THE LUNAR SOCIETY OF BIRMINGHAM AND THE PRACTICE OF SCIENCE IN 18TH CENTURY GREAT BRITAIN: A STUDY OF JOSPEH PRIESTLEY, JAMES WATT AND WILLIAM WITHERING

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ABSTRACT

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This thesis examines the scientific and technological advancements facilitated by members of the Lunar Society of Birmingham in eighteenth-century Britain. The study relies on a number of primary sources, which range from the regular correspondence of its members to their various published scientific works. The secondary sources used for this project range from comprehensive books about the society as a whole to sources concentrating on particular members. The Lunar Society comprised only fourteen members throughout its existence, but for the purposes of this study, three of them were analyzed: Joseph Priestley, James Watt and William Withering.

These three individuals played different roles within the society and their respective careers reflected these roles. Joseph Priestley's personality had a large impact on the Lunar Society. His selflessness and wide base of knowledge became quite welcome within the group, and this level of acceptance was valuable for him. He also appeared to be an effective facilitator for the other members of the Society.

James Watt also gave himself tirelessly to the Lunar Society. He was a hard worker who devoted himself diligently to the group and received much in return. Watt constantly looked to other members of the society either for personal support or for the scientific knowledge he needed to benefit his scientific pursuits. Despite his capitalistic tendencies, Watt was also very helpful to other associates of the Society.

William Withering was probably the least active member of the group. Although an associate for an extended period, he did not appear to cooperate with other members quite as much as Watt and Priestley. Nonetheless, the physician benefitted considerably from the group when it came to scientific matters, although he also experienced the downside to collaboration when other people attempted to take credit for his work.

Overall, the Lunar Society of Birmingham was responsible for numerous scientific advancements and much innovation during its twenty-five years of existence. Different personalities found acceptance within the Lunar Society, which increased the group's scientific correspondence. The achievements of its individual members can be credited in part to their intellectual abilities, but the new pattern of scientific cooperation among the Lunar members also led to their success. Suddenly scientists were no longer making achievements in isolation, but rather through collaboration and working with others. These partnerships led to synergy that propelled Britain into the Industrial Age

The Lunar Society of Birmingham was unique for its period. Its most important feature was an abundance of communication and collaboration outside of the meetings. Its members redefined the social relations of eighteenth-century science, stressing joint efforts that promoted synergy. Frequent contact and correspondence led to interdisciplinary achievements whose quality and quantity were superior to that of other, contemporary institutions, such as the Royal Society of London. Most important, the practical application of the results of their teamwork had a revolutionary impact on both Britain and the world.

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Introduction and History of the Lunar Society of Birmingham

The Lunar Society of Birmingham is one of the most overlooked influential intellectual gatherings in the history of Europe. The group included James Watt; the man who helped improve the steam engine, Joseph Priestley, the man who isolated oxygen, and William Withering, the first man to use the heart drug, digitalis, in practice. In addition, those who also were members of the Lunar Society of Birmingham were Erasmus Darwin, Matthew Boulton, Thomas Day, Richard Lovell Edgeworth, Samuel Galton Jr., James Keir, William Small, Jonathan Stokes, Josiah Wedgwood, Robert Augustus Johnson and John Whitehurst. These men helped propel England into the Industrial Revolution at the turn of the century. What made this group noteworthy was the method in which this variety of scientific personalities came together and collaborated, producing synergy and notable results. They changed the social interactions and patterns of scientists through constant and continual scientific communication, which in turn led to numerous discoveries and accomplishments. The Lunar Society of Birmingham was successful because of all the teamwork, communication and resulting synergy that the group applied to science and technology during the eighteenth century.

The Lunar Society of Birmingham had very humble beginnings, known by scholars as the Lunar Circle. During their earlier meetings, the group did not refer to themselves as the Lunar Society, nor have regular assemblies, rather they were simply a group of friends meeting to discuss their ideas of science, politics and education. The formation of the Lunar Circle started in 1765 with the arrival of Dr. William Small, from

Virginia. Dr. Small brought a lot with him to Birmingham, including his practice, a passion for friendship and a letter from Ben Franklin to Matthew Boulton.[1] Even though he claimed not to be a fan of "societies", it appeared that Dr. Small often meet with a regular group of intellectuals back in Virginia on a frequent basis, a group that also included Thomas Jefferson.[2] Therefore, when Small moved to Birmingham he wanted to continue with a similar intellectual society.

Dr. William Small first became friends with Matthew Boulton, to whom he became extremely close with, and then quickly established relationships with Erasmus Darwin and John Whitehurst.[3] Matthew Boulton was a local native to Birmingham who inherited his father's buckle factory, the Soho Works. Erasmus Darwin was a physician who had a practice established in close by Lichfield, and John Whitehurst was a clock and instrument maker living in the area.[4] Whitehurst, Darwin and Boulton all had known each other for around ten years before Small's arrival. Nonetheless, Small was essential for the cohesion of the group, "Almost at once, Small became Boulton's family physician, and from 1765 until Small's death in 1775 Boulton did very little, particularly in scientific matters, without Small's advice. Nor was the impact of his personality less on other members of the growing Lunar Circle."[5]Another interesting aspect of Small's career was that he never joined an official scientific society, or published a scientific paper, but was a huge part in the success of the Lunar Society.[6] The role of Dr. William Small in the lives of members of the Lunar Circle, and later Lunar Society, is summed up by Richard Lovell Edgeworth who said,

> By means of Mr. Keir I became acquainted with Dr. Small of Birmingham, a man esteemed by all who knew him, and by all who were admitted to his friendship beloved with no common enthusiasm. Dr. Small formed a link which

> combined Mr. Boulton, Mr. Watt, Dr. Darwin, Mr. Wedgwood, Mr. Day and myself together- men of very different character but all devoted to literature and science.[7]

Soon after the arrival of Dr. Small the group began to recruit more members to their informal gatherings. The first of these new, recruited members was Josiah Wedgewood who was a pottery manufacturer who originally connected to the group through his associations Darwin.[8] Wedgewood possessed a large interest in transportation, as well as any area of science that would help his pottery manufacturing. Wedgewood's interest in transportation included carriages and steam power, which were passions of other members of the Lunar Circle. Wedgwood first started coming to the gatherings in 1766, and so did Richard Lovell Edgeworth. Edgeworth was a gentleman who shared a lot of the same interests as the members of the Lunar circle, especially their enthusiasm for transportation and mechanical inventions.[9] The third member recruited who joined the group was the eccentric Thomas Day. Edgeworth had become friends with Day while going to school at Corpus Christi, Oxford. Day was did not possess the scientific talent that some of the other members did but he was very interested and own a very quirky personality with willingness to invest projects. Even thought very unconventional, the group was satisfied to have him in attendance at their meetings.

Another very important visitor came to Birmingham during 1767, by the name of James Watt. Watt was on his way to London in order to receive his steam engine patent and wanted to stop in Birmingham in order to see the Soho Manufactory. Boulton was not present but Darwin and Small showed Watt around the facility. Watt did not move to Birmingham until 1774 but until that point, he remained in constant correspondence with many members of the Lunar Circle, especially concerning many topics that interested him which included ceramics, chemistry, dyeing, metallurgy, horology and optical

systems.[10] One more member joined the Lunar Circle in 1767, by the name of James Keir. Keir lived in the area and became connected to the Lunar Circle through his association with Darwin resulting from the time both of them had spent at the University of Edinburgh. Keir actually left Edinburgh early in order to join the army during the Seven Years' War. Keir's passions of chemistry and metallurgy aligned perfectly with the other members of the Lunar Circle.[11] Therefore, in a few short years, by 1678 they had assembled the core of the Lunar Circle.

One of the first topics, which sparked the interests of the members of the Lunar Circle, was electricity. Benjamin Franklin was also passionate about the study of electricity and this connection helped strengthen the relationships of the Lunar Circle. Franklin was friends with almost all of the original members including, Day, Small, and Whitehurst.[12] Not only did Franklin's circle of friends provide to be valuable but Franklin was supportive of groups that promoted reform and new thinking, such as the Lunar Society, a couple decades later.[13] As it turned out, both Boulton and Darwin were very fond of Benjamin Franklin's work, and their admiration for the man brought the two even closer together. They individually met Franklin and then further pursued work with electricity; Boulton started making small electrical machines and Darwin produced a paper that contained properties of electricity.[14] Darwin's work caught the attention of one of the leading electricity scientists of the day, Joseph Priestley. Priestley, a fellow of the Royal Society and a future member of the Lunar Society, wrote his own comprehensive work on electricity, *The History and Present State of Electricity, with Original Experiment* in 1767.[15] Not only did Priestley consult Darwin while writing his paper but he also started to work with Josiah Wedgewood about applying electricity to

pottery.[16] At the time electricity was not just an area of interest for members of the Lunar Circle but rather a huge topic of interest throughout England, "The interest in electricity went beyond the thrill of experiment. Indeed, it aroused hot arguments on the propriety of demonstrating in public at all."[17] Electricity was a common interest that brought together future members of the Lunar Society of Birmingham before 1780.

