turned his attention to Maria, who was now a young lady desperately seeking affection. Maria was short,[3] physically unattractive, and painfully shy. Her prospects for marriage were dim. Glad to have finally captured her father's attention, she turned to completing the educational work her father had begun, using her considerable talents as a storyteller to instruct both parents and children. The combination of Maria and her father, Richard Lovell Edgeworth, present a formidable alliance in the production of scientific material for children. As a member of the Lunar society, Edgeworth was in sympathy with many of the society's radical political leanings. He was especially influenced by Priestley and shared his support for the American and French Revolutions. Heavily influenced by the philosophy of Locke and the writings of Rousseau, the Edgeworths produced a prodigious number[4] of stories and books and attempted to integrate their ideas into a comprehensive and scientific theory of education.[5]

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[3]Seward reports that Maria was so short that the family tried hanging her by her neck in order to give her greater stature. One only hopes that this is another exaggeration by the vindictive Mrs. Seward. Disappointed in her desire to marry Erasmus Darwin, Seward wrote rather uncomplimentary stories about him and his circle of friends. In Edgeworth's memoirs, completed by Maria, reference is made to the vicious attack on Darwin, which Seward published immediately after Darwin's death. Maria openly accuses her of slander. *Memoirs*, 2:266-269.

[4]The *Parent Assistant* series had over sixty stories, *Early Lessons* had at least twenty different stories. The *Harry and Lucy concluded* series went to four volumes. Another series, *Popular Tales*, included at least another twenty stories.

[5]Edgeworth kept records of the learning styles and progress of his children. He tried to set up a systematic approach to judge the value of various techniques. Using his own twenty-two children as subjects, he was able to elaborate on his ideas in a variety of forums, but mainly through Maria's early writings. Mitzi Myers, "Warranted Entertaining: Tasks, Toys and Books in Maria Edgeworth's *Practical Education,*"

Maria was also greatly influenced by the Lunar Society. As a major figure in the Lunar Society, her father's educational theories resulted in large part from his conversations with Joseph Priestley[6] and Erasmus Darwin, as well as his unique reading of Rousseau and Locke. Moreover, Maria lived for a short time in the home of Thomas Day, another member of the Lunar Society. Day influenced her thinking and she was fully aware of his influence on her father. Maria agreed with the members of the society, who believed that home was the proper site for education. Later, not only was Maria carrying out the dictates of Day, Priestley and her father, but her stories were often biographical sketches of her own life.

This dissertation is concerned with the show that occurred as Newtonian science influenced the general culture of England in the latter half of the eighteenth century. Changes include the movement away from rote learning and acceptance of authority in favor of scientific inquiry and experimentation. Maria wrote three series of books, all of which illustrate this shift. These series, *The Parent's Assistant, The Early Lessons* and *Harry and Lucy concluded,* all seek to teach children scientific principles. In addition to the science they present, they also reflect the growing social awareness linking hard work

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Presentation at Inaugural Conference of the Cotsen Children's Library, Princeton University, October, 30 1997.

[6]Priestley, a dissenter, having been excluded from the established English educational system, attended Daventry and later taught at Warrington. These were two of the more important dissenting academies. After leaving teaching, he wrote *An Essay on the Course of a Liberal Education (London, 1768)*. It was based on courses taught at Warrington. He argued for reasoning over memorization and urged a more utilitarian selection of subject matter. Butler, *Maria*, 60-62.

and useful endeavors with emotional and economical success. Issues of nationalism are present to the degree that applied science is related to economic success for Britain.

Maria is best known for *The Parent's Assistant*.[7] This six-volume collection of stories for children, written in very sophisticated language, aims to teach a variety of lessons, not the least of which are the rewards of hard labor. The stories in the *Parent's Assistant* always have a happy ending and reaffirm the innate goodness of the individual. This series, first published in 1796,[8] stresses the combination of hard work, virtuous living and knowledge of scientific principles that is necessary to move the protagonists along the path of success and wealth.

As Maria states in the introduction, ". . . it [the book] is intended to incite with a spirit of industry, separating, as much as possible, industry and avarice."[9] This statement is basic to an understanding of much that transpires in all of these stories. Jacob[10] identifies the concern with industry as one of the pivotal issues of the seventeenth century. Tracing the idea from the Baconians through the Royal Society virtuosi, Jacob proves that sufficiency, not avarice, was the explicit goal of the science-driven industry.

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[7]Maria Edgeworth, *The Parent's Assistant or Stories for Children* (London: Baldwin, Cradock, and Joy, 1817). All further references will be cited as *PA*.

[8]It was actually written much earlier, but Edgeworth was so aware of Thomas Day's disapproval of women writers that he did not allow his daughter to publish anything until after Day's death.

[9] *PA*, Preface, 1:9.

[10]James R. Jacob, "The Political Economy of Science in Seventeenth-Century England," *Social Research* 59, no.3 (Fall 1992):506-532.

The idea of untold wealth was not seen as a benefit for the individual nor was it seen as beneficial to society. In his work, Jacob makes clear the difference between work as a social good providing a sufficiency of products and employment and the more prevalent linkage of avarice with capitalism. This latter view, associated with Max Weber and Robert Merton,[11] makes acquisition a measure of the success of industry. The common good is secondary to the goal of individual riches. With the expansion of personal wealth, the desire for conspicuous consumption feeds upon itself, demanding greater goods to satisfy newly created wants. This view of industry is a far cry from the earlier views of Boyle, Wren, Platts and the founders of the Royal Society. It is also a far cry from the sentiments Maria is espousing. She would have the child see competency as an intrinsic reward, hard work as a prerequisite to satisfaction, and frugality as insurance against scarcity.

In general, her method, much like Day's, is to contrast two children --divergent in temperament but similar in background-- who, primarily because of parental influence, represent opposite lifestyles: One child is geared toward virtue and industry; the other is clearly on the road to perdition. Some children are maneuvered into a more industrious path. Often, however, a bad child is portrayed as unredeemable, not because the child is innately bad but because he is unable to escape bad habits formed in the early years. In

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[11]Talcott Parson, *Max Weber: The Theory of Social and Economic Organization* (New York: Oxford University Press, 1947), and Robert Merton, *Science, Technology and Society in Seventeenth Century England* (New York: Harper and Row, 1970).

"Lazy Lawrence," the young boy who has gone astray is sent off to Birdswell for a month, but the stableboy who led him astray is transported to Botany Bay.[12]

The stories present a wide variety of ne'er do well parents as well as a statistically unusual number of orphans. There are several reasons why the child might be presented as an orphan. The historical record indicates that frequent childbearing killed women at an early age, leaving their offspring motherless. Additional blows of fate, illness or accident also rendered many children fatherless. On a more subtle, psychological level, if an author wants to teach self-reliance, there is nothing more starkly independent than an orphan abandoned to his or her own devices.[13] Certainly one could speculate that Maria herself often felt like an orphan and found it easy to portray these feelings in her characters.

Some of the stories are set in other countries, many in the English countryside, and a few in London. The stories that take place outside England always have an additional theme of English nationalism.[14] The setting for "The Little Merchants" is sunny Italy, with all the local color one might expect. The main characters are two young boys, Francesco and Piedro, each of whom quickly settles on his divergent path of

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[12]*PA*, "Lazy Lawrence," 1:72.

[13]Isaac Kramnick, "Children's Literature and Bourgeois Ideology: Observations on Culture and Industrial Capitalism in the Later Eighteenth Century," *Studies in Eighteenth-Century Culture* 12 (1983): 11-44.

[14]Margaret Hunt, "Racism, Imperialism and the Traveler's Gaze in Eighteenth-Century England," *Journal of British Studies* 32(4) Oct.1993:333-357, delineates the varieties of nationalism and racism abounding in English writings. She points out that stereotypes persist and travelers continued to see the faults of the French, Irish, Indians and Dutch as ingrained and resistant to change.

honesty or dishonesty, as the case may be. Both boys have stalls in the marketplace. The first indication of the difference between Francesco and Piedro occurs in their interaction with an English servant who stops to buy a melon. Francesco, who is the proprietor of the fruit stand, points out a spot on the underside of the melon. The English servant is much impressed by Francesco's honesty, especially as Piedro had sold him stale fish the day before.

When a disagreement threatens to become a mob scene in the marketplace, the English servant demands that Piedro be given a trial by a jury of twelve peers rather than leaving his fate up to the "emotional . . . mob solution" of the Italians. As the story unfolds, much is made of the value of the Englishman's composure in the face of adversity and his ability to understand the rudiments of justice. It is the English servant who tries to show these "foreigners" the beauty of the English trial-by-jury system, the superiority of reason over emotion and, above all, the loyalty that Englishmen are famous for, since "there is no friend as good a friend as an Englishman." However, the mob rules and Piedro's bench is broken.[15]

The Italians are depicted, not surprisingly, as impulsive, emotional and somewhat irrational. On occasion, a rare Italian hero is presented as staid, brave, honest and true. In light of these national stereotypes, it is not unexpected to find rampant anti-Semitism expressed with phrases such as the "Jew and all of his kind." In every instance, the introduction of a Jew into a story means that someone wants to unload stolen property,

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[15] *PA*, "The Little Merchant," *3: 79-235.* A broken bench was the sign that a merchant was no longer in business - thus the word "bankrupt" or ruptured bench.

borrow money or have some shady work done. There is no exception to that image. In some of the other stories, the individual Italian or Scotsman might prove to be the exception to the stereotype, but the Jew is never depicted in a positive light. As a matter of fact, unlike other minorities in the stories, the Jew is not even given a proper name.[16] The British are portrayed as supreme in most endeavors.

In another story, it is the Scotsman who is looked upon as a shrewd trader and someone to be distrusted. His neighbor had tried to be friendly

> . . . but he still secretly suspected this civility, as he said, was all show and that he was not , nor could not, being a Scotchman, be such a hearty friend as a true-born Englishman.[17]

This inclusion of nationalism in children's stories can be traced to a more general theme in the nation's press and popular opinion. The increase in trade, the conflict with the colonies, and the competition with France all merged to inflame the British with a sense of "empire."[18] Various nationalities were seen as more or less distanced from the British cultural ideals of justice and what J.G.A. Pocock[19] has called civic humanism

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[16]Maria was, by all reports, a very warm and accepting person. This is especially interesting since, in her later writings, she worried about offending other nationalities. Rather than depicting a character in *Helen* as a Scotsman who destroyed his property to gain status, she changed the character to an Englishman. She apparently was horrified when she was older to find that she was accused of anti-Semitism and wrote a story with a Jewish hero in order to exonerate herself. Butler, *Maria,* 267-268.

[17]*PA,* "Forgive and Forget," 5:220.

[18]Bob Harris, "American Idols: Empire, War and the Middling Ranks in Mid-Eighteenth-Century Britain," *Past and Present* 150 (Feb. 1996):111-141.

[19]J.G.A. Pocock, *The Machiavellian Moment: Florentine Political Thought and the Atlantic Republican Tradition* (Princeton: Princeton University Press, 1975). These

(commitment to the public good and the subordination of individual or selfish interests). In contrast to Day's favorable treatment of other cultures, there is, in Maria's books, a consistent ethnocentrism that allows only the English and the Irish to be heroic.