A second area of science that proved to be a bonding interest for many of these members was a desire to improve current forms of transportation. One specific portion of transportation that intrigued most of the Lunar Men were canals, "In their frustration with the roads and their eagerness for profit, the entrepreneurs and landowners, the surveyors and engineers, the visionaries such as Darwin and the manufactures such as Boulton and Wedgwood, all turned their minds more and more to dreams of inland waterways."[18] This interest in canals would also go on to consume Small and Watt, yet again brining these members closer together.[19] Members possessed their own motivations; Darwin's was purely of the entrepreneurial nature, while Wedgwood wanted to benefit his pottery industry through better inland transportation.[20] The relationship between Darwin and Wedgwood formed because of Darwin's knowledge and Wedgwood's desire for it, which exemplified many other relationships of the Lunar Men.

Their work proved to be successful for English industries as a whole, as well on a personal basis for many members of the Lunar Circle. England experienced a canal boom starting in 1768, continuing until the American Wars in 1776.[21] This led to the formation of the Birmingham Navigation Committee, which included Small and Boulton, as well as the construction of the Birmingham Canal, that in the end, greatly benefitted the coal

industry in the surrounding area.[22] The interest of the members in the Lunar Society in canals cannot be understated,

> Almost all the Lunar men own canal shares, and Boulton had a lucrative sideline supplying metal parts, locks, bolts, brass valves for pistons, copper boxes, taps and rings. Wedgwood was the king, but Small's interest was also substantial as he gradually bought transfers from other shareholders. He and Boulton even began to dream of working canal boats by steam. And he carefully kept abreast of developments elsewhere through a new friendship, with James Watt.[23]

Boulton and Watt originally bonded together over their interests in canals, which led to a passion for steam power and then their famous business. As the Lunar Men strengthened the canal systems all over England and Scotland, they also strengthened their friendships, especially between Darwin, Small, Watt and Boulton.[24] The bond between Small and Watt would help Watt through many of his difficult times, including the depression he encountered throughout his life. An interest for canals brought these men together yet again, "But they were still natural philosophers, and in building canals- even while transforming whole regions- they could still seek after hidden knowledge."[25] Transportation and electricity brought these men together but later activities would insure their bonds stayed strong.

During 1774 and 1775, drastic changes took hold of the Lunar Circle. First, one of the most famous members, James Watt, physically came to join the Lunar Circle in Birmingham. James Watt brought with him a large amount of scientific talent and passion. He also brought with him a strong friendship with Boulton, as well as their business partnership. However, in 1775, tragedy struck and Dr. Small died. This was a large loss on both an intellectual level and personal level for the group. Also during

1775, the group lost Whitehurst because he accepted a new position and moved to London.[26] However the loss of Whitehurst proved no to be permanent, and at times useful because he remained in continual correspondence with the members of the Lunar Circle. In addition, after he became a member of the Royal Society in 1779 he often brought his friends to the meetings.

Even though Dr. Small's death was unfortunate, the Lunar Circle decided to turn his death into as positive situation as they could and started to head into a new direction. Regrettably when Small passed away the Lunar Society started to head in a slightly different route with their pursuits, "Withering did not have Small's interests in clocks, optics or astronomy and these subjects soon disappeared from the serious Lunar Society investigation."[27] Even though the group started to head in a new direction, they certainly became more serious with their society quickly after Small's death. The first official Lunar Society meeting appears to have occurred Sunday, December 31, 1775.[28] The second meeting occurred about a month later on Sunday, February 4, 1776.[29] Because the members did not speak publically about their meetings, therefore scholars deduced the dates of the meetings through examining personal correspondents between the members. The group decided on meeting on the Sunday that was the closest to the full moon, in order that the trips home would be more manageable with the light.[30] They held the meetings at Boulton's house and were more regular and slightly more formal than previously, marking this as the true beginning of the Lunar Society.

Small's death left a large void to fill and the group attempted to fill the vacancy. Based on the recommendation of Darwin, the group started to encourage Dr. William Withering to move to Birmingham. Their intention was for Withering to take over

Small's practice and to join their intellectual and scientific discussions.[31] Withering had also met and corresponded with Boulton, who wanted Withering to move to Birmingham. Withering did not have the same intellectual interests that Small had nor the same easygoing personality, two qualities that, in time, would substantially affect the Lunar Society. The Lunar Society appeared only to have two serious disagreements between members and Withering was the center of both of them. However, the arrival of Withering did appear to bring out about a reinvigoration of the group. After his arrival, the group decided that they should hold meetings more regularly.

The next five years, 1775 to 1780, proved to the busiest for many members of the Lunar Society. James Watt and Matthew Boulton became extremely busy with their steam engine business, both improving the design and trying to sell their products all over England and Scotland. Due to their full schedules, the business partners decided they should hire a manager to insure everything stayed in order while the other two were gone. James Keir rose to the task and started working with Watt and Boulton, both on their steam engine business and on a number of other projects as well.[32] Keir pursued many other chemistry products during this period, and had a few works published. During this period Wedgewood did very little of significance except for setting the foundation for future accomplishments and in 1778, Whitehurst published one of his more famous works, *An Inquiry into the Original State and Formation of the Earth.*[33] Other members of the Lunar Society were also busy, for example, Darwin and Withering were very preoccupied with their expanding practices. Darwin did not publish any major scientific work but Withering did publish *An Account of the Scarlet Fever and Sore Throat, or Scarlatina; Particularly as it Appeared at Birmingham in the Year 1778.*[34] Day became

married, moved to an area just outside of London and started to grow apart from his Lunar connections. At the beginning of 1780, the Lunar Society lost another member, Richard Lovell Edgeworth who left for Ireland, however, the next five years would contain many more members coming and going.

Around 1780 the group again saw a decline in the frequency in which they met. One reason for this decline was that up until this point, most meetings held were at Boulton's house. Often the meetings would begin around two o'clock in the afternoon and go until at least eight and potentially much later, into the evening.[35] Even though Boulton was enthusiastic about the meetings, he was not always at his house because he was often away from home on business. Both Watt and Boulton spent a large amount of time away from their homes due to the fact their business was becoming successful and in those days, business was done face to face, with little long distance communication. Other members of the Lunar Society were quite busy as well, making meetings difficult to organize.

However, in 1781, Lunar Society addressed this infrequency of meetings and its individual members would welcome in some of their most successful years. Fortunately, 1780 brought the Lunar Society one of its most prestigious members in Joseph Priestley. Priestley had previously been working for a patron but that relationship deteriorated and he became persuaded to look for a minister position in Birmingham. Eventually he found one and moved to Birmingham during the summer of 1780. Prior to his move, Priestley had already had a large amount of interaction with many members of the Lunar Society.[36] He had been in constant correspondence with Boulton and Keir prior to his arrival. Priestley was friendly with Benjamin Franklin and was well aware of the scientific work

of Darwin, Small and Withering as well.[37] Because Priestley was a minister, he was not able to meet with the other members on Sundays; therefore, the members decided to move meetings to Mondays nearest the full moons instead.

Soon after Priestley arrived, the Society lost one of its original members in Erasmus Darwin. Darwin remarried and got into a large dispute with Withering about the introduction of foxglove into medical practice, causing him to move away and stop attending meetings.[38] Even though Darwin physically left Birmingham, he kept in constant correspondence with his Lunar friends as much as he could and visited when time allowed. In order to fill the void left by Darwin's departure the group invited Samuel Galton Jr. to attend their meetings. Galton was a Quaker gun manufacturer that was capable and interested enough in the sciences to be a worthy addition.[39] In 1782, Edgeworth had returned to Ireland, along with his family, but he too also kept in continual communication with the Lunar Society. While in Ireland, he continued to publish articles in the *Philosophical Transactions of the Royal Society of London* and various scientific journals in Ireland.[40] In 1783 the Lunar Society replaced Edgeworth's void with a man by the name of Jonathan Stokes. Stokes was a man known for his interests in botany, chemistry and geology, all interests that corresponded with those of other members in the Lunar Society.[41] As it turned out, Stokes interests were too well in tune with Withering's and a feud between the two forced Stokes to leave the group, again causing a vacancy. In 1787, the Lunar Society added Robert Augustus Johnson as a member; however he would not leave much of an impact on the group. Out of all the additions of members between 1780 and 1787, by the far the addition of Joseph Priestley

was the most important inclusion that propelled the Lunar members into their golden period.

Even though members were coming and going from 1780 and 1785, the Lunar Society of Birmingham saw its members achieve their greatest successes. During the prime of the Lunar Society, Watt and Boulton started to gain the financial rewards they had hoped for from their steam engine partnership and started to improve the facilities at Soho. Furthermore, the two men started to gained more notoriety within a larger scientific community, signified by both men joining the Royal Society of London and the Royal Society of Edinburgh.[42] Keir started to find even more success in the field of chemistry, he had multiple articles published in the *Philosophical Transactions* and started his own comprehensive work, *Dictionary of Chemistry*.[43] Priestley had already achieved much of his scientific success before the peak of the Lunar Society; nonetheless, he remained active in science, especially within the field of chemistry. However, the majority of his actual publications during this period dealt with religion or politics. Besides his successful medical practice, Withering was publishing papers in the *Philosophical Transactions* and most importantly, he published his *An Account of the Foxglove*, which would gain Withering much notoriety.[44] Also during period of Lunar maturity, Wedgewood had a number of chemistry papers published in the *Philosophical Transactions*. Nevertheless, the period of success and prosperity of the Lunar Society as whole started to end in 1785.

By 1785, the regularity at which the member of the Lunar Society of Birmingham started to meet and correspondence started to diminish, and so did their accomplishments and by 1791 the situation became much worse due to the French Revolution. By 1791,

"The French Revolution interposed itself, life the turning earth casting its shadow on the mood, covering the circle of talk and experiment until all that remained was a shadow, glowing red with reflected light."[45] Naturally, members within the Lunar Society possessed various views of the French Revolution but internal turmoil would not bring down the Lunar Society as much as external pressure would. Tensions were becoming very high in Great Britain; London was experiencing an extremely hot summer and Thomas Paine publishing a second part of his *Rights of Man,* further increasing the anxiety.[46] The Lunar Society was not immune to the tensions around them and their meetings began to contain more talks about politics than science. A few members were particularly worried during the French Revolution. Watt and Priestley were worried about their sons who were living in Paris and "A gloomy terror sat on almost every countenance."[47] Eventually Boulton and Watt's children quietly came back to Birmingham, but it was too late the Lunar Society remained on the decline.

During 1791 tragedy struck Birmingham. Tensions were at an all-time high due to the French Revolution, a situation that eventually turned to violence. Eighteenth Century Birmingham was a city that was always a step away from a riot, and in 1971 a handful of residents crossed the line. The Church-and-King riots were particularly disastrous for the Lunar Society because one of the mobs specifically targeted two members. The homes of William Withering and Joseph Priestley became targets of the mob and fortunately, both men and their families were not present when the mobs arrived.[48] The ability to freely congregate and discuss ideas in and out of the meetings was one reason the Lunar Society was so successful, and therefore when this ability was taken away from the members, they became less effective. Not only were members

personally distraught by the French Revolution but also so were their businesses. Members had to work even harder to sell their industrial products in those uncertain times.

The Lunar Society essentially had reached its end by 1795. At this point in time, Day, Whitehurst and Small were all dead and Wedgwood died by the end of the year. Edgeworth and Darwin had moved away and were no longer corresponding at the frequency at which they were previously.[49] The riots forced Priestley out of Birmingham and eventually to a new continent, settling in America. He remained in touch with a few members but without the daily correspondence that he, and so many other members had become accustomed to.[50] By 1792, Withering had given up his medical practice and was constantly suffering from sickness, most often consumption.[51] He achieved very little during his remaining years and eventually died in 1799. Stokes was no longer a part of the Society and therefore, the only remaining members were Watt, Boulton, Galton and Keir.

These four men, while still highly respected scientists, did not have the ability to keep the meetings going, and for the most part, went their separate ways. By this point, some of the Lunar Society members had children that started attending meetings, but they no longer possessed the same spirit and atmosphere that previously existed. As Johnson explained, "Our Lunar meetings I am sorry to say are not held so regularly as they used to be. Our reduced numbers make the absence of one member material, & therefore we can only meet when it suits the conveniency of all."[52] In addition to the political turmoil, a lack of motivation from the older members the group did not help the group through this

period of turmoil. The drive of these great men started to come from other, unrelated motives,

> A primary reason for the failure of the Society seems to be lack of any compelling motive to continue co-operative endeavour. The majority of members, in 1791, were in their late fifties and early sixties, an age of consolidation, not of reconstruction and creativity. The Society had been a source of technological and scientific inspiration for men on their way to success. Now that had been achieved and there remained only to preserve the gains and pass them on to their descendents. [53]

Even though meetings became irregular and almost nonexistent, that did not stop individual members from producing scientific accomplishments. Nonetheless, these accomplishments appear to be simply continuations of their earlier work with the Lunar Society, rather than new and original works.[54] For example, Withering produced yet another edition of his *Botanical Arrangements* despite his condition, and Priestley published some chemical works in America. Darwin published a few more works including *Zoonomia, Phytologia,* and *Temple of Nature*, while Edgeworth published two works titled, *Practical Education* and *Professional Education.*[55] Again, throughout all of these publications very little evidence shows that these remaining members were constantly coordinating or assisting each other in their work, a trait shared by earlier achievements by members of the Lunar Society of Birmingham.

One last topic united the members of the Lunar Society of Birmingham, their attack on consumption. The disease personally affected numerous members of the Lunar Society.

Edgeworth's wife died of consumption, two of Watt's children, his son Gregory and his daughter, Janet were victims of the disease.[56] William Withering also suffered from the disease, further proving this disease hit close to home for the members of the Lunar

Society. Their passion to defeat the disease led them to Dr. Thomas Beddoes. Beddoes and Darwin had been friends for years. The two men kept up a correspondence for years and Dr. Beddoes had actually married the daughter of Edgeworth. Dr. Beddoes, along with the help of his Lunar friends, attempted to start the Pneumatic Medical Institute. The intention of the Pneumatic Medical Institute was a "joint laboratory and hospital where the possible curative powers of these gases would receive clinical testing."[57] Lunar members helped in numerous ways with the institute. For example, Wedgwood gave £1,000 right before his death, quite a considerable sum at the time, especially for a medical technique that was unproven. [58] However, other members were very active in the scientific research of the institution including Darwin, Withering, Edgeworth, and Watt who commented on Beddoes findings, giving him feedback and encouragement. Watt was probably the most beneficial for the institute because he assisted in inventing an apparatus to administer the gases, as well as allowing his son to work with Beddoes in their efforts.[59] Regrettably, the clinic did not prove the healing powers of gases in the area of consumption; however, the hospital portion of the clinic was functional for many years.[60]

Unfortunately, this last attempt was not enough and the members of the Lunar Society of Birmingham continued to grow apart. Sadly, "With the closing of the Pneumatic Medical Institute, the last co-operative endeavour of the Lunar Society had ended. It had been their only joint activity for almost ten years and, at best, it was little more than a vicarious experience with other people doing most of the work. The typical post-1791 activities of members neither inspired nor required joint action."[61] The members of the Lunar Society of Birmingham no longer shared the same passions and

thirst for knowledge they once shared. Only a handful of members had the motivation and ability to make discoveries of interest. Boulton, Watt and Keir's success carried on but they were becoming less active in areas outside of their business.[62] Sons of the Lunar members started to take over the areas that their fathers had ruled for the previous forty years. Nonetheless, Withering, Darwin and Edgeworth, "alone did significant, creative work after the Lunar Society had ceased to provide them with new inspiration. Even so, it is possible to see in their work more of continuing momentum from the Lunar past than any establishment of independence."[63] The highly successful nature of the Lunar Society was based upon their large amount of correspondence, and at the end of the eighteenth century, this communication had been reduced to a minimum between most members, if not nonexistent. Because their collaboration ceased, so did their synergy and accomplishments.

Comparison to the Royal Society of London

The important of the Lunar Society was not in the fact it was the only scientific society of the period. The Royal Society of London was also a very prominent scientific society in Great Britain; however, the two societies were vastly different. The largest difference between the two societies was one was a very formal and public society while the other was the opposite, extremely informal and private. The Royal Society of London preceded the Lunar Society by a hundred years and always existed and operated with a very strict and rigid style that the institution facilitated. However, one hundred years after the formation of the Royal Society, their one model of science was deep-rooted and ineffective. Due to its informal approach, the Lunar Society worked in a completely, different and innovative manner. These scientific minds and personalities varied, but still

produced scientific results. The associates of the group not only tolerated these different personalities, but also always attempted to keep the group diverse and lively. Their scientific style included high amounts of communication and teamwork that led to synergy and achievements that would not have been capable by individual members. Friendships within the Royal Society were temperamental and subject to fads but those of the Lunar Society were permanent and deep.

The Royal Society and the Lunar Society had very stark structural differences. Very much unlike the Royal Society of London, the Lunar Society had no officers, no dues and did not keep records.[64] Numerous members of the Lunar Society had papers published through the Royal Society, but no one formerly published a paper through the Lunar Society. Again, a lack of a formal publication outlet of the Lunar Society was contrary to the Royal Society of London, where the King of England had previously given them the right for their own publication. Through their official publication, the *Philosophical Transactions of the Royal Society,* fellows of the Royal Society of London, and contributors took every chance they could to share their discoveries with the world. Many members of the Lunar Society were also members of the Royal Society and published work in the *Philosophical Transactions of the Royal Society,* however, none of them spoke of their involvement in the Lunar Society.[65] The meetings of the Lunar Society did not remain closed to purely membership at all times. Often wives were a part of the dinner portion of the meetings and children were always running about.[66] Also throughout the existence of the Lunar Society numerous individuals came in and out of the group or attended individual meetings, proving that attendance was not strictly limited.