After the triumph of *The Parent's Assistant,* Maria was urged to do more writing on scientific topics. In response, she wrote *Early Lessons,* aimed at the age group from four to seven. She was somewhat overawed by the endeavor and felt that she did not have the proper grasp of science to publish such material. However, she felt it was necessary to teach her little brother, William,[20] all the science that he needed to know and she dedicated *Early Lessons* to him. The stories are not terribly compelling and they lack the insight and story line found in *The Parent's Assistant. Early Lessons* attempted to present both science and morality. Frank, a precocious six-year-old and the protagonist in this four-part series, is a bit of a plodder and these stories, unlike Maria's earlier works, should be read in sequence. These stories were more contrived, as they serve to instruct rather than to entertain.

After the publication of *Early Lessons,* Maria returned to an earlier project that had been abandoned by Edgeworth and his second wife, Honora. They had attempted to write a series that would extend the instruction in science for children from four to fourteen years of age. The goal of the series was to teach all the scientific principles one might need for the remainder of one's school years. Shortly before he died, Edgeworth

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virtues would eventually lead the individual to greater personal glory whether in war or in trade but that was a secondary gain and subservient to the greatness of Britain.

[20] Edgeworth, as part of his educational experimentation, turned his son William over to Maria to raise so that some of his theories could be tested.

gave Maria eighteen pages of scientific information[21] which she was expected to incorporate into her stories. After several false starts, she wrote a four- volume set entitled *Harry and Lucy Concluded*.[22]

This series is the first of the books under consideration to make applied science a topic of study. Each episode is intended to bring the reader one step closer to an appreciation of applied science and to suggest ways in which such thinking will revamp England. Isaac Kramnick [23]sees Maria and others as leading an assault on the position of the aristocracy. Day condemned the aristocracy for existing. Maria simply shows the relationship between industry and economic expansion. She has the children tour a variety of commercial establishments. In each case, the point is made that both the workmen and the customers are enjoying a better life.

Initially started in 1796 and finally published in 1825, *Harry and Lucy Concluded* represents Maria Edgeworth's attempt to follow the spirit of the eighteen pages of scientific notes given to her. The first volume of *Harry and Lucy* introduces a wide range of scientific equipment, much of which is geared to various types of measurement.

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[21]These eighteen pages remained in the possession of the Edgeworth family until they were given Bodleian library. Now available on microfilm, I found the writing to be more stream-of- consciousness than any systematic presentation of material. It is not unusual to find on the same page a discussion of galvanism, a quotation from Voltaire, and an outline of a method for teaching language.

[22]The first *Harry and Lucy* was written for very young children. The title was abandoned and reworked as *Early Lessons*. In a letter to his daughter, Edgeworth reacts strongly to the first *Harry and Lucy* because it was too difficult for the four-year-olds it was geared to. He admonishes Maria that it will turn the children away from ever reading again. Edgeworth, *Memoirs*, 1: 358.

[23]Kramnick, *Children's Literature, 227.*

After a discussion of the appropriate material for study by both boys and girls, Maria proceeds to a rather turgid discussion of barometers and hygrometers. Some of it is amusing, such as the considerations as to why Lucy's hair comes uncurled in the rain. This leads to a discussion of other ways to measure moisture in the air.[24] Harry is given a portable barometer and is so intrigued by it that he climbs to the top of the church steeple *twice* in order to record the correct measurements. Lucy, on the other hand, does not find the process of measuring and remeasuring to be particularly enjoyable. She is more intrigued by the little men and women who pop out of their house to predict the weather than by her brother's extensive and pedantic explanation of the hygrometer. Lucy finds the brightly clad figures delightful; in fact, she is so enchanted by them that she fails to follow the discussion in which her brother is pointing out the really important elements in a diagram of the hygrometer. Lucy is quickly made aware of her brother's displeasure and is reprimanded for her lack of attention. Eventually, the principle on which a hygrometer works is spelled out in detail.

The family spends a great deal of time discussing scientific instruments. The children talk about a particular diagram of a hygrometer; they discuss various parts of the diagram but no accompanying diagram is provided for the reader.[25] Lucy has a difficult time following the discussions, but she finally comes to understand the principles involved. As her reward, she is shown yet another hygrometer, one composed

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[24]*Harry and Lucy*, 1: 44.

[25]The diagram in question is of DeLuc's whalebone hygrometer. I have not been able to find a copy of this diagram.

of a type of Indian grass, a grass not unlike a plant known as " the beard of Abraham." It is similar to English oats. This Indian grass twists and untwists with dryness or moisture making from ten to sixteen revolutions. The conditions range from extreme moisture to extreme dryness.[26] The source of this wonderful instrument is found in the *Rees' Cyclopedia*[27] and was the remarkable invention of Captain Henry Kater. While in India, he needed a very sensitive hygrometer. He discovered he could use a certain native grass that proved to be sensitive to moisture. When removing his socks, he noticed the grass had wound itself very tightly. Kater [28] proceeded to develop a new type of hygrometer.

> "How very lucky that it plagued him that day," said Lucy, "by sticking in his stockings."
>
> "How well it was that he observed its properties when he took it out," said Harry, "and applied it to some good use."[29]

The children's uncle, who has been explaining this wonderful instrument, has two friends: one in America and one in Ireland, both measuring humidity with Kater's hygrometer. The children agree that they will keep track of the moisture for England.

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[26]*Harry and Lucy*, 1:79. Reference is made to the fact that Hook(e) had created a hygrometer from English oats.

[27]*Rees' Encyclopedia* will be discussed in detail later in the chapter.

[28]Captain Kater is one of the many individuals mentioned in the text. These names form a sort of index of the popular scientists of the day. They were, for the most part, individuals who were extending the usefulness of science onto the industrial scene.

[29]*Harry and Lucy*, 1:83. This aspect of serendipity is referred to often in discussing various inventions and discoveries. It is the ready mind that turns the tide, **not** the luck of the event. With almost every consideration of the virtue of industry goes the admonishment not to trust in luck or chance.

They are admonished that if they take on this task, it must be done with accuracy and they will be required to keep a record for six months. Lucy feels that to be a long time to remain loyal to the task, but Harry does not see it as a problem, especially since Lucy can keep the numbers in neat columns and act as his secretary. At a slightly earlier period there had been a worldwide attempt to collect information on weather conditions. It was conjectured that worldwide weather conditions could be used to predict and control disease. Later, the amount of heat and humidity in the air was linked to electricity and magnetism.[30]

The two children investigate the air pump. Harry has a glass pump [31] that is readily available for Lucy to see. Several types of pumps are discussed, the principle of the vacuum is explained and, finally, Boyle's air pump is analyzed. Harry reminds his sister that it was really Otto von Guericke's invention.[32] The children go into the yard to use the pump to demonstrate all that they have learned. Later, the father explains to them that in London inventors have figured out a way to make ice using the air pump. The children try such an experiment but are not terribly successful. Then they attempt to make ice cream in an air pump. When this effort does not work out, their father

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[30]Geoffrey Sutton, "Electric Medicine and Mesmerism," *ISIS* 72 (1981): 375-392.

[31]The quantity of scientific equipment in the possession of these two children suggests one of two things. Either the growth of the manufacturing of scientific equipment made it relatively inexpensive to own or the Edgeworth household was so unique that Maria never questioned that these elements would be available for other children.

[32]*Harry and Lucy*, 1:116 Throughout the series there are references to inventors and discoverers not usually associated with a given invention. The source in each case seems to be *Rees' Cyclopedia*.

promises to take the children to London to see the ice machine made by Mr. Carey. For the Edgeworths, there should always be a reward for attempting to master an idea.

In another experiment, Harry wants to construct a keystone bridge. He sets out to build such a bridge across the small stream on the property. The first attempt washes away before his parents even get a chance to see it. The second venture, which costs his father a considerable sum of money because he has to hire masons, also ends in failure. The bridge remains standing but is apparently unstable since a mule absolutely refuses to set foot on it, and that alerts everyone to the danger of the bridge. It must be torn down. The failure of the bridge is used as a way of enforcing two messages: that one should not attempt projects without sufficient information and that knowledge of mathematics is prerequiste to any engineering project. The problem is resolved when Harry builds a suspension bridge of much simpler design.

In the 1780s, certain regions of England had already begun to experience economic change as factories replaced farms as the major source of employment. The parents of Harry and Lucy want the children to understand the changes that science has brought about. They undertake a tour of England. The children are taken on a tour of the Midlands of Industrial England during which they have a series of adventures. They descend into a coal mine, tour Sir Richard Arkwright's textile factory, and travel on a steamship perfected by Isaac Watts. All these activities increase their enthusiasm for science and for new experimentation. At the same time, serious questions arise as they experience the beginnings of the Industrial Revolution. The landscape has undergone a transformation. Green fields and rolling hills are replaced by smokestacks and chimneys spewing forth dirt and grime. Coal fields are needed to feed the furnaces of industry and piles of coal become an unsightly feature on the horizon. While Harry is enthralled with the machinery, the assembly line, and the rapid output of material products, Lucy laments the dust, the dirt, the scars on the landscape, and the smell of smoke and burning coal. Some serious questions are raised as to whether the machine is a an unqualified blessing. Lucy wants only to get away from the noise, the dirt and the confusion of the factories. She is frightened by the machines and does not like the conditions under which people are forced to work.

Industrialization completely changed the rhythm of life for the workers. They now are forced to answer to a series of bells, to work all day every day, and to find time for enjoyment outside the work day. There are no seasonal variations to break the pattern of work, as there had been on the farm. Employers made demands and regulated activities that impinged on the life of the factory and on the workday of the individuals. Even leisure activities were subject to the factory owners approval.

But despite misgivings, the trip continues and various famous figures are brought into the discussion. The highlight of the trip is a visit to the Wedgwood factory. Josiah Wedgwood(1730-1795) exemplifies the combined thinker and doer much admired by the Edgeworths.[33] His business sense, combined with the scientific skills of John Keir and Matthew Boulton, enabled him to develop his pottery works from a local family-

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[33] As a member of the Lunar Society, Wedgwood communicated extensively with Matthew Boulton, "toymaker" and silversmith; John Keir. an experimental chemist, and William Small, a physician and sometime professor of mathematics. These men linked their scientific knowledge with Wedgwood's business acumen to create one of the great industries of the eighteenth century.

owned business into a world-renowned enterprise. He used Erasmus Darwin's ingenious horizontal windmill in manufacturing pottery. [34]0.Reilly, 113.[35]

When Maria wrote for children she singled out Josiah Wedgwood as the prime example of a man able to marry science with industry. He was both a social reformer[36] and an inventor. Like other members of the Lunar Society, he was a dissenter and a radical liberal.[37] In *Harry and Lucy,* the children are given two gifts, the "slave medallion"[38] and a Sidney Cove medallion. Both medallions were produced by Wedgwood's Factory. The Sidney Cove piece was made in 1789 from clay brought back from Sir Joseph Banks' voyage to Botany Bay. The clay was not easily shaped into pottery but, not wanting to disappoint Sir Joseph, Wedgwood worked with it until he was able to produce a marketable medallion. He created it to encourage the natives of Botany

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[34]John Brewer, *The Pleasures of the Imagination* (New York: Farrar Straus Giroux, 1997), 594, points out that many of Darwin's inventions were immediately adopted by Wedgwood as he attempted to improve his factory system. Wedgwood also enjoyed engaging Darwin in controversial discussions of slavery, economics, free trade and copyright laws -- some of the more important political and social questions of the day.