On the surface, the Lunar Society had very similar in goals and aims to that of the Royal Society of London. In fact, eleven of the fourteen members of the Lunar Society actually became fellows of the Royal Society. However, a large amount of differences existed between the two societies. First, at the time the Lunar Society of Birmingham was forming, the Royal Society was useless from a scientific perspective. By the middle of the eighteenth century, an opinion formed that the Royal Society of London was more of a social stigma, rather than an organization with actual scientific achievements. Many people at the time realized "the Royal Society was in doldrums during this period."[67] While members in the Royal Society were producing achievements during this period, they were often results of individual efforts and minimal collaborations with other members. This proved, "For many eighteenth-century English scientists, membership in the Royal Society was a matter only of social prestige, while eighteenth-century manufactures were members of the Society of Arts on the off-chance that something useful might almost accidentally result from its endeavours."[68]

Even though members had been meeting for a considerable amount of time beforehand, July 15, 1662 was the date that Royal Society of London officially received its charter. The need for a charter from the King of England also marks a dramatic difference, in that the Royal Society needed legal approval for their existence. The Royal Society soon drafted and approved the statutes of their society.[69] This formation of rules and establishment of officers indicates a huge difference between the Lunar and Royal Societies. The Lunar Society had no official hierarchy, or recorded rules. Conversely, some positions of the Royal Society received a salary, thus also leading to the establishment of dues in the society.[70] The members of the Lunar Society had to pay no

dues, but at times were responsible for hosting other members. In addition, the establishment of an official scientific journal in 1664, *The Philosophical Transaction of the Royal Society of London,* marked the society's desire to spread publically their knowledge to as many people as possible.[71] The Royal Society's desire to remain a prestigious institution was quite evident. One example of this is the fact they commissioned Dr. Thomas Sprat to write a history of the newly formed society.[72]

The two premiere scientific societies of Eighteenth Century England had similar goals but completely different methods. The first, the Royal Society of London achieved their goal through recruiting the most prestigious and socially relevant scientists of the day. The society would then publish their findings for the whole world to see. The Royal Society was concerned about sharing knowledge to gain fame. Therefore, the members that Royal Society sought out were usually very similar in levels of education, social prestige and from one general model. The Lunar Society of Birmingham was much more informal and less concerned about prestige and actively pulled in members based on scientific ability and friendships instead. Different scientific styles and personalities were always welcome, which led to increased collaboration and achievements. This group changed the social patterns of science and in turn, changed science itself. The members of the Lunar Society did not simply meet once a month, they were in constant contact. This constant contact and support for one another led to collaboration and synergy which in turned produced amazing results.

Scholars cannot contribute the success of the Lunar Society to the fact that these members were individually more intelligent than other men of the period were, but rather to the ways in which the members used each other for support and then applied their

knowledge. Another difference between the Royal and Lunar Societies was the importance of their meetings. The Royal Society‘s meetings were important because that is when the majority of their progress was made. People would share their findings and experiments, and then everyone would go home until the next meeting when other people would share information about other topics. This resulted in very fragmented, inefficient intellectual process. The Lunar Society’s meetings were more the opposite, the members were the most successful outside of their meetings. The meetings were important because they brought people together and strengthened their friendships but made real progress outside of the meetings. These strong friendships then resulted in constant collaboration in between meetings, further facilitating their scientific activity. For example, even before the time Watt physically arrived in Birmingham he was very active in the lives of Lunar circle members, he was constantly working with Boulton on the steam engine, corresponding with Small emotional support and working on canals with Darwin.[73] Another example was when Darwin remarried and moved away from Birmingham but remained in contact with his lunar friends. Again, when Whitehurst moved to London, the Lunar circle lost a good friend for their meetings but many members still stayed in contact and Whitehurst remained a valuable contact with the Royal Society.

The social patterns of science were changing within the Lunar Society. Prestige and social status were not requirements of membership, but rather friendship was the prerequisite for admission. These strong friendships led to a large amount of correspondence and collaboration outside of meetings. This large volume of communication between members was unrivaled by other scientific societies during the

period, due to the strength of their friendships, as well as their close proximity. Some members that lived close together associated almost every day but members who lived farther away sent letters as frequently as once a week.[74] Information sharing occurred on a real-time basis and not simply through prescribed meetings or through a formal publication medium. Such swift knowledge sharing was a goal Priestley had preached and lobbied for in his *History and Present State of Electricity*.[75] Priestley believed that when knowledge becomes shared then progress is made. Therefore, if scientific information and findings are shared faster, then more progress can be made. Priestley criticized those philosophers in the past that hesitated to publish their findings; they "ought to make an apology to the public, for delaying the communication of their experiments and discoveries so long as they have done."[76] The Lunar Society of Birmingham fit these requirements for Priestley who could instantly receive the results from experiments of his fellow members. Him and his other members could then use this new information and apply it to their own scientific tasks. This amount of communication led to a direct sharing of information, which was processed and applied.

The Lunar Society functioned during a period of science that lacked the number of disciplines and specialists that characterize modern science. A lack of specialty of the sciences allowed members of the Lunar Society to share in projects and interests. Very little isolation of interests existed, partially due to how interconnected the members were and due to a fewer number of specialties and subspecialties. The scientists of the Lunar Society were working on innovative technology and science for their period, but they still possessed the ability to work together. Modern science today, is completely different. Specialists and subspecialists rarely branch out of their own discipline and work with

leading authorities in other subjects. However, the Lunar Society was completely different. For example, the electricity expert, Priestley was still very active in matters of chemistry, especially when assisting Wedgwood in his potter endeavors. Not only was pre-disciplinary science simple enough that people could easily work across fields, but the Lunar Society had the social characteristics that led to very little isolation of interests. When one member became interested, that passion immediately spread throughout the society, "It is assumed that the interest of more than two of these individuals in any subject at the same time may reasonably be claimed as an interest of the Society."[77] For example, when Withering arrived Lunar interest in botany activity increased dramatically.[78]

The social aspect of this society went beyond an increase of collaboration and synergy of scientific efforts but also influenced their personal lives as well. Personal support throughout the Lunar Society came in a variety of forms. James Watt had several bouts of depression where he constantly looked towards Small for strength.[79] Despite Watt's brilliance and technical abilities, he needed the encouragement from his friends during the difficult times and long nights. Joseph Priestley felt very indebted to the Lunar Society because they showed him a level of social acceptance that his life was lacking for numerous years. What Priestly needed from the Lunar Society was not necessarily the scientific minds of the men, but their friendship, because "for Joseph Priestly these were years of security and repose- the only he had known or was to know in his lifetime."[80] Often in his later writings, while in America, he lamented on the acceptance he felt while a part of the Lunar Society. [81] Not only did the Lunar Society provide social benefits but economic benefits as well. For example, when Watt's original

business partner Roebuck was losing money, Boulton stepped in to help. Priestley also received financial support from his Lunar friends, while he resided in Birmingham. In addition the wealthier members constantly exercised their capitalistic traits and sought out member's projects to invest in.[82] Not only did the greater scientific community benefit from the results of such amount of collaboration, but also so did the members of the Lunar Society themselves.

The Lunar Society's success largely came from their friendship and social correspondence, and thus the detrimental impact of the French Revolution was an enormous factor in the decline of the group. The French Revolution destroyed many relationships within the Lunar Society, hence demolished the solid foundation of success that the society was based upon. Because of some of the political views differed, personal relationships became under strain during this period, which was not an issue during the American Revolution.[83] In addition, many members were facing persecution from the public including Priestley and Withering. The Church and King riots that occurring in Birmingham during 1791 further made members uncomfortable. Resulting from all of the social unrest, many members could not keep up with the same amount of correspondence, or even attend the meetings with the same frequency they did in the past. In addition, many members had already moved or passed away and recreating the social bonds of previous decades proved to be difficult. Members still sent each other letters, but not with the regularity or passion for science that so characterized earlier letters. The overlying elements, which the Lunar Society usually operated, were missing after the French Revolution.