[36]Anthony Burton, *Josiah Wedgwood, a Biography* (London: Andre Deutsch, 1976), 199. He emphasizes Wedgwood's intense interest inthe question of slavery and his contributions to the Society for the Suppression of the Slave Trade.

[37]Isaac Kramnick, "Eighteenth-Century Science and Radical Social Theory: The Case of Joseph Priestley's Scientific Liberalism," *Journal of British Studies* 25 (January, 1986):1-30.

[38]Thomas Day wrote a poem, "The Dying Negro," and Wedgwood commemorated it with a medallion. The medallion was used to further the abolitionists' cause both in England and in America.

Bay to make something useful out of the clay. The inscription read: "Work for Prosperity in Hope -- encouraging Art and Labor with Peace."

Wedgwood developed an elaborate system of measuring the temperature of fire in a kiln. He began by testing the change occurring in small bits of clay when they were immersed in fire. *Lucy and Harry* contains a detailed description of the process, describes exactly how the instrument works, mentions what other forms of pyrometers exist, and tells how they differ from this one. When the children pose the question of how the pyrometers can be uniform if different types of clay are used, they learn that Wedgwood has donated to the Royal Society a plot of land containing sufficient clay for the wedges to be universally available for the ages. Although Edgeworth does not credit him as the originator of the clay pyrometer, modern sources do.[39]

Besides the famous Jasper ware and the Queen's ware, Wedgwood also produced many items for children. As the concern for children and their education created new markets, Wedgwood, like many of his competitors, produced cups, plates and cameos for children. These cups and plates were sometimes imprinted with a special recommendation, "For a well-turned Seam" or "For a Good Boy." Other items expounded special virtues, such as thrift, temperance, generosity, and, always, industry.[40]

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[39]Neil McKenrick. "Josiah Wedgwood and Factory Discipline," *The Historical Journal* 4, 1(1961):30-55.

[40]Noel Riley, in *Gifts for Good Children: The History of Children's China 1790-1890* (Somerset: Richard Dennis, 1991), 68, found only about fifteen pieces of the sixteen hundred items in the collection marked specifically with the Wedgwood stamp. This is not surprising given the fact that about seventy-five percent of this material is unmarked. It was very cheap ware and not worth the extra time and expense of providing an imprint. Riley also points out that various other potters sometimes forged Wedgwood's name to

It is safe to assume that many of the plates and cups featuring maxims by Benjamin Franklin originated in the Wedgwood Factory, for they were close friends and shared political and scientific concerns. He would have seen Franklin as a more than adequate role model for children.

Maria Edgeworth's stories show that scientific knowledge can be acquired from a variety of sources. Some children learn by trial and error, while others turn to adult readings or adult authorities for information. Edgeworth emphasized that practical, utilitarian, mechanical knowledge that a child acquires in his day-to-day environment is of primary importance. In *Early Lessons,* Frank investigates the way in which the tea table is constructed, wondering what will happen if he folds one of its legs. His mother removes the teapot and dishes so he can explore the mechanism that makes the third leg of the table a stabilizing force.

Both *Early Lessons* and Maria's later work, *Harry and Lucy Concluded*, contain a variety of discussions about the way things work. Not only are the children encouraged to investigate mechanical devices, but they are also told of ingenious inventions and elaborate constructions that enable people to do seemingly impossible things. One such instance is the detailed discussion of the Slide of Alpnack, a logrolling device created in Germany. By using felled trees and running water, the ingenious owner of the forest is able to move logs over several miles.[41] Stories of inventiveness allows a child to solve

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be make their own products more saleable.

[41] This device is attributed to an engineer named Rupp. From the text it would seem that this was a much-discussed mechanical marvel at the time. *Harry and Lucy,* 3:171-176.

a problem and turn a bad situation into a success. Some of the information is basic, such as knowing how to use flax, heather, or some particular fiber to build a better shoe, basket, mat or a candle substitute. Knowledge of heat convection enables Harry to explain to the gardener how to place the pipes in the greenhouse so as to provide the correct amount of moisture. When Harry observes gunpowder dribbling from a keg in a cart, he is aware of the consequences if a spark should happen to ignite it. Harry informs the driver of the cart of the problem and a disaster is averted.[42] Children survive because they understand the habits of animals, principles of combustion, or the way tides ebb and flow.

Today one might be surprised to find an article from *Scientific American* embedded in a story by Dr. Suess. However, Edgeworth, in books obviously written for youngsters under twelve, includes verbatim segments from the *Philosophical Transactions*. For instance, "The Little Merchants" is set near Mt. Vesuvius. In discussing the eruption of this volcano in Italy, a description of the event is simply lifted from the *Transactions* and placed in the middle of the story.[43] An expectation that the child will understand sophisticated information is characteristic of Maria's writings. She uses even more complicated material in another story, "The Orphan Children." The children are very poor and the little boy discovers a way of saving money by not purchasing candles. Instead, he processes a reed that grows near an abandoned castle. In

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[42]*Harry and Lucy*, 2:129-130.

[43]Embedded in the story is the history of Mt. Vesuvius taken from the *Philosophical Transactions*, *PA*, "The Little Merchants," 4:160-163.

describing the reeds used in place of candles,[44] Edgeworth inserts a four-page footnote that elaborates on the manner of collecting, preparing and using the rush-- the way to pick it and preserve it --so that it serves as a candle-substitute. The author shows value of applied science in everyday life. There is a lengthy discussion of the amount of money that could be saved by the poor in England if they would use this method and not waste money on candles.[45]

A third source of scientific information is seen in the story of the orphan children forced to live in the remains of a broken-down castle. A family of poor children, abandoned by their father, left orphaned when their mother dies, ousted from their home by the wicked landlord, take up residence in a dilapidated castle. Each child, through a knowledge of the natural world, elementary science or native wit, manages to produce something that can be sold, bartered or utilized for his or her survival. The local aristocratic ladies periodically assist the children with food, flax or shoes. When one wall of the castle collapses, the orphans find a hoard of gold pieces. They turn to their benefactor, a young woman who has taught them much, to learn how to deal with this windfall. They sensibly take it to their friend and benefactor who, as the author suggests, "being of a higher social class also has a superior knowledge." Having an extensive knowledge of chemistry, the young woman applies *aqua regia* to the coins. By this activity she is successfully establishes the gold content of the coins. One of the orphans

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[44] *PA*, "The Orphan Children," 84 -86.

[45]Maria quotes her source as Cf. Whyte's "Natural History of Selbourne" quarto edition. 198. Ibid., 85-88.

remembers seeing a book with pictures of antique coins. They find the book and check the age of the coins. The children turn the gold over to the ubiquitous crooked lawyer. Although he attempts to cheat them, they finally reap the reward of their honesty and endeavors.

The distinguishing mark of the *Harry and Lucy* series is the consistent use of experimentation by the children. In Elizabethan times, it was popularly believed that the barnacle goose had an unusual origin. The presence of the goose near barnacles caused people to assume that the goose sprang from the barnacle. Harry and Lucy ridicule such naïveté and proceed to set up conditions for an experiment, including the need for an unbiased observer, controlled conditions, and logical reasoning. The same conditions need to apply in any experiment. It was common practice to use birds in situations where they might die from iron fumes so as to alert humans to this hazard. Lucy points out that it is not a good experiment because there is no evidence that the lungs of birds and man have anything in common. What is deadly to a bird might not be deadly to a human.

When Lucy tours the garden of a noted horticulturalist, she decides that she will alter the treatment of her own rosebushes so they will flower far into the fall. When she declares that she will treat all her roses this way, Harry immediately cautions her to try the new process on only half the bushes or it will not be a fair experiment.

Horticulture seems to be the starting point for many scientific endeavors. Not only must one know how to dig and plant; one must also be able to prune, attempt to create hybrids, and identify assorted species of plants. Edgeworth's stories hinge on the rivalries for new plants, the hostility engendered by a neighbor who has the secret of a lush raspberry bush, or the need to keep someone from sharing tulip bulbs. Women seem to have been assigned botany as their special province. There are two reasons for this: botany did not engender philosophical controversy and one did not need to know mathematics.

A social aspect of gardening was the jealousy and hostility engendered over gardens as a major status symbol. The variety of plants, the size of the fruit they produce or the colors of the flowers were points of enormous pride and gratification.[46] The latter part of the eighteenth century is characterized by an obsession with gardens. There is an extensive body of literature showing the great gardens of England and the importance of gardens in establishing one's social position. When Lucy visits a garden, she asks her hostess if she may have some cuttings from both the tulips and the hyacinths. The gardener becomes apoplectic when the lady of the house agrees. He is more protective and competitive than his mistress. There is reference to a not-uncommon practice of agreeing to share a plant with an acquaintance but boiling the root first to ensurre the plant will not grow. In Tillyrand's work on the Lennox sisters she documents their rise in wealth by the renovations in both house and gardens.[47] This rivalry over gardens is

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[46]In " Forgive and Forget" a man refuses to speak to his neighbor. Because his Scottish neighbor grows remarkable raspberries, the Englishman, through a misunderstanding, wrongly believes that the Scotsman will not give him offshoots of the raspberry plant. This feud escalates to the point where the two children are not allowed to speak to each other and end up inadvertently doing physical harm to one child. The story ends with an excerpt from the *Monthly Magazine* about a similar strawberry plant named *Brobdignag. Monthly Magazine*, Dec. 1798, 421. Maria is making the point that her stories are drawn from real life.

[47]Gardens as status symbols have been discussed by a number of authors: John Brewer, *The Pleasures of the Imagination* (New York: Farrar Straus and Giroux, 1997);

reminiscent of some of the excesses of the tulip craze in Holland. More importantly, it signals a change that is brought about by the surplus of wealth. Gardens represent a visible means of showing one's social superiority. Even on a small plot of land, almost everyone can produce a garden, demonstrating both the ability to acquire the plants and the scientific knowledge to bring them to fruition. However, horticulture never attracted as much social notice as did other types of science.

In one story, Lucy, an eighteenth-century Eve, is staying with the Ruperts. She wants to know what is behind the iron door she has been forbidden to open. Harry admonishes her not to open the door even though he realizes "curiosity in ladies is a natural." When Lucy finally "accidentally" falls against the door, she is amazed to find herself in a laboratory designed exclusively for the study of electricity.[48] Her enthusiasm for learning about electricity is contagious, and her brother joins her in begging their host

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Stella Tillyard, *The Aristocrats: Caroline, Emily, Louisa and Sarah Lennox 1740-1832* (New York: Farrar, Straus and Giroux, 1994); Keith Thomas, *Man and the Natural World, Changing Attitudes in England 1500-1800* (New York: Oxford University Press, 1983); Derek Jarrett, *England in the Age of Hogarth* (New York: Yale University Press, 1974), and Paul Langford, *Private Life and the Propertied Englishman* (Oxford: Clarendon Press, 1991).