The Lunar Society of Birmingham was a unique gathering of scientific personalities during the second half of the eighteenth century in England. Their strength came from their social interactions and friendship rather than sheer intellectual abilities. The group operated in a distinctive method compared to their peers of the period,

> How typical it all was: concerted effort to find a practical application for the scientific discoveries of one of the members which, moreover, would have broad social value; careful (and probably premature) scientific experimentation combined with capital investment and political action; direct personal interest and the possibility of financial gain; and to conclude it all, ancillary scientific discovery and the encouragement of young scientists who were to influence the future.[84]

The members of the Lunar Society were intensely fixated on the sciences and their quest to harness it, but they were also passionate about each other. This acceptance of different personalities allowed each member to flourish and achieve more than they would individually. This new scientific style led to an increase of knowledge distribution and collaborating, which was uncharacteristic of other scientific societies during the period. In return, this rise in synergy led to numerous scientific and technological advances. Joseph Priestley, James Watt and William Withering were all excellent scientific minds during the eighteenth century in Great Britain. All three scientists were quite different concerning their careers, motivations and goals. Despite their differences, all three men became members of the Lunar Society and greatly benefitted from this new scientific style.

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[19] Musson 141.
[20] Uglow, 109-111.
[21] Uglow, 118.
[22] Uglow, 118.
[23] Uglow, 121.
[24] Uglow, 120.
[25] Uglow, 121.
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[28] Schofield, *The Lunar Society of Birmingham*, 140.
[29] Schofield, *The Lunar Society of Birmingham*, 140.
[30] Schofield, "A Bicentenary Appraisal", 150.
[31] Schofield, "A Bicentenary Appraisal", 150.
[32] Schofield, "A Bicentenary Appraisal", 151.
[33] Schofield, "A Bicentenary Appraisal", 152.
[34] Schofield, "A Bicentenary Appraisal", 152.
[35] Uglow, 124.
[36] Schofield "A Bicentenary Appraisal", 153.
[37] Schofield "A Bicentenary Appraisal", 153.
[38] Schofield "A Bicentenary Appraisal", 154.
[39] Schofield "A Bicentenary Appraisal", 154.
[40] Schofield "A Bicentenary Appraisal", 155.
[41] Schofield "A Bicentenary Appraisal", 155.
[42] Schofield "A Bicentenary Appraisal", 156.
[43] Schofield "A Bicentenary Appraisal", 156.
[44] Schofield "A Bicentenary Appraisal" 157.
[45] Uglow, 450.
[46] Uglow, 452.
[47] Uglow, 456.

[48] Schofield "A Bicentenary Appraisal", 157.
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[50] Schofield, *The Lunar Society of Birmingham*, 202.
[51]Schofield, *The Lunar Society of Birmingham*, 391.
[52]Schofield, *The Lunar Society of Birmingham*, 370.
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[54] Schofield "A Bicentenary Appraisal" 158.
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[60] Schofield, *The Lunar Society of Birmingham*, 376.
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[78] Schofield, *The Lunar Society of Birmingham*, 125.
[79] Uglow, 121.
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Chapter 2- The Scientific Minister: Joseph Priestley

Joseph Priestley was the last of a dying breed. He embodied an intersection of knowledge; Priestley was representative of the past and a symbol for the future. He possessed the deep roots of a humanistic education, being very fluent in the dead languages, theology and had a deep passion for the subject of education. At the same time, Priestley was very active in a new branch of knowledge, the practical sciences. However, what made Priestley so unique was not simply the fact he indulged himself in so many areas of study and exploration, but rather that he was widely considered an expert in almost every area of knowledge that he studied. Unfortunately, by the end of his career in Great Britain, many of his peers did not have a favorable opinion of him because of his liberal views, nonetheless, is no reason to forget what a great man that he was. Joseph Priestley was a unique member of the Lunar Society whose scientific personality flourished while an associate of the Lunar Society of Birmingham.

Joseph Priestley was born on March 13, 1733 at Birstall Fieldhed, in Yorkshire, which is about six miles south-west of Leeds.[1] He was the first of many children produced by his parents; and living in such a large family, nine children in all, had a large impact on his childhood. Due to a lack of attention, he felt estranged from his family.[2] Another notable aspect of his childhood was that his mother died when he was seven years old, and his father ended up remarrying five years later.[3] Therefore, Priestley did not know much about his mother and looked to other members of his family to help him. His extended family consisted of Calvinists and thus Priestley quickly became accustomed to working hard. When he was of age, he was sent to the Bartley Grammar School in order to learn Latin and Greek.

By the time he had turned sixteen, Joseph Priestley had decided that he wanted to be a minister and started looking at other schools of higher education. Cambridge or Oxford did not allow him to attend, due to his religious affiliations, and so he ended up at Daventry Academy in September of 1752.[4] The Daventry Academy was a very great fit and Priestley felt very comfortable at the school. He enjoyed the intellectual freedom that such a liberal school provided and he studied a wide variety of subject, including the ancient languages, biblical stories, and history. Also at this institution, he took up formal studies of the sciences.[5] These subjects included medical chemistry, anatomy, natural philosophy and even some mathematics. Priestley was always trying to read and learn outside of class, which even at a young age included the works of *Logic* by Isaac Watt and John Locke's *Essay Concerning Human Understanding*[6]. During his studies at the Daventry Academy, he became even more detached from his family. An important aspect of this increasing distance between him and his family was that it did not result from ill intensions or hostility but rather a lack of mutual affection. He eventually graduated in 1755 and moved to Suffolk to work at the chapel of Neeham Market.[7]

Priestley's appointment to the parish in Suffolk brought both good and bad periods. Priestley was never obsessed about amassing a fortune; however, his salary of 30 pounds per year was much less than the promised 40 pounds when he originally accepted the position.[8] Another negative aspect of his first parish was he did not get along very well with some of the elder clergy members in the Church. Being the young minister that he was, he thought he should try to remain as uncontroversial as possible. Nevertheless, this proved to be rather difficult and Priestley himself sums up his issues at this parish

> Though I had made it a rule to myself to introduce nothing that could lead to controversy in the pulpit; yet making no secret of my real opinions in conversation, it was soon found that I was Arian. From the time of this discovery, my hearers fell off apace, especially as the old minister took a decided part against me. The principal families, however still continued with me; notwithstanding this, my salary fell far short of thirty pounds per annum.[9]

Also included in his struggles of this parish was an attempted to create a school, which eventually failed due to a lack of support from the parish, as well as low attendance.[10] However, with the downsides of this post, some positive aspects presented themselves as well. Priestley very much enjoyed the people he lived with, as well as the opportunity to advance his classical and theological studies.[11] Nonetheless, at the same time he did express regret in not being able to pursue his scientific studies as much as he wanted. Also during his post in Suffolk, he started to publish some of his writings, eventually gaining slight notoriety. For example during this period in Suffolk, Priestley experienced first publishing of his works, *The Scriptural Doctrine of Remission* in 1761.

Shortly after his first publication came out, Priestley moved and took a position at the Warrington Academy. Soon after this move, Priestley life took a turn for the better. In 1762 he was ordained and shortly after became married to his wife, Mary Wilkinson and then in April 1763 the couple had their first child, Sarah.[12] While at his position at Warrington, Priestley did a large amount of work with grammar and analyzing higher education. Priestley gravitated towards these areas of the academic world because he was not a great speaker and felt more comfortable studying rather, than constantly lecturing and giving sermons. Another beneficial aspect of his position at Warrington was that Priestley also had the time and resources to devote to studying the sciences. Overall Priestley was relatively satisfied with this portion of his life.

During 1765 Joseph Priestley's career started to improve drastically. Throughout that year, Priestley started writing about his studies of electricity.[13] In addition, during 1765 he met John Canton, who happened to be friends with Benjamin Franklin, another well-known electricity expert of the time. By 1766 Priestley was well known for his work involving electricity, so famous in fact that on the 12th of June he was appointed a fellow of the Royal Society of London.[14] He quickly followed this accomplishment with publishing one of his most famous non-theological works, *The History and Present State of Electricity, with Original Experiments*. In the book, he used a lot of his own experiments, as well as the work of his close friends that were dealing with electricity as well at the time. In addition, some consider this work "A primary source for eighteenth-century understanding of electricity" and "is credited with for the first statement of the inverse square law of electrical force based on reasonable deduction from experiment."[15] All of this notoriety got him another job offer, this time to preach at Mill Hill Chapel in Leeds. Priestley took the job, partly because of the increase in salary, but also partly due to his desire to accommodate his wife's health.[16] During his stay at Leeds, he appeared happy, but started to receive criticism for his calls to reform politics and religion. Meanwhile he published minimal scientific work. However, with what little attention he turned to science he started to focus on chemistry. This new passion is evidence in his publishing of his work, *Directions for Impregnating Water with Fixed Air*, which was published in 1772 and describes probably the first method for carbonating beverages.[17]

In 1773, he moved to Calne to work for Lord Shelburne. This move got him closer to his new friends of the Lunar Society of Birmingham. During this period, Priestley did not have a parish to attend to, therefore he could devote a lot of time to his

experiments and writing. One of his most famous publications during this time consisted of his scientific work, *Observations on Different Kinds of Air*. This work describes Priestley's discovery and isolation of different gasses including ammonia gas, nitrous oxide, nitrogen dioxide and oxygen.[18] Much of his work during this period, especially his experiments involving gasses, ended up in the *Philosophical Transactions of the Royal Society*. Then in 1779, Priestley remarried and by 1780 he had accepted a new position, moving to Birmingham.[19]

The move to Birmingham did wonders for Priestley personally and professionally. Not only did he have a new wife, but also he had a new position as a minister at the New Meetinghouse.[20] Even though he achieved success in many other disciplines Priestley found the most joy in being a minister. In addition, Priestley joined the Lunar Society, which in time, would mean a great deal to him. Before he moved to Birmingham, Priestley already knew and corresponded with a few of the members including Matthew Boulton, James Kier and William Withering.[21] Priestley had been connected to Boulton through their interests in chemistry, and when Priestley had previously visited Birmingham for an experiment, he in fact visited Boulton in order to get samples of the Birmingham air.[22] In addition, before his move to Birmingham Priestley had worked with Keir on a number of chemistry experiments and often consulted Keir on matters of chemistry.[23]

Not until Priestley moved to Birmingham and actually began working with and directly corresponding to all the members of the Lunar Society, did he fully appreciate the group. Priestley expressed his joy for the Society, his current situation at the time, "I consider my settlement at Birmingham as the happiest event in my life, being highly

favourable to every object I had in view philosophical or theological."[24] Throughout his autobiography, Priestley mentions other groups of men that he dined or met with to discuss theology and philosophy while in Birmingham, but he speaks much more passionately, and with greater awe, about the members of the Lunar Society. Another important aspect from his time in Birmingham was the fact he was the only member of the Lunar Society to publically name or discuss the society while the society was still in session.[25] He mentions the Lunar Society in his memoirs of the time, an act which no other members were bold enough to perform. Another fascinating aspect of Priestley's time in Birmingham was that his scientific publications and accomplishments appeared to slow during this period, despite the fact that some of the most intelligent scientific minds of the time surrounded him. However even though he had minimal published scientific work, he was still doing a lot of work in the sciences but mostly on other people's endeavors.

Priestley's time in Birmingham was some of the greatest years of his life, but by the end of his time there, also provided some of his most traumatic moments. Not only was Birmingham full of hard working entrepreneurial citizens that made Birmingham such an exciting place to be, but was also a very explosive town. Birmingham had a history of riots throughout the entirety of the Eighteenth Century, not only when Priestley was in town.[26] During the time, Birmingham was "of great fame for hearty, willful, affected disloyalty to the King as any place in England."[27] Not only was Birmingham normally a very volatile town, but Europe at the time, was a place of heated tempers and opinions, especially in the wake of the American and French Revolutions. Priestley did not go looking for trouble with members of Birmingham but he certainly did not help

himself stay out of trouble either. Specifically he supported the colonists during the American Revolution, which did not sit well with many members of the greater Birmingham community.[28] In addition, Priestley was also radical in his education and religious opinions. For example, he tried to teach both boys and girls in his schools, as well as was in favor of the disestablishment of religion, another opinion that did not sit well with many people.[29]

All of these hostile feelings culminated on 14 July 1791. A few members of Birmingham were having a dinner in order to celebrate the second anniversary of the fall of the Bastille and this started to cause some dissent in the community.[30] Meanwhile a mob formed to express their disapproval, which quickly turned into a riot that trounced various establishments all of Birmingham for two and a half day. One of these establishments included Priestley's house, which he was not present at the time. Priestley returned to Birmingham for a short while afterwards but was persuaded by his friends to leave, because as Watt had claimed, he had a duty "to your family, to your friends, & to humanity in general…not to risk your life so valuable to them all."[31] Eventually Priestley did leave for good and headed towards London for a short period. However, London did not provide the necessary refuge that he sought and as he himself explains, "Being in some personal danger on their occasion, I went to London; and so violent was the spirit of the party which then prevailed, that I believe I could hardly have been safe in any other place. There, however, I was perfectly so, though I continued to be an object of troublesome attention until I left the country altogether."[32] In addition during this period the Royal Society started, as he expressed, was "shunning me on account of my religious or political opinions, so that I at length withdrew myself from them."[33] Overall these

events, as well as the composure and makeup of Joseph Priestley, can be summed up by his reflections of the event that he wrote while living in America,

> When I wrote the preceding part of these Memoirs, I was happy, as must have appeared in the course of them, in the prospect of spending the remainder of my life at Birmingham, were I had every advantage for pursuing my studies, both philosophical and theological; but it pleased the sovereign disposer of all things to appoint for me other removals, and the manner in which they were brought about, were more painful to me than the removal themselves. I am far, however, from questioning the wisdom or the goodness of the appointments respecting myself or others.[34]

Even through these difficult times, Priestley retained good composure and put his trust in God and himself when he moved to London afterward. However, this proved to not be enough and he eventually had to leave.

Joseph Priestley had seriously considered leaving England as early as September of 1791. He thought about immigrating to France, both in order to insure the safety of his family, as well as to secure work for his sons, who were having a difficult time finding work due to the reputation of their father.[35] However, this move proved impossible when in 1793 war was declared in France. Because France was no longer an option Priestley then decided to join his two sons in America. Prior to his arrival in the Unites States, Priestley was in correspondence with John Adams, whom happened to be the vice president of the United States at the time, and who was a large follower of Priestley's work.[36] Eventually Priestley ended up settling in the greater Philadelphia area. Priestley was quite popular in the United States, mostly due to his friendship with Benjamin Franklin as well as his support of the colonists during the American Revolution.[37]

Even though Joseph Priestley was nearing the end of his life, he was very busy and flourished in an environment where he felt accepted. He went on to publish twenty-

five books or pamphlets during his ten years in the United States.[38] In fact, three of these books included topics on the sciences, continually maintaining his passion for chemistry during this period. Priestley also published many writings on the education system of the United States, which included criticism on Jefferson's College of Virginia, as well as was a large proponent of more liberal arts education establishments in America.[39] During this period, Priestley's wife encountered many periods of sickness, and eventually died in 1796.[40] Overall Priestley had very good health, until 1801 when he started to deteriorate. Despite that his health was failing, his spirits remained high. He enjoyed being under the administration of Thomas Jefferson and his ideas, of whom he often corresponded. Priestley was consumed with his garden, as well as his work in chemistry and theology until his death.[41] At the end of 1803, his health started to deteriorate even more quickly and his son Joseph looked after him until his death on February 6, 1804. The end of Joseph Priestley's life, "sufficiently proved the value of his religious principles, and how much he was influenced by them, yet the force of them was so conspicuously displayed during his last illness."[42] Even though much of his life was dedicated to theology and education, Priestley remains remembered most for his accomplishments in the sciences.

Joseph Priestley felt very indebted to the Lunar Society of Birmingham at the end of his life. During his time as a member of the group, he received financial, social, and intellectual support from his fellow members. In addition, a more in-depth look at his scientific accomplishments helps to put the Lunar Society into the perspective of Joseph Priestley's life. His career successes as a member of the Lunar Society was different compared to his accomplishments while not in constant contact with this set of friends.

Not only did he owe a lot to the Lunar Society of Birmingham but also he contributed a lot to the careers and accomplishments of his friends. This sense of collaboration and communication are what epitomizes the Lunar Society during this period and helps to explain its success compared to other societies of the period.

One of the many reasons that Joseph Priestley felt so obliged to the Lunar Society and its members was that many of them helped finance him, his family and his experiments during this period. Priestley did not quite have the inheritance that other prominent intellectuals of the time possessed, and was not was the successful entrepreneurial businessperson that others like Boulton, were. While at his position at Birmingham, he received some funding from private donors to continue his studies but still was not enough on its own. When Priestley had left Lord Shelburne, to come to Birmingham he lost half of his annual income.[43] However arriving in Birmingham he received many benefactors that "some of the subscriptions were made with a view to defray the expence of my experiments only; but the greater part of the subscribers were persons equally friends of my theological studies."[44] Two of his new benefactors included Wedgewood and Samuel Galton Jr., both of whom were members of the Lunar Society. Priestley acknowledged that part of the reason for writing his memoirs was due to the work and support of his benefactors, some of who remained unanimous. [45] A lot of the money that the members of the Lunar Society gave to Priestley was bestowed with much tact to insure that Priestley did not feel patronized.[46] One example of this is a correspondence between Boulton and Wedgewood in 1782,

> I cannot help wishing you wd. put the business (wch you & I have talked over respecting the Annual Expenses of Dr. Priestley's Laboratory) into some train that ye subscribers may pay & ye doctor receive the Money without trouble &

> pain to either party…I have not paid anything yet & wish to do it, but as I have never spoke to ye Dr. upon the subject I wish to avoid it & so doth my Neighbour Galton. therefore I beg you will manage the matter so that we may contribute our mites so laudable a plan without the Drs. Knowing anything of the matter & favr. me with a line at your leisure.[47]