[48] The description of the workshop would rival many professional establishments. "It was a large irregular room, surrounded by shelves and drawers and racks for tools with various bricks for carpenters and carvers, and for braziers and smiths; three laths were placed obliquely to the windows: in the middle of the room stood a circular saw machine, a lapidary's wheel, and a treadle blowpipe; and there are two flogged recessed, partly screened off, and contrived for a camp forge and a small casting furnace. . . behind these Lucy discovered a door. . . ." *Harry and Lucy* 4: 1-3.

to teach them all about the electrical kite, the Leyden phial, conductors and non-conductors, "electrics" and "non-electrics."[49]

The study of magnetism and electricity demarcates one of the more captivating scientific endeavors of the eighteenth century. In 1703, Newton in his new role as president, headed the Royal Society. He engaged Francis Hauksbee to give a demonstration that would engage the members. Looking for something more exciting than an air pump, he turned to the study of mercurial phosphorous and the light emitted when it was placed in his new chafing machine. The end result was to propel Hauksbee in a direction suggested by Newton, who had earlier demonstrated what Heilbron describes as "chaffing" the top of a telescope lens which caused electrical vapors [sparks] to pour from the bottom.[50] From this point on, the study of electricity became a serious pursuit for a number of English scientists.

Harry and Lucy inveigle Sir Rupert into showing them the electrical lab, they find an remarkable array of equipment. Lucy demonstrates a keen knowledge of electrical terminology and admits that electricity was a lively topic at Aunt Pierrepont's, where she lived for a while. Lucy reports that many of the fashionable ladies and gentlemen were urging the use of electricity to cure many ailments. A spinoff from the extended study of

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[49]All of these subjects are detailed in Joyce's *Scientific Dialogues.* In this book, the father explains in detail to Charles and Emma exactly why and how things work. Maria does nothing of the sort. She simply mentions a piece of equipment or an experiment but does not go into any explanation with the exception of the Leyden phial.
This she seems to have taken almost entirely from Joyce's work.

[50]J. L. Heilbron, *Electricity in the 17th and 18th Centuries: A Study of Early Modern Physics* (Los Angeles: University of California Press, 1979), 231-232.

electricity was the work of a peripatetic lecturer, Nicolas-Phillipe Le Dru, in France.[51] Since electricity was produced in storms and there seemed to be a correlation between certain weather conditions and some diseases, Le Dru proposed a series of cures, most of which involved applying an electrical shock to the affected areas of the body. The medical establishment did not totally reject such "cures" and,for a time, at least on the continent, they were quite popular.

In the story Lucy reports on a variety of electrical treatments. Some women attempted to use them to cure nervous conditions, others to stop head pain. An elderly duke has palsy in his arm cured by electrical shock.[52] (Even Thomas Day used electricity in an attempt to cure his rheumatism). While the children are being shown a demonstration of electrical attraction and repulsion, Lucy asks whether electrical shock has any medical benefits. The vagueness of the answer reflects the state of knowledge of the field in general.[53] She does learn about a variety of experiments being conducted by scientists and pseudoscientists, in the hope of finding some lucrative and beneficial uses for electricity.

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[51]Sutton, "Electric Medicine,"375-379.

[52]The point is made that, shortly thereafter, all the patients find their ailments have returned as the effects of the shock treatment wear off. *Harry and Lucy*, 4:6.

[53]Ibid., 4: 23. The author editorializes: "So far Lucy has not obtained much more actual knowledge than she had before." Maria then comments on the answer given by Sir Rupert: ". . . it is characteristic of the caution and modesty of real philosophers' speech; so unlike the assertions of half-informed persons, or one with conceited pretense to science."

After the discussion of the elements of electricity, the children explore the wonders of the Leyden Jar. The brother and sister investigate conductors and non conductors, as well as the characteristics of amber that initially caused it to be seen as the source of electricity. This section on electricity is the most complete in terms of information, experimentation and explanation -- yet in the end the children are warned away from it as a course of study because electricity is obviously a problem. They are told that the study of electricity is not yet backed by a well-developed theory. There is the suggestion, however, that so many peculiar experiments and suppositions surround electricity, including the notion of electrical shock as a cure, that Maria Edgeworth seems to think it a bit outré for children to be introduced to electricity. It still seems to have something of the occult attached to it.

The problem of the occult and electricity is related to the issue of sympathetic attractions that seem to exist in both magnetism and electricity. Mesmer, through his doctrine of animal magnetism, had created an enormous stir in France during the latter part of the century. His use of presumed magnetic forces in the body to cure it of a variety of ills, also included the use of the electrical "bath" to stimulate the circulation of "appropriate subtle fluids" in the body. Various diseases called for positive and negative baths lasting anywhere from forty-five minutes to three days. The uses of electricity spread into a variety of other venues as philosophers tried to figure out the relationships between magnetism and electricity.

The children are told stories of the latest fad in France, parties where people standing in a circle holding hands while an electrical shock is sent through the group.

The children learn about Abbé Nollet, who had the silk- rope experiment tried on himself and was quite startled to see light sparks leave his body. Lucy agrees to allow herself to be shocked but is quite upset at the effect. She declares an end to her involvement with electrical demonstrations, but she is anxious to learn about other people who have succeeded with electrical experiments. Both Harry and Lucy are intrigued by the practice of suspending a child by silk ropes and then passing electrical current through his body. They are told of Abbè Nollet's famous demonstration of electricity in which he electrified an entire army of guards before the king of France. He was also credited with passing electricity one thousand yards down a garden path by means of wet packet thread.[54] It was one of the first attempts to ascertain whether electricity could be made to travel in a directed channel and thus be harnessed for greater use.

Nollet, like other key figures, takes a secondary position to the more heroic figure of Benjamin Franklin, who is treated in children's literature of the period as one of the great champions of the age. Edgeworth did not praise him for his contributions to the study of electricity. She felt that since he had already seen Nollet's experiments in France, his own discoveries are not all that original.[55] What is attributed to Franklin, more than any original invention, is his acute observations, indefatigable patience, great

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[54]Not to be outdone, Sir Rupert points out that an unnamed Englishman succeeded in conducting electricity for four miles at Shorter's Hill. This is yet another occasion to show the superiority of the English. *Harry and Lucy,* 4:33.

[55]Ibid., 4:36.

curiosity in trying experiments, close reasoning and innovative designs. Maria greatly admired his intellectual powers.[56]

In the first book of the *Harry and Lucy* series, Harry is entranced by a book that he finds in his father's library. His father removes the book and warns Harry not to read it. In the last book of the series, Harry rediscovers the book in the library of Sir Rupert Digby and, again, begins to devour it. The book may well have been Joseph Priestley's *History of Electricity,* as it would seem to be an enticing text for the child. It is replete with experiments and diagrams pertaining to electricity. The children are anxious to pursue these experiments. But their father hovers over the enterprise with great disfavor. Finally, he strongly urges the children to give up the study of electricity. He explains that it is a very new science and the material they are reading is already wrong. "But," protests Harry, "certainly the experiments cannot be wrong!" His father agrees because, obviously, the empirical data are always true, but the theory is not yet right and it will be very difficult to unlearn. The notion of primacy[57] in learning is certainly way ahead of its time in the Edgeworth's philosophy. As the father tells Harry, "Because you learned it wrong at first, you cannot get it out of your head."[58]

The children are not totally discouraged from reading about electricity because there is an extended discussion of "The Electric Party of Pleasure." Such a party utilizes

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[56]Ibid., 4: 46-49.

[57]Psychologists have proved that a thing first learned is hard to unlearn. A.S. Luciens, "Primacy-recency in impression formation" in *The Order of Presentation in Persuasion,*.ed. C.I. Hovland (New Haven: Yale University Press, 1957)

[58]*Harry and Lucy*, 4:55.

all things connected with this wonderful discovery. Not only will there be electric eels but the

> "turkey is to be killed by an electrical shock, roasted on an electrical jack before a fire kindled by an electrical spark; the health of all the company to be drunk in electrical bumpers, under the discharge of an electrical battery.[59]

They also learn how Boyle made light shoot from a diamond in a dark room. The discussion of Newton's discovery of "excited glass" whets the children's appetite for more electrical experimentation and they return to the laboratory for another session with the Leyden jar.

In order to provide the necessary background for such experiments, Maria relied heavily on the first-hand knowledge she received from members of the Lunar Society, but she also made extensive use of two popular sources, *Scientific Dialogues* and *Rees' Encyclopedia.*

When Harry and Lucy lack specific information, they turn to *Scientific Dialogues* by Rev. Joyce. He was a minor eighteenth-century scientific and political figure. He spent time in the Tower of London, having been accused of treason, but was later released. As is usual in these texts, the author is closely associated with the Edgeworths. The preface of the first edition makes several pointed statements about the soundness of Richard Lovell Edgeworth's educational theory. The second volume of the three volume set is dedicated to Maria. These books go far beyond any of the attempts by Maria Edgeworth to teach science. The subjects are treated in depth, the explanations

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[59]Ibid., 4:51. Maria indicates this piece was originally written by Franklin.

include complex mathematical reasoning, and each chapter ends with a series of examination questions. Ideally suited to home instruction, these volumes represent a serious attempt to carry forward the ideal of home schooling in science.

Scientific Dialogues,[60] as the name implies, consists of a series of discussions between a father and his two children, Emma and Charles. The first volume follows this format but subsequent volumes evolve into a discussion between the boy and his tutor. The content of these three volumes includes most of the material currently associated with an introductory general-science class, including attraction and repulsion of matter, the attraction of gravity, hydrostatics, pneumatics, electricity, and astronomy. But the author does not include a discussion of chemistry. He acknowledges the need for such a chapter and states that his original intention was to provide important chemical information. Joyce suggests that chemistry is little more than a series of tables showing possible elements and their products resulting from combinations and solutions for each element. The tables were constantly undergoing change from printing to printing and represented a significant outlay of money for the printer.

Scientific Dialogues includes, in the final chapter, a discussion of "Recent Discoveries" encompassing such items as Foucault's pendulum, the screw propeller, and the telegraph as well as an extensive discussion of electricity. The chapter ends with a list of thirty- three facts that one should know about the latter subject.[61] Interestingly enough,

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[60]J. Joyce, *The Scientific Dialogues for the Instruction and Entertainment of Young People in which the First Principles of Natural and Experimental Science are Fully Explained* (Philadelphia: 1815), New American Edition, vols. 1- 3.

[61]*Scientific Dialogues*, 543.

those thirty- three facts bear a strong resemblance to the elements that Maria stresses as Harry and Lucy cavort through the electrical laboratory of Sir Rupert. The first discussion centers on the connection between amber and electricity. Although Maria does not spell out the relationship, Joyce does. He points out that the qualities of amber made early observers assume that it was the source of electricity. Objects seem to adhere to amber, fall away when moistened and re-adhere when heated. Joyce explains why a variety of objects, including sealing wax, may take on the same qualities as amber. He refers to Boyle's discovery that a diamond gives off a spark in a dark room. He mentions Newton's discovery of "excited glass"- electrical sparks created by rubbing glass. Joyce's list includes the properties of conductors, nonconductors, and the construction and use of the Leyden jar. In Joyce's text he relates the story of Muschenbroeck's reaction on experiencing the electrical shock produced by the Leyden phial,"I would not take a second shock for the whole kingdom of France."[62] Interestingly, Maria's Lucy uses almost the same words in her reaction to the electrical shock.

The second source often referred to in Maria's work is *Rees' Encyclopedia.* Rees, a dissenter preacher and scientific lecturer, wrote an amalgamation of history and natural history. His books include selected topics written by various authorities at the time.[63] Rees went beyond the simple replication of others' work, continually editing and

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[62]Ibid, 507.

[63]Rees' work as a encyclopidist began as he sought to improve the Cyclopedia of Ephraim Chambers, originally published in 1728. Re-edited by Rees this two volume work was reorganized. Supplements were added and it was made into a four-volumes edition by 1778 and re-edited in 1781. In recognition of his labor, he was elected in 1786 a fellow of the Royal Society, and, subsequently, of the Linnean Society and the

re-editing the material. His frequent updating of the work made it a highly regarded source[64] which was praised by Maria both for its wealth of information and availability. Rees argued against simple alphabetical listing.[65] He favored comprehensive treatises and cross referencing. A look at the section on horology gives some insight into the scope of his knowledge and the depth of his research. The plates included in the text show the intricate designs of clocks, watches, and chronometers of all types.[66] Other topics are treated with similar detail and afford Harry and Lucy a great deal of information for their scientific quests.

Harry and Lucy find that some questions will not be answered. They ask Sir Rupert Digby if he will explain galvanism and magnetism. "No, Harry, I cannot - I will not"[67] This reply abruptly ends the entire discussion. One might suppose that the outlandish behavior associated with mesmerism[68] in France around this time may be one

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American Society.

[64]Richard Yeo, "Reading encyclopedias: Science and the Organization of Knowledge in the British Dictionary of Art and Science 1730-1850," *ISIS* 1991, 82:14-49, 25. Yeo reports a critic as citing Abraham Rees' work as "a glory over this country unattainable by conquest and domination."

[65]Ibid, 42.

[66]Abraham Rees, *Rees' Clocks, Watches and Chronometers (1819 -1820):A Selection from Cyclopedia or Universal Dictionary of Arts, Science and Literature.* Reprinted from the original cyclopedia by Charles E. Tuttle (Rutland, Vermont: 1970). In his work on chronometers, there is frequent mention of the "famous James Ferguson" and readers are referred to Ferguson's *Mechanical Exercises.*

[67]*Harry and Lucy*, 4:.48.

[68]Robert Darnton, *Mesmerism and the End* of *the Enlightenment in France* (Cambridge: Harvard University Press, 1968).

reason for this abrupt dismissal of the topic. If mesmerism had a bad name, galvanism was even more to be condemned by socially aware parents. All of the experiments consisted in torturing animals. During this period, a new concern for the feelings of animals, prohibitions against cruelty to animals, and new sensitivities to animal life made such study unpopular.

In her recent book, Patricia Fara offers another reason why magnetism was not considered a proper study for children. She has investigated the role of beliefs and symbols associated with magnetic practices. She notes that the Edgeworths were particularly vehement against including magnets in the study of science. They, like Priestley and many others, felt the use of magnetic tricks like the astrologer's "Magician's Circle" which told fortunes, guaranteed that young boys would only develop into conjurers, not philosophers. In the eighteenth century, magnetism was viewed as a branch of knowledge separate from electricity. Galvanism and magnetism both retained a flavor of the occult.[69] For Lucy and Harry there are many other topics that vie for their attention.

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[69]Patricia Fara, *Sympathetic Attractions: Magnetic Practices, Beliefs, and Symbolism in Eighteenth-Century England* (Princeton: Princeton University Press, 1996), 12, points out that in trees of knowledge used throughout this period it was not unusual to find the branch marked "rational" leading to religion, metaphysics and mathematics, However, the branches of optics, pneumatics, and astronomy are linked to falconry, alchemy, and sculpture. Off this branch the traveler would find himself directed to a small branch labeled "thaumaturgicks," the science of conjuring and wonders. The Edgeworths assumed magnets to be part of this science.

The 1794 edition of Newbery's *Newtonian Philosophy* mentions Mr. Blanchard and Dr. Jeffries,[70] the men who crossed the English Channel from Dover to France in a hot-air balloon.[71] Maria also includes these worthy gentlemen in her fourth volume of *Harry and Lucy Concluded.* Obviously, this event signaled a major breakthrough for applied science. In retrospect, although we make little of it, ballooning did represent the first successful attainment of one of man's earliest goals -- the desire to fly. Several attempts were made to accomplish this objective. Wings had been tried by a variety of experimenters. An unnamed Jesuit had devised an unsuccessful system of vacuums and globes that were supposed to produce flight. Maria mentions a person referred to only as Galien, who had hypothesized that flight could be achieved if one could find an air lighter than common air. Then, he argued, one would have only to fill a bag with such air and fly away. Eventually, hydrogen was isolated and used for that purpose, but not before more ingenious and more dangerous methods had been tried.

In early 1783, the Montgolfier bothers accomplished the first public unmanned flight at Annonay near Lyons. It was an eight-minute experiment using sack cloth, paper, 1000 buttons, and burning wool and straw. The balloon rose to an altitude of 3,000 feet and floated one and one-half miles. The wool and straw were burned during the flight.

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[70]John Jeffries was a physician with a lucrative London practice. Since he had little expertise in the area of ballooning, he hired Blanchard for one hundred pounds to take him on a "scientific" flight. Beyond recording air pressure and temperature and collecting a few air specimens, not much of note was learned. On January 7, 1785, he and Blanchard
completed the first flight across the English Channel.

[71]*Tom Telescope* 1794, 56.

The problem of controlling the fire once the balloon was aloft made the flight dangerous, but very exciting.

While France was agog over the Montgolfier brothers' exploits, the British seemed to take a more reserved approach. Benjamin Franklin was present in France at the flight of one of the first hydrogen-filled balloons in August 1783 and wrote to the Royal Society to urge that body to fund research in this marvelous mode of transportation. The reply of the Royal Society, through its president, Joseph Banks, counselled great caution in experimenting with a process that had little immediate use. Franklin wrote again to goad the society into making the most of this opportunity. He responded to the issue of utility with "What use is a new born child?"[72]

The Lunar Society grudgingly underwrote a small research project on ballooning and issued a publication on the subject. The treatise was a guide for those who, "having no math," wished to experiment with balloons.[73] Balloon rides continued to attract crowds in fairs and celebrations on the Continent. Eventually the English also had champion balloonists. In the book, Harry and Lucy are eager to know all about this new mode of transportation.

The excitement that the children in *Harry and Lucy* generate in building their own balloon probably reflects contemporary societal interest. Sir Rupert explains that the idea of a balloon originated with Roger Bacon, the supposed inventor of gunpowder.

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[72]Quoted in John T. Alexander, "Aeromania, 'Fire-Balloons,' and Catherine the Great's Ban of 1784." *The Historian* 58, 3 (Spring 1996): 497-516.

[73]Richard Gillespie, "Ballooning in France and Britain, 1783-1786, Aerostation and Adventurism," *ISIS*, 75 (1985):249-268.

He then directs the children to the *Edinburgh Encyclopedia* [74] to look up the directions for constructing a balloon. Lucy declares that she has the mathematical ability to create sufficient gores of material to make a round ball for holding air. She indicates the need for innumerable decimals and mathematical accuracy. After several attempts, she is able to construct the needed parallelogram. Despite her hard work, Harry makes it clear that the important part of the project is yet to be completed. The balloon may be constructed but without some type of air it will not fly. He is the scientist and so with the guidance of his father he produces hydrogen by heating water, sulfur and iron filings.[75]

Finally, the balloon is launched and the children are rewarded for their effort by seeing the balloon actually fly for a short period. They then try to figure out some practical use for this rather complicated toy. Their solution is a contraption consisting of a kite, a rope and a balloon to be used to rescue people in boat accidents. Richard Lovell Edgeworth had in fact invented just such a device. According to Maria, the device is referred to in the "Transactions of the Society for the Encouragement of the Arts"[76] where Maria asserts, it is described in some detail.

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[74]*Harry and Lucy*, 4:106. The instructions printed in the encyclopedia include the need for a globe 18 feet in circumference, necessitating a series of gores, each 18 inches across with a length of half the circumference. "Paste the sheets together to form a parallelogram nine feet long and 18 inches wide. Curve the sides with a margin of 3/4 inches from each side."

[75]Ibid., 4:114. Harry appreciates all of Lucy's hard work, but with his usual tact, he points out, "What those in command often prefer to ability, -- is prompt and mute obedience."

[76]*Transactions of the Society for the Encouragement of the Arts*, Vol. 41. This is the reference as given by Maria Edgeworth in *Harry and Lucy*, 4:98.

Lucy discovers, in her research, a wonderful device that will make balloon travel a bit safer-- the parachute. She is quite intrigued with this device and wants to see one work. In the course of the discussions on balloons and parachutes, Lucy voices her fear that some harm might come to Harry if he were to venture to use either. He explains that since one must die anyway, would it not be better to die in the service of science than any other way? He repeats this conviction three times during the last book of the series.

"It is a man's business to brave danger," said Harry. But only if it is in a good cause argues Lucy. They are of different opinions as to what constitutes a good cause. Harry settles the question: "Is not the cause of science, my dear, a great cause?" Harry feels it is something worth hazarding one's life for. [77]

Not all their discoveries elicit such passion. The children are given a ball to play with, one so light that it appears to float in air. It bounces to great heights and is extremely light-weight. The only problem is, the ball hits a nail and bursts. It is explained that the material for this amazing ball is called *caoutchouc*[78] and is manufactured to such a thinness that it could function as a balloon when filled with air. It is suggested that the balloon be covered in leather to prevent it from collapsing when it hits a nail. This would seem to suggest the design of the basketball. It is an example of using a series of new discoveries to produce a practical product. A more conventional

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[77] *Harry and Lucy,* 4:99.

[78] The footnote in the book identifies this as the Spanish name for rubber.

way of creating a balloon was to take the craw of a turkey, seal any air holes,[79] and fill it with hydrogen gas.

At the end of the series Harry and Lucy begin to consider more abstract issues. The children in *Newtonian Philosophy* focus on the way sense data are conveyed to the brain. Harry and Lucy engage in extensive introspection as to how they think and why their thinking is sometimes derailed. For example, they ponder why they find themselves unable to answer their father's questions. In the ensuing discussion, they identify five of the more common reasons for inattention. Lucy admits that when a particular question is asked, it immediately sets off a chain of associations in her mind and she loses track of the initial issue. Harry finds that he often fails to respond because of a lack of flexibility. He is too rigidly fixed to a specific idea, he says. Both children agree that they often fail to answer because they assume the question is too difficult for them to handle. Lucy sometimes suffers from answering too quickly, while Harry's prejudices lead him astray. Modern psychology would label both children as suffering from attention-deficit disorder, but Maria is only parroting Locke's *Some Thoughts Concerning Education.*[80]

At the end of the last volume of *Harry and Lucy,* Harry asks his father to show him how to succeed as a scientist. The father's recommendations include reading Francis

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[79]The holes are covered with gold beaters skin, also used for healing. It is made from the inner intestines of an ox, the narrow strips joined by moistening each flap and fusing it to the other. *Harry and Lucy*, 4:70.

[80]John Locke, *Some Thoughts Concerning Education*, eds. John W. and Jean Yolton (Oxford: Clarendon Press, 1989),223, Section 167. In this section, Locke delineates some of the reasons why children fail to learn. Among the causes, not unlike the ones described by Harry and Lucy, are inadvertency, forgetfulness, unsteadiness and wandering of the mind. Locke refers to all of these as the natural faults of childhood.

Bacon's *Advancement of Learning,* Robert Hooke's *On the Means of Improving Natural Philosophy*, and Playfair's *History of the Process of Physical Science.* Having said this, however, he then advises his son to refrain from reading any of these just yet, but to continue with the process of mutual instruction.[81] On this note, Maria ends the series with these last words to her readers.