Also in his memoirs, Priestley discussed that he indeed did amass a small fortune, however such an outcome was never his intention starting out and the money he raised was for his experiments and studies, further displaying how humble he was.[48] Nonetheless, despite his humbleness he did amass one of the more impressive library and set of experiment equipment in all of England.[49] He also mentioned that he much rather preferred being funded by people that believed in him rather than through the courts. It appears that Priestley viewed himself as being economically independent, when in reality this was far from the truth but the other, wealthier members had no problems with this.[50]

The members of the Lunar Society of Birmingham provide financial support to Joseph Priestley but also the social acceptance and support which Priestley desperately needed. Priestley had met many other equally intellectually capable individuals before but all of a sudden, he had a group that accepted him,

> Priestley thoroughly enjoyed the intellectual and social attractions of that part of Birmingham life manifested in the meetings of the Lunar Society. He was forty-seven when he settled in the city, in the prime of his life and fame, and found a group of appreciative, and sympathetic equals. He probably gained from his friendly intercourse with such a galaxy of genius a misleading impression of the growth of understanding and support for him.[51]

This level of acceptance was unrivaled throughout Priestley's life and it allowed him to concentrate on all areas of his study without being afraid of ridicule by his peers in the Lunar Society. Even when the rest of Birmingham did not agree with what Priestley said,

he could at least freely speak about his ideas within the society. In addition to gaining acceptance of the Lunar Society, the members also helped to introduce Priestley into other academic groups and circles of the time. For example, after arriving in Birmingham, Priestley became a member of the Académie Royale des Sciences, American Philosophical Society, the American Academy of Arts and Sciences, as well as an honorary member of the Medical Society of Edinburgh.[52] Even though he was very active within intellectual circles throughout Europe and America, he was the closet with his associates of the Lunar Society.

Although Priestley left Birmingham and the Lunar Society, his connection with the other members did not stop. While Priestley was taking up residence in London, "He missed his friends of the Lunar Society, associates of the Royal Society avoided him, and he ceased attending meetings, publishing his continued attack on Lavoisian chemistry,"[53] Again the Royal Society had started cutting their ties with Priestley due to his political and theological beliefs. Priestley acknowledges such alienation in his memoir, "most of the members of the Royal Society shunning me on account of my religious or political opinions, so that I at length withdrew myself from them."[54] Even with all the public negatively, Priestley still attempted to remain in contact with his friends from Birmingham. The affection did not appear to be just one way either for Priestley was still regularly invited to the meetings of the Lunar Society, and even though he deeply wished to return, he knew that he could not.[55] Another aspect of note, this mutual support of one another did continue when Priestley left the European continent for America. Not only did he keep up some correspondences, but Watt and Wedgewood sent gifts to Priestley when he was living in the United States.[56]

The scientific career of Joseph Priestley benefited by his membership in the Lunar Society of Birmingham; however he did also have an impressive career before he became a member. The first work produced by Joseph Priestley was his *Rudiments of English Grammar,* which he published during 1761 while he was at Sufflolk.[57] Not until 1765 did Priestley start to pursue scientific matters. After meeting John Canton who was friends with Benjamin Franklin they sparked Priestley's interest in electricity and he started to do what he did best, write about the matter. In fact before this endeavor Priestley had never performed an experiment concerning electricity, had only had read books on the matter. [58] Priestley would go on to perform numerous experiments in detail, for his book and even proved that some of the previously performed experiments were incorrect.[59] The book, titled, *History and Present State of Electricity, with Original Experiments*, turned out to be a huge success, both on financial and career levels for Priestley. Not only was his scientific knowledge very vast but he put it into current context and "His book became far more than an exposition of the currently-known facts of the subject. It turned out to be a statement of the new approach to science in the new age."[60] Another important aspect of this work was "He discussed the need for specialist societies to cultivate the new branches of science, and better methods of quick communication and publication of discoveries."[61] Not only was Priestley concerned about electricity but the greater cause of scientific knowledge and that this knowledge is shared as quickly as possible. Later while Priestley was working with other Lunar Society members, he must have been impressed and pleased with being able to share progress with other members so quickly because they simply lived across town. During the process of writing his book, Priestley encountered members of the Lunar Society

including Darwin and Boulton who were both friends with Benjamin Franklin.[62] In the book, Priestley also referenced some of Darwin's previous work with electricity.

After Priestley published the *History and Present State of Electricity, with Original Experiments*, his scientific works remained constant. In 1768 he published *A Familiar Introduction to the Study of Electricity*. Due to his critics of his book he explains, "My principal design was to promote discoveries in the science, by exhibiting a distinct view of the progres in it hitherto, and suggesting the best hints that I could for continuing and accelerating the process: but I thought the same treatise might also be perfectly intangible for beginners. It seems however, that I was mistaken in that exception."[63] In other words, he tried to stay true to his beliefs and write a volume that almost anyone could understand and thus would increase interest in the subject. He then followed this work up with *A Familiar Introduction to the Theory and Practice of Perspective* in 1770 and in 1772, his next scientific work was *The History and Present State of Discoveries Relating to Vision, Light and Colours*.[64] Robert Hooke and Robert Boyle were very influential in getting Priestley to write this book and intended this work was written in a similar way that his first *History*. However, this book never gained the notoriety that Priestley's first book did.

The lack of success of his l772 book did not deter Priestley and he proceeded to keep up with his scientific writings, however these new writings covered new topics. 1772 was a busy year for Priestley for he also published his work titled, *Directions for Impregnating Water with Fixed Air*. This work was essential because this was the first work in which Priestley dealt with chemistry and with air. Priestley became one of the foremost experts on the chemistry of air, "From this time until his death in 1804 there

were no developments in pneumatic chemistry which occurred entirely independent of the work of Priestley."[65] While Priestley was living at Leeds, he was situated right next to brewery and saw this as an opportunity to work with chemistry.[66] He also wrote a paper that he sent to the Royal Society about the discovery of two new gases, nitric acid and hydrochloric acid. [67] However, in 1772 he ended up leaving Leeds and going to work for Lord Shelburne and he experienced a change in scenery.

This change in scenery helped Priestley produce another one of his influential works. This work published, in 1774, titled *Observations on Different Kinds of Air*. Originally intended for the *Philosophical Transactions*, to work still became very popular within the medical community.[68] While producing this volume Priestley worked with Boulton and Small with their attempts to work with igniting air. Priestley's discovery of oxygen was also a portion of this publication; however, he did not quite realize exactly the importance of the gas. In addition, he made deductions that helped to lead to photosynthesis and discovered the gases ammonia and nitrous oxide.[69] During this period of his scientific investigation, Priestley was constantly in correspondence with Boulton. The two men discussed techniques Priestley could use for his experiments as well as the new discovery of oxygen and its practical implications.[70]

Up until the time that Priestley joined the Lunar Society at Birmingham, he published few scientific papers of significance. In 1776 he published *Observations on Respiration and the Use of Blood*, which was read at a meeting of the Royal Society on January 25, 1776.[71] In 1777 he managed to publish new editions of some of his previous works. Lastly, in 1779 Priestley published a work titled, *Experiments and Observations Relating to Various Branches of Natural Philosophy* which also included some more

comments on his *Observations of Air*.[72] Priestley produced a large amount of scientific information before he reached the Lunar Society. Nonetheless, Priestley's first scientific work was successful because of the comprehensiveness of the book, making it the first of its kind in the field of electricity. The breadth of such a large subject would not have been possible without the sheer amount of communication and collaboration that Priestley used when producing his book. In addition, he managed to compile a large amount of information in a relatively short period of time, a benefit of being able to communicate so quickly with people. The ease at which Priestley communicated with other scientists and collaborated with them was very similar to the way in which the Lunar Society functioned. The success of Priestley's *History and Observations of Electricity* and the Lunar Society as a whole prove that this new social direction science was taking proved to be effective method to encourage scientific progress.