> The reader may perhaps feel relieved by these words from certain fears, which may have arisen in his mind, that the history might extend to a thousand and one volumes.[82]

By the time Maria completed the task set by her father, she had introduced the children to a remarkable array of scientific ideas, instruments, and experiments. She had given credit to obscure figures for their contributions and she had created heroes of both Wedgwood and Franklin, using wit and humor to accomplish her task. Finally, she lauded the work of Newton. Although he was only mentioned tangentially through all four volumes, she celebrated his famous experiments on light and color, referring her readers to Joyce's *Scientific Dialogues,* where all such experiments were described. She talked about Newton's exactness, his repetition of experiments, his refusal to take anything for granted and, finally, his practice of never hazarding general conclusions from a few facts.

All three sets of books —*The Parent's Assistant, Early Lessons,* and *Harry and Lucy Concluded* — express the principle that what is learned in pain will be long

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[81]*Harry and Lucy*, 4:332.

[82]Ibid, 4:336.

remembered. When Frank burns himself and refrains from crying, his father shakes his hand and congratulates him on his bravery. When the boy continues to carry on an experiment with hydrogen, despite the risk of being burned again, he is encouraged to forget the pain. Pain may result from a number of sources. Lucy spills candle wax and is pinched by the suction of the air pump. Harry burns himself while trying to produce hydrogen to fill a balloon. In these and other instances, both child and adult agree, that pain will imprint the learning. On the other hand, when Harry is embarrassed by his lack of mathematical knowledge even though he has recently begun to be more diligent in his study, his father refrains from comment. Since the boy is moving toward his goal imposing pain would be cruel, and therefore "unnecessary" punishment.

A second major component of learning is remembered sensations. The more senses involved in learning, the more likely the learner will retain the information. So the children are often told about a topic, then given a book to read describing it (usually with diagrams) and, finally, given some object connected with the topic for closer examination. Any step in this process that is skipped reduces the likelihood of the child's learning.

This type of mediated learning is utilized frequently. The child is given a great deal of information about a problem, then presented with parallel problems and finally, left on his own to find a solution. When Harry wants to design a roof for Widow Preston's house, he is given enough information about the problem to be able to present a design to the local laborers, who adapt it according to their own experience. The child is expected to work with the problem until he has a solution, or several solutions, which can be put to the test by adults working with him.

Every instance of luck, good fortune, gambling or reliance on wit alone leaves the protagonist in the most dire condition. The boy who starts out pitching pennies to make up for his lost shilling ends up in prison, the old lady who follows St. Patrick's promise of gold ends up drunk and homeless, and the young merchant who tries to trade on his good name without really delivering the goods ends up a thief and is finally driven from society. The servant boy who enjoys the special status of being the butler's favorite falls into the clutches of robbers and loses his position in the household. He is then turned out without references and his chances of survival are much reduced.

Maria Edgeworth's characters achieve their goals not just because they are morally good and work hard but, in addition, because they have some knowledge of the natural world. They understand the laws of nature, some principle of science, or some aspect of animal behavior. Jem, in "Lazy Lawrence," weaves rugs from heather because he has observed that it has the right texture and strength. The orphans who find the treasure, know how to have the coins tested for gold, and mark them with a secret sign. They know how to use a library to ascertain the age of the treasure and they are shrewd enough to find an expert who can verify their claim to the gold. It is not just a matter of luck, though the old Irish hag argues otherwise. She sees the gold as a reward of the little people who live under the mountain.

All the stories perpetuate national stereotypes, depicting the Jew, the Italian and the Frenchman in a very bad light. The African comes off a little better but is an object of pity rather than respect. On the other hand, the view of learning that is put forth is one of self-directed, motivated and intelligent children discovering through experimentation those principles that govern the natural world. They are urged to acquire competency and mastery while, at the same time, remaining inquisitive about the world of science. Experimentation and observation are the basic methods of learning within the Edgeworth plan.

In her stories, Maria seems not to have forgotten the pain of childhood. She uses the disappointments and the loneliness of childhood to lead her young readers to find ways to manipulate the physical world, to increase their feelings of competency, and to equip themselves for survival. She encourages the child to master the world by resorting to wit, intelligence and scientific principles.

Conclusion

Scholars have extensively explored both children's literature of the eighteenth century and the popularization of science in the same period. This dissertation carves out a niche tangentially recognized but not fully explored by either of these intellectual interests. In the course of this dissertation, a sampling of science books for children and the untutored has been studied. The authors and their books reflect a vital segment of eighteenth-century scientific and social thought deemed appropriate for children.

In this dissertation, the interconnectedness between the authors and the larger intellectual community has been documented. The science, as it is presented, as well as where it intersects with larger scientific issues, has been explicated. Scientific methodology, especially observation and experimentation, has been chronicled as part of a changing world view. Where applicable, these issues have been related to the larger concerns of scientific societies. Values impinging on family structure, gender issues and religious dogma have been explored. The philosophies touching on these matters have been surveyed, as have the varying views of nationalism.

Children's literature generally reflects the concerns of the previous generation. The books under consideration offer a glimpse of the social and cognitive changes occurring in eighteenth-century society. A brief re-examination of the authors' lives illustrates this point. The authors discussed here considered themselves to be part of a greater intellectual community. Because of their connections, they were involved in shaping the ideas of the people around them and each was recognized in an arena other than children's literature.

Algarotti was a world traveler, his presence and his opinions on art and music were sought in the courts of Europe. Newbery pioneered the publication of children's literature. Ferguson was a member of the Royal Society, a celebrated lecturer and a regularly published scientific author. Both Day and Edgeworth were intimately connected with the social and scientific concerns of the Lunar Society, including the radical political beliefs and scientific inquiries of Priestley, the industrial experimentation of Wedgwood, and the insights of Darwin. Maria Edgeworth was primarily a novelist. Yet, despite a variety of incentives to work only in the adult sphere, each author isolated an area of scientific and/or philosophical thought deemed important for children, women and the untutored. All were involved in the larger area of rethinking the world of the child. Each saw a similar vision of how children should be educated, and all rejected rote learning and strict obedience. Despite diverse subject matter, all concurred that experimentation was basic to scientific inquiry.

In most cases, experimentation assumes some degree of observation. As discussed in chapter three, Ferguson's protagonists must observe the heavens to understand astronomy, but they also observe the motion of ships, the path of falling objects, and the differences in the reflections cast by a sphere or a plate. The manipulation of mundane objects furthers the understanding of observational astronomy.

Tom Telescope teaches his pupils to observe the coach on fire, to listen to the popgun, to feel the texture of a leaf, and to smell the differences between fresh and contaminated air. All this sense data leads the children to a greater appreciation of the physical world. Having observed the physical world, they are then able to accept the principles that Locke has laid out for them as discussed in chapter two.

Observation is valued over memorization. Even Day, who does not propose to present much scientific material, leads Harry and Tommy not only to observe the natural world but also to look at the lifestyles of alien people. By exhorting the child to place himself in a foreign environment, Day hopes to lead the child to rethink his reactions to situations different from his own. By encouraging the child to study the relationship between the physical environments and a people's daily life, Day leads the child to question national stereotypes. Day wants the child to ponder variations in cultures, rather than denigrate or dismiss people because they are different.

The authors offer fresh ways of looking at the world. Francesco Algarotti introduces Newton's *Opticks* in a highly popularized form. In *Newton for the Ladies,* he acquaints his readers with the vocabulary of refrangibility, refraction and the nature of prisms. In his desire to replace Cartesianism with Newtonianism, he makes a strong case for experimentation as the basis of scientific enterprise. Newton, as the scientist-hero, is admired both for his authority and for his mastery in conducting experiments. As

Algarotti points out, Aristotle was accepted as an authority, performed experiments and was rarely challenged. Later, Aristotle's place is usurped by Galileo who used a combination of "thought experiments" and experience to explore motion and related concepts.

As Peter Dear argues, many so-called experiments, ancient and modern, are simply demonstrative science, such as "falling bodies accelerate." Dear refers to this as "truth of experience."[1] This is significantly different from the modern notion of an experiment, defined by Erin McMullin as a ". . . discrete, contrived and reported event fit for use in establishing knowledge-claims about nature."[2] The methodology of science evolved over a long period and, as Simon Schaffer[3] observes, the notion of an experiment changed drastically from Newton's time to the present day. In the stories under discussion, the authors exhort their readers to engage in experimentation but, with the exception of Maria Edgeworth, they do little to establish what the exact process entails.

Maria Edgeworth has Harry and Lucy engage in a series of experiments and, more importantly, she has the children discuss the conditions for a valid experiment. Despite her own insecurity about her scientific competency, she advances plausible

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[1]Peter Dear, *The Literary Structure of Scientific Arguments* (Philadelphia: University of Pennsylvania Press, 1991), 152.

[2]Erin McMullin, "Conceptions of Science in the Scientific Revolution," in *Reappraisals of the Scientific Revolution,* ed. David C. Lindberg and Richard S. Westman (New York: Cambridge University Press, 1990): 27-92.

[3]Simon Schaffer as quoted in Mary Hamer, *Signs of Cleopatra: History, Politics, and Representation* (New York: Routledge, 1993), 57.

scientific problems demanding both observations and experimentation. From such experimentation, the child comprehends a series of scientific principles. One additional message, voiced by both Day and Edgeworth, is that these principles must, in turn, be put to some practical use. The practical application of such principles should lead to some social or economic good. Whether that good was a new method for rescuing stranded boats, a better means of testing clay in a kiln, or building a simple bridge to gain access to better pasture, it mattered not.

The books under consideration demonstrate that observation and experimentation are tools leading the scientist to the goal of prediction. Ferguson begins with that premise in *Astronomy,* particularly, as he discusses the transit of Venus. It appears again, more fully developed, in the Harry and Lucy stories. Using what is currently called mediated learning, Maria assists the children when their predictions fall short of reality. The youngsters are led through a sequence of observation, exploration, and experimentation and urged to predict a future outcome. If the expected outcome fails to materialize, as it does when the children try to make ice cream in an air pump, then the child is led to further questioning and rethinking of the problem.

There is universal preference for curiosity over obedience. Most other children's books make obedience a major issue. While these authors occasionally urge the child to respect parental authority, they do not stress obedience. The obvious message is that the greater the curiosity of the child, the greater the degree of success in scientific endeavors. Curiosity and exploration make the child anxious to learn more. Hard work ensures his reaching his goal. This, in turn, provides him with the rewards to which his interest in science and his devotion to a course of action entitle him.

Edgeworth presents a world in which effort pays off — but not unrealistically. One of the engaging aspects of Edgeworth's stories is the relationship between success and accomplishment; success is measured in small increments. Help, when it comes, comes by way of a small contribution, not a windfall. In the "Orphan Children," the aristocratic ladies desire to help the children, asking them what they need most. The eldest sister responds that she needs more flax to make more thread and thus knit more stockings. The response is to give her enough flax to last her two more weeks. One might characterize this as niggardly in the light of the needs of the children and the resources of the aristocracy. However, the moral about wealth in the eighteenth century is clearly a linkage between industry and money, not sudden fortune. By contrast, when the bad boy in "The Little Merchant" finds the diamond necklace and pawns it with the Jewish pawnbroker (who, of course, cheats him), he is already lost. The author makes it clear that he should have worked diligently to find the owner and restore the property.

In the beginning of the eighteenth century, the "trader" was still viewed as a mean, grubby, uninspired fellow in contrast to the much venerated aristocrats who held money without working. Gradually, however, the view of commerce softened and writers began to extol the virtues of commerce:

> Commerce tends to wear off those prejudices which maintain distinctions and animosity between nations. It softens and polishes the manners of men.[4]

For men like the members of the Lunar Society, such "softening and polishing" was only a side issue. Hard work linked to material profit was the mark of a civilized man. Jacob has considered the issue of interests and shows that the underlying premise of capitalism is not acquisition of wealth for its own sake, but prudent use of wealth for reinvestment and improvement of the greater society.[5] The early Baconian writers never envisioned greed and avarice as the end result of applied science. Edgeworth's view was similar. She spent a great deal of time urging children to acquire the virtue of "industry," by which she meant the combination of hard work, competency and intelligent exploration. This virtue is usually teamed with a discussion about pursuing one's "interests" but not to the detriment of the larger community.

Edgeworth, influenced by the members of the Lunar Society, selected some of her heroes from their ranks. Her use of Wedgwood and Franklin as heroes is a determined effort to wean children from the fantasy world of *Jack the Giant Killer* to the real world of industry. Fantasy figures were considered bad for the child and gave him an unrealistic role model. Wedgwood was more accessible as a hero, easier to emulate and more likely to lead to a profitable outcome. The fact that all of these stories eschew magic and fantasy in favor of realism is not accidental. This issue was a bone of contention

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[4] Albert O. Hirschman, *The Passions and the Interests: Political Arguments for Capitalism before its Triumph* (Princeton: Princeton University Press, 1977), 60.

[5] James R. Jacob, "The Political Economy of Science in Seventeenth-Century England," *Social Research* 59, 3 (Fall 1992):505-532.

among writers and educators in the eighteenth century. Charles Lamb[6] marshaled his forces against the attack on fantasy. He argued specifically against the kind of writing Maria was generating. He found it pedantic and soul destroying. Many people agreed that fantasy was essential to the child. Today Bruno Bettlehiem[7] has echoed Lamb's plea for the need for fantasy in *The Uses of Enchantment.* Arguing that fairy tales do for a child what dreaming does for an adult, he lauds the repetition and ambiguity that allows the child to project his fears onto a witch or an ogre. Luckily, most parents did not feel compelled to make a categorical decision either way. Both types of books sold very well, but fantasy and magic certainly outsold science and moral tracts. Nevertheless, the science books under consideration all went through significant printings, all lasted beyond their own generation, and most were still being reprinted fifty years later.

One real-life issue pervades all of the works on science. The place of women in the scientific enterprise is discussed by Algarotti, Ferguson, and Edgeworth. In Ferguson's work, Eudosia is fearful she will be a social outcast if she mentions her love of astronomy. Eudosia questions whether it is a fit course of study for a young lady.

Maria Edgeworth modifies her stated goal of teaching science by first discussing the role of women in science. She warns that no member of the female gender should become an *affected lady of science.* This term signals some sort of fear that a woman

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[6]A letter from Charles Lamb to Coleridge, 23 October 1802, as quoted in Marjorie Moon, *John Harris: Books for Youth 1801-1843* (London: Five Owls Press Limited, 1976), Appendix D, 155.

[7]Bruno Bettelheim, *The Uses of Enchantment: The Power and Importance of Fairy Tales* (New York: Harmondsworth, 1978).

might speak out on scientific matters without due regard for the need for decorum and meekness, and her place in the society. This admonition is repeated when Lucy and her mother discuss in detail the changing relationship between the ten-year-old Lucy and her fourteen-year-old brother, Harry. Lucy leaves the discussion, convinced that while she may learn from her brother, she does not want to become an *affected lady of science*; therefore, she will avoid engaging in too many scientific experiments.[8] Similarly, Eudosia, in *Astronomy,* was allowed to learn astronomy but ought not talk about it while visiting family friends.

Samuel Johnson saw this tendency to teach science to young ladies as troublesome. "You teach your daughters the distance to the stars and then wonder why they do not delight in your company."[9] Young girls were expected to be the mainstay of the family, the peacemaker and the charmer, not the scientist.[10] Eudosia sighs and moans about the fact that women cannot go to the university and learn science. Her brother agrees that many women want to learn science but because learning science is so difficult

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[8]Prof. James Jacob has suggested that this may be a reference to Margaret Cavendish, Duchess of Newcastle, a truly "affected lady" of the seventeenth century. See Katie Lilley's preface to *The Blazing World and Other Writings* (New York: Penguin Books, 1994).

[9]Quoted in Hester Lynch Piozzi, *Anecdotes of the Late Samuel Johnson* (London: T. Codell, 1786).

[10]Recent scholarship has devoted much space to this issue. See Londa Schiebinger, *Nature's Body: Gender in the Making of Modern Science* (Boston: Beacon Press, 1993), and Barbara Maria Stafford, *Artful Science: Enlightenment Entertainment and the Eclipse of Visual Education* (Cambridge: MIT Press, 1994).

for husbands, fathers and brothers, men assume that it is far above the capabilities of women.

In *The Newtonian Philosophy,* the role of women changes with each edition. In the first edition, the voice of Lady Caroline is heard repeatedly, offering interesting observations and raising many questions. With each subsequent edition, there are fewer and fewer comments from Lady Caroline until she is finally reduced to a silent figure in the American edition of 1820. This seems to parallel Thomas Day's view of women. In *Sandford and Merton,* women barely exist, with the exception of the mother of a poor family about to lose their farm, several empty-headed young society belles who ridicule Sandford, and Tommy Merton's aristocratic mother, who is suspicious of any person of lower social standing. In Day's *History of Sandford and Merton* there are no models a young lady might feel compelled to emulate, certainly none that seem to be a role model for scientific endeavor.

Several recent authors, concerned with the lack of female scientists, have attempted to study the place of women and science in the eighteenth century. Carolyn Merchant[11] argues that the new male version of nature, inherent in Newtonianism, is mechanical and lacks vitality precisely because it is so mathematical. She asserts that this view of nature has replaced the older, feminine view in which nature is seen as vital, organic and productive. It is the loss of this view that causes women to be thrust aside in

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[11]Carolyn Merchant, *The Death of Nature, Women, Ecology and the Scientific Revolution* (New York: Harper and Row, 1980).

the new science and only allowed a place in botany or horticulture. Ann Shteir[12] has taken much the same position. She contends that the average woman, interested in science, was shunted to the study of biology and botany in order to capitalize on their "nurturing ability" and because of their lack of intelligence. *Nature's Body* presents the views of Londa Schiebinger,[13] who argues that patriarchal attitudes kept both women and blacks from the study of science.

Both Merchant and Shteir present an ahistorical view. Shteir's argument, while plausible, fails to recognize the work of such women as Caroline Herschel in astronomy, Maria Jacson in chemistry and Madame Châtelet in natural philosophy. Gender did not prevent Madam Banchard[14] from taking over her husband's ballooning enterprise. Her sixty-seven trips aloft suggest she had more than a passing knowledge of the science required for eighteenth-century aerodynamics. More importantly, it is overly simplistic to assume that some larger male conspiracy dictates social class conventions. The eighteenth century did not have just one view of women. Day's position was extreme and, probably for that reason, most interesting to study. His outrageous behavior toward women, his unrealistic demands on them and his bizarre expectations are repeatedly noted by historians, precisely because his actions are so far outside the norm.

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[12]Ann B. Shteir, *Cultivating Women, Cultivating* Science (Baltimore: John Hopkins University Press, 1996).

[13]Londa Schiebinger, *Nature's Body: Gender in the Making of Modern Science* (Boston: Beacon Press, 1993).

[14]Charles Coulton Gillespie, *The Montgolfier Brothers and the Invention of Aviation: 1783-1784* (Princeton: Princeton University Press, 1983).

Merchant's arguments about the male and female qualities of science are the most intriguing. By assigning intuition to women as a primary characteristic, she leaves no way out of the false dichotomy she has created. If women are intuitive, then men are rational. This is the major fallacy. Most ingenious people, male and female, are both rational and intuitive. Intuition is the heart of genius. For example, few would question Newton's rationality, yet his key optical experiment was based on intuition. Once the idea presents itself, everything else is in the details; the working out of the mathematical formulae. The more apropos question centers on this latter detail. Is the difference in mathematical ability a true gender difference? Could the lack of scientific endeavor be linked to a genetic difference? The jury is still out on the issue of spatial-versus-linguistic gender differences.

Most of the current arguments on the issue fail to recognize historical complexity. As eighteenth-century thinkers redefined children, they also redefined women. If home schooling was the answer to dysfunctional schools, then the mother was thrust into the role of caretaker and teacher. Mothers handled everything inside the house and fathers controlled the outside world. Mother encouraged the child but the father was often the instructor. For example, in *Early Lessons*, the child complained that he always confuses "25" and "52." His mother made no attempt to teach the difference, but she assured Frank that his father would review the idea with him later. The nurturing role of the mother was more important than the educational one.

A second issue representing both a social dilemma and a cognitive shift is Newbery's diatribe against gambling at the beginning of *Newtonian Philosophy.* Two problems seem to be involved. The first is the reality that since gambling presupposes a world based on luck and chance without set patterns and rules its very essence is unscientific. Secondly, any competent mathematical calculation can suggest the improbability of gambling actually producing a long-term profit. Therefore, gambling, by its very nature, denies a Newtonian world that is logical, mathematical and predictable. The successful person in the eighteenth century focuses on the rational, the practical and the useful. Repeatedly in these stories, the person who takes the shortcut, the easy way out, is disparaged. The gambler and the con artist both come to a bad end.

Social change is driven by a variety of religious, philosophical and economic forces but it also routinely occurs because of the push of technology. However, in most instances, there is a philosophical voice that directs that change, giving it a vocabulary and a plan of action. This was certainly true in the eighteenth century, when many conflicting philosophical issues were hotly debated. However, in the realm of children's literature two voices were prominent: Locke and Rousseau.

Locke dominates children's literature. In addition to providing the text for *Newtonian Philosophy,* Locke spelled out the idea of mediated learning: One should show the child the object under discussion, give examples, provide periods of observation and, finally, allow the child to reach his own conclusions. Locke's recommendations were not just generalizations; he gave detailed directions for making blocks to teach the alphabet to the child; he recommended specific readings, including Boyle and Newton, he delineated the characteristics needed in a tutor; and he spelled out the manual trades that would be profitable for a child to learn.[15] Locke specifically commented on the fact that variety and freedom delight children. He urged teachers to take this into account. He acknowledged the natural faults of children that cause them to be forgetful, unsteady, and wandering, but he insists that it is the sense of wonder that must be preserved in the child.

Neither Algarotti nor Ferguson is explicit in his use of Locke's ideas. However, Maria Edgeworth not only follows Locke's principles, she also quotes extensively from his works. Harry and Lucy read a selection from Locke to underline the need for mathematics, but they also discuss his ideas of learning, just as Tom Telescope used Locke's writing to outline the process of sensation and cognition. A primary reason for Maria's acceptance of Locke is based on experience. Maria worked with her twenty brothers and sisters, kept notebooks of their behavior and conversations, and tried out her stories on this ready audience. Locke's notions of how a child learns are mirrored in Maria's daily experience working closely with children. In addition, Locke's *tabula rasa* is a more liberating and optimistic view of the child than the older pessimistic view of earlier years. The child has been liberated from a religious system that envisioned him already weighed down with sins and repercussions suffered in Eden. It was very refreshing for the eighteenth-century parent to encounter a child who could observe, absorb and create within the Newtonian universe. No longer were parents being urged to monitor every action in order to detect signs of perdition. Now the parent could reap the

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[15] John Locke, *Some Thoughts Concerning Education*, ed. John W. and Jean S. Yolton (Oxford: Clarendon Press, 1989), 86-261.

joys of parenthood by participating in the wonder and spontaneity inherent in the child's view.