Priestley's move to Birmingham had a peculiar effect on his scientific career. He appeared to be extremely active with doing scientific work; however, his scientific publications appeared to drop off. Priestley was very busy with his new parish but he did manage to find ample time to publish other papers, usually concerning social or educational reform. During his time at Birmingham, Priestley published nine papers for the *Philosophical Transactions*; however, most of these works were simply defending his previous discoveries that had come under attack.[73] On June 26, 1783 he attended a meeting at the Royal Society and presented a paper regarding his experiments and theory with phlogiston. This turned into a paper published in 1784 called *Experiments Relating to Phlogiston and the Seeming Conversion of Water Into Air*. Priestley had become quite fascinated with the chemistry of air, especially the theory of phlogiston. Proving or

disproving phlogiston was a consuming task for both Priestley and the Lunar Society as a whole. In 1788 Priestley published his work titled, *Additional Experiments and Observations Relating to the Principle of Acidity, the Decomposition of Water, and Phlogiston,* which shows his continued passion for chemistry. In addition, this paper was read at the Royal Society and included a section of letters from Withering and Keir while they collaborated with Priestley on the matter.[74]

Despite Priestley's lack of notably scientific work during this period, the Lunar Society, as a whole, appeared to go through a phase of relative success. This era of prosperity started in about 1781 and continued up until about 1786. This revival of the Lunar Society comes at a very similar period in time to that of Joseph Priestley's membership. Such an occurrence could perfectly be coincidence; however, a further investigation into the matter reveals that such an explosion in activity was more than pure chance. Priestley was the most well rounded member, intellectually within the Lunar Society, evident by the fact he was part of scholarly groups of varying types in all different countries.[75] His expertise and knowledge went far beyond just one or two topics, and his vast array of knowledge potentially served as the glue to the group, facilitating the assimilation of different areas of knowledge. Therefore, the issue becomes what characteristics or actions Priestley brought that helped all of these members succeed in a variety of academic areas? First of all Priestley, "was the most complex and one of the most talented members of the Lunar Society."[76] Again, all of the members of the Lunar Society were intelligent, but few had the expertise in both the learned knowledge, such as the classics, as well as the practical knowledge such as the increasing relevant fields of chemistry and electricity. Another aspect to consider is that

when Priestley was in Birmingham he produced very little of his own, original scientific researched. The majority of his published, scientific work when in Birmingham was written before he arrived. Therefore, Priestley in essence might have spent more time helping others with their work rather than on fully concentrating on his own work.

One factor that contributed the success of the Lunar Society together was that chemistry was becoming an increasingly popular and practical field of knowledge. Thus with the arrival of Priestley, all of a sudden the society had brought in an expert. At the time "Chemistry was the science that attracted the attention of more Lunar members than any other, and the addition of Priestley to their number greatly increase the amount of time they spent on chemical experiments."[77] Groups are certainly more passionate when they have a common goal, rather than a scattering of random interests. Almost all members of the Lunar Society at the time had some knowledge in chemistry, therefore, Priestley was just the right person to turn that into a group passion because, "When Priestley arrived in Birmingham late in 1780, he was a dominant figure in world chemistry, his papers were eagerly read, and his opinion was serious."[78] Priestley's knowledge of chemistry was vital because many members of the Lunar Society were concerned with geology and minerals, especially working with acids and alkalis.[79] Consequently, the demise of the Lunar Society corresponding with the fall of Priestley, at the end of the decade, also makes sense in this context.

Examples of Priestley being able to help his fellow members of the Lunar Society were everywhere throughout the period. For instance, Priestley was an essential consultant to Boulton and Watt in their business ventures because of Priestley's knowledge of different types of airs. Priestley performed experiments investigating the

effects of heat on certain gases, which was essential to Watt's experiments. This knowledge of air was essential because Watt was always worrying that models of his engines would be stolen by the competition, or that a completely new version of the engine would be produced. Therefore, Priestley worked with Watt to help to both settle Watt's fears as well as improve his models of the engine.[80] This turned out to be a successful relationship because, while working with Priestley, Watt perfected and patented his "expansive, double-acting engine."[81] Priestley contribution to Wedgwood's work came in the form of suggesting a clay thermometer that Wedgewood found essential in the success of some of his later, influential findings.[82] Surely, Keir benefitted from knowing Priestley, and used him for his knowledge of gases when in 1789 he put together his dictionary of chemistry called, *The First Part of a Dictionary of Chemistry*. Priestley did not necessarily have the charisma or machine-like drive to bring a group of such intellectuals together but he had the knowledge to help everyone. Another example of Priestley's presence benefitting other members of the Lunar Society includes his interactions with Wedgwood who was a potter. Wedgwood like the amount of detail that Priestley used in his published papers and often attempted to use Priestley's knowledge of electricity in his pottery business.[83] The influence of Priestley on Darwin is a bit more difficult to discern however. During this period, Darwin actually moved away from Birmingham with his new wife, which might suggest that the influence of Priestley on Darwin was minimal. However, in his work *The Botanic Garden* he referenced many members of the Lunar Society, specifically quoting Priestley throughout the volume.[84]

Another example of the collaboration of the Lunar Society is noticeable with their work concerning balloons during the 1780s. In the summer of 1783 "balloon mania"

stared in France, traveled to Switzerland and eventually reached Priestley by September.[85] As typical of the Lunar Society when one member became infatuated with one particular topic, other members became impassioned and contributed their own skills. Priestley was interested in the subject because of his experience with gases and chemistry. Watt found the calculations involved to be very interested and corresponded to his expertise of expanding gases.[86] Boulton, Darwin and Withering also participated in a series of experiments with the balloons. For one experiment, the group tried to send a balloon to Boulton's garden but due to the wind carried it to his neighbor's house.[87] Eventually their passion for balloons subsided, probably from when Priestley was trying to gather air for experiments in his balloon and then hit a tree during the winter of 1785.[88] The last experience concerning balloons was a paper that Priestley read to the Royal Society during a meeting on 24 February 1785.[89]

Even after Priestley left Birmingham and ended up in America his scientific work continued. In 1793 he published a paper in the *Philosophical Transactions,* again on the topic of investigating his phlogiston theory. He followed that up with a fourth edition of his *History and Present State of Electricity.* During 1796 while he was residing in Philadelphia, he published *Considerations on the Doctrine of Phlogiston, and the Decomposition of Water.* What makes this work interesting is both the fact he is still fascinated with Phlogiston, and that he expresses his membership in the Lunar Society. Priestly laments, "And now that Dr. Crawford is dead, I hardly know any person, except my friends of the Lunar Society at Birmingham, who adhere to the doctrine of phlogiston."[90] However, that work proved to not to be his last scientific paper published and despite his ill health in 1800 he published one last article regarding phlogiston. The

paper was titled, *The Doctrine of Phlogiston Established, and that of the Composition of Water Refuted* and even though there was minimal of scientific achievement the work contained some aspects of importance. First of all the paper is dedicated to Samuel Galton Jr., one of the remaining members of the Lunar Society. He goes on to thank him for his friendship and his other friendships that did not stop when he left Birmingham. Priestley laments about being a member of the Lunar Society, "The interviews we have had at the *lunar society*, and on other occasions, I now look back upon with peculiar satisfaction, tho' mixed with regret. There is no lunar society to which I can communicate my observations, and from which I can receive my light in return, in this place."[91] Not only was Priestley still affected personally by members of the Lunar Society be he also mentions the work of Kier and Dr. Beddoes, who was a good friend to many members.

Analyzing the effect of the Lunar Society on Joseph Priestley is difficult to quantify. His amount of scientific publications produced during his time as a member of the Lunar Society was quite low. During that period, Priestley was turning out publications that dealt more with the social and religious issues of his day, especially during the French Revolution, which he was heavily invested. However, he remained extremely busy performing experiments for both himself and his friends. Priestley was active working with many experiments and dealing with his phlogiston theory. This work consumed him, as the majority of his remaining scientific publications were concerned with the topic. Therefore, Priestley's lack of published scientific work during his Lunar years cannot be connected with a lack of trying, but rather a lack of results to publish in the area of phlogiston, as well as his concentrated efforts on projects of Lunar

members. Thus, the effect of the Lunar Society on Priestley's career can be seen in the social benefits he received from this group of friends and the assistance he gave to other members in their various endeavors.

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[3] Priestley, *Autobiography*, 69.
[4] Matthew and Hanson, 352.
[5] Matthew and Hanson, 352.
[6] Matthew and Hanson, 351.
[7] Matthew and Hanson, 353.
[8] Priestley, *Autobiography*, 79.
[9] Priestley, *Autobiography*, 79.
[10] Matthew and Hanson, 353.
[11] Priestley, *Autobiography*, 81.
[12] Matthew and Hanson, 353.
[13] Matthew and Hanson, 354.
[14] Matthew and Hanson, 354.
[15] Matthew and Hanson, 354.
[16] Matthew and Hanson, 354.
[17] Matthew and Hanson, 355.
[18] Matthew and Hanson, 356.
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[20] Priestley, *Autobiography* , 25.
[21] Priestley, *Autobiography*, 24.
[22] Robert E. Schofield, *The Enlightened Joseph Priestley* (University Park, Penn.: Pennsylvania State University Press, 2002), 150.
[23] Schofield, *The Enlightened Joseph Priestley* , 150.
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[26] Schofield, *The Lunar Society of Birmingham*, 263.
[27] Edward Hyde, Earl of Clarendon, *The History of the Rebellion and Civil Wars in England* (Oxford: Clarendon Press, 1717), vol 2, pt. 1, 233.
[28] Schofield, *Lunar Society of Birmingham*, 264.
[29] Schofield, *Lunar Society of Birmingham*, 264.
[30] Schofield, *Lunar Society of Birmingham*, 264.
[31] Schofield, *Lunar Society of Birmingham*, 289.
[32] Priestley, *Autobiography*, 