Locke grew in popularity as the century progressed, but he was forced to share the limelight with Rousseau. Thomas Day revered and imitated Rousseau, not just in his children's books but in his private life as well. Day's adaptation of Rousseau's animal psychology led him to refuse to have horses broken or dogs restrained. His view of domestic animals was not distinguishable from his view of children. All were to be treated with kindness, allowed freedom to explore nature and learn by trial and error. He refused to accept the notion of dangerous animals and died, as a result, in a fall from an unbroken horse.

Initially, Maria Edgeworth was instructed by both Thomas Day and her father about the value of Rousseau. However, her father's dismal failure in his experiment to raise his son in an environment defined by Rousseau left the Edgeworths a bit leery of following his dictates in isolation. As a result, they turned to a mixture of Locke and Rousseau, with a heavy overlay of the more practical suggestions of members of the Lunar Society. Men like Wedgwood, Darwin, Priestly and Kier not only read philosophy, they also looked for practical applications of scientific theories, aware that their world was changing. They insisted that the future belonged to the scientific elite who knew how to combine the practical application of science with the hardheaded decisions and economic realities of the business world. If there were to be heroes, they needed to be men of industry.

Kramnick[16] accurately recognizes the importance of this shift to the scientist as hero. He traces the pattern which begins with the celebration of Sir Isaac Newton as the quintessential English scientist and continues with frequent mention of Robert Boyle and Benjamin Franklin. Later, his attention turns to those who capitalized on applied science, industrialists such as Richard Arkwright and Josiah Wedgwood. Maria's stories advanced such heroes for children. Industrialists— individuals who overcame physical handicaps and economic hardships, augmenting their skills with experimentation and innovation— were replacing the military hero. These men, different from the traditional military hero, favor curiosity, innovation and intelligence over the more traditional values of authority, regimentation and violence usually associated with the military hero.

David McClelland, in his work on achievement motivation, examines the role of hero stories. Looking at a variety of cultures from ancient Greece to modern America, he correlated economic development over time with the type of heroes honored in each culture. In extensive research into classical and folk tales, he documents that when a group is involved in increased economic production, it looks to stories of daring and moral rectitude. The stories that feature heroes who survive by their own strength, wit or virtue are preferred over heroes gifted with special powers by the gods. Repeated telling of hero stories gives the child a model to emulate. If the hero has some limitations, the child is encouraged even more in his struggle to gain mastery over himself and his world. The writers of the late eighteenth century selected heroes from the rank of science and

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[16]Isaac Kramnick, "Children's Literature and Bourgeois Ideology: Observations on Culture and Industrial Capitalism in the Later Eighteenth Century," *Studies in Eighteenth-Century Culture* 12 (1983):11-44.

industry. By using Newton, Franklin and Wedgwood as heroes they gave reasonable and exacting role models.

McClelland studied a multiplicity of cultures, but, for the purposes of this dissertation, his work on England is most appropriate and most telling.[17] Using economic figures such as coal production, per capita income and foreign trade, he has traced the economic highs and lows of England from 1400 through 1830. His survey of the period 1750 to 1830s shows not only a tremendous increase in the prosperity of the country, but also documents the large number of industrial innovators coming out of the English dissenting religious groups. The dissenters made up seven percent of the population but they account for thirty-four percent of the innovators. Looking at plays and street ballads, McClelland shows that the country at large experienced an increase in need achievement motifs.[18] The connections between success in business, adherence to dissenting beliefs and stories expressing high need achievement are also reflected in Maria Edgeworth's stories, which combined science with the larger issues of industry and hard work.

McClelland has shown that children's stories are extremely useful in teaching values. If McClelland's research on need achievement is correct, these writers capitalized

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[17]David McClelland, *The Achieving Society* (New York: Free Press, 1961). The sample of innovators was taken from a history of technology and was assumed to be an impartial catalogue of such achievers. This sample yielded the reported percentages.

[18]Ibid., 138-145. Need achievement motifs, as defined by McClelland, include combining moderate risk taking with the ability to make realistic assessments as to the outcome of a particular course of behavior. Beyond such risk taking and assessment, success is also linked to the skills one brings to a particular task.

on the very thing for which children's literature is ideally suited. Such literature can be used to teach values and virtues by offering strong role models. It can depict heroes and villains in sharp contrast. It leaves no doubt in the child's mind as to the approved and socially accepted system of rewards and punishment operating in the society. These stories hammer home the message that knowledge of the laws of nature, coupled with the practice of virtue, positions the individual for success. It is not enough to simply have some hope of success; one must have the tools to achieve that success, and those tools are to be found in scientific knowledge and experimentation.

The modern-day parallels found in this study cannot be ignored. Faced with the computer revolution, we see a middle class able to offer its children the vocabulary and the technology necessary for success in a world defined by access to information. We see individuals in lower social strata turning to excessive gambling to make easy money. Like our eighteenth-century counterparts, we lament the conditions of the schools, the inability to educate whole groups of the society, and the failure of private education to make up the difference. The discussion again turns to home schooling as a viable option. Parental-child relationships are being rethought as women decide to give up careers to nurture children or attempt to find the perfect tutor or nanny to do the job. However, today children's literature, with but few exceptions, is unlikely to tackle the issue of character formation, one of the major components of the eighteenth-century stories.

Reading stories written for children may be engaging, and investigating the popularization of science is intriguing, but this dissertation is more than just an examination of eighteenth-century pleasantries. During the period under discussion the concern of educated individuals and scientific groups centered on the problem of preparing the next generation for a changing world. Adults, already recognized in other fields of endeavor, spent significant energy to bring the new science to those outside the normal circles of discourse. In doing so, they employed sophisticated vocabulary, elaborate instrumentation and complex concepts. They expected a lot from their readers, and they insisted that parents involve themselves in the process. They, in a word, prepared the next generation for the future they could envision and in the process shaped the outcome.

The impetus to this investigation of science within children's literature originated with James Secord's admonition to pursue this realm of the popularization of science. Secord characterized children's literature as the "bottom rung" of the ladder of scientific research. This metaphor is misleading. A bridge rather than a ladder suggests a more apt metaphor.

This study, though exploratory in nature, seeks to establish the fact that these writers, and their books, exemplify connections between several populations. These authors in their popularizations of science link the untutored with the larger society. The authors in question, members of elite scientific societies, join their scientific knowledge with their concern for the unlettered and attempt to ford the educational gap. This investigation spans the chasm between those involved with the popularization of science and those who explore children's literature. Finally, these works serve as a bridge between the unexplored territory of science and storytelling, between children and their heroes and, like most bridges, join isolated territories to the advantage of both.

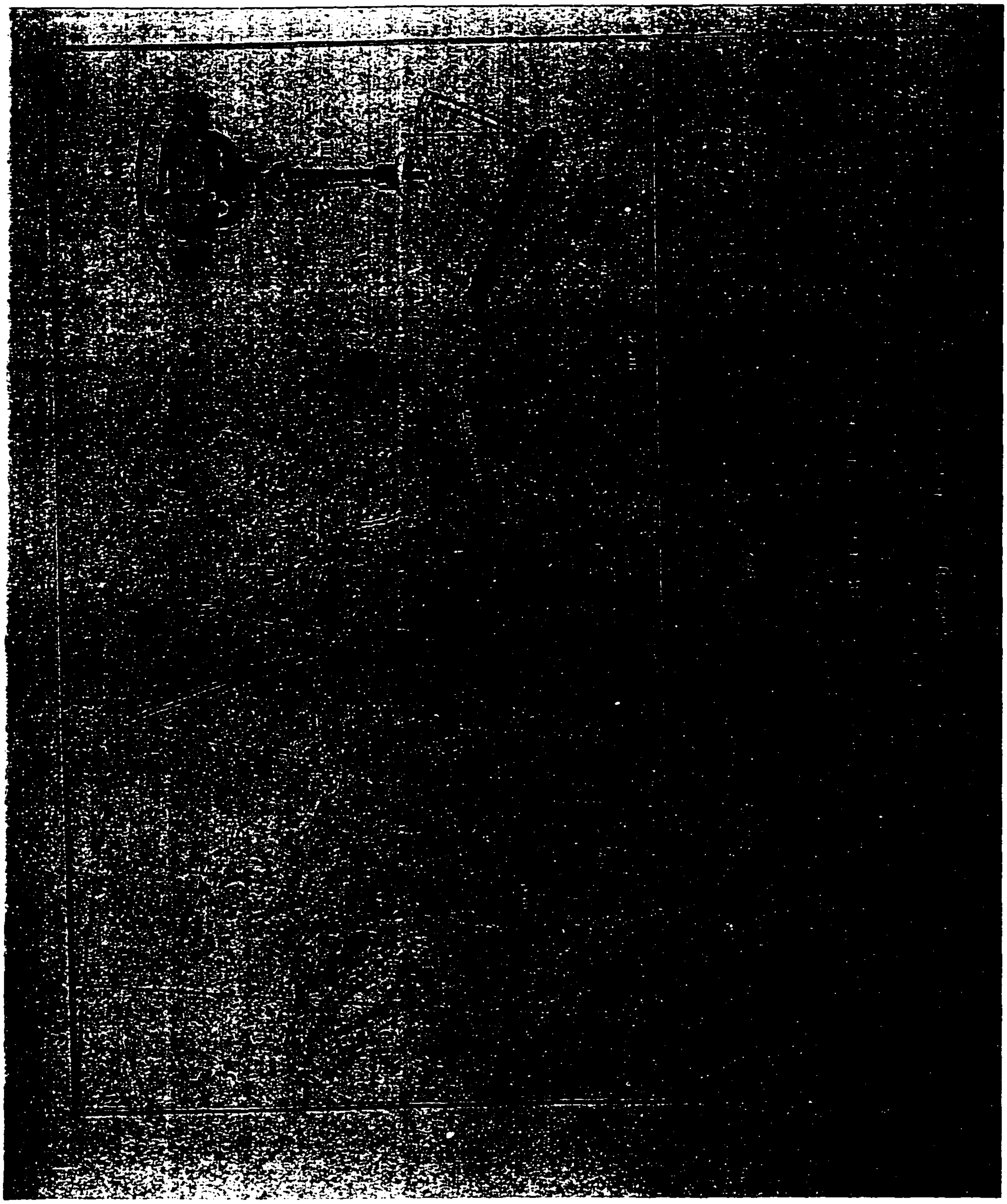

Plate V

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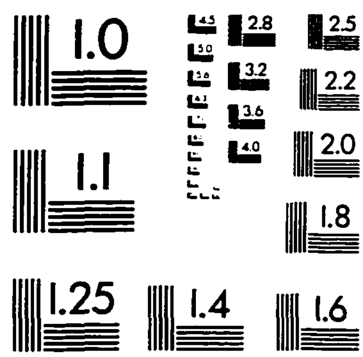

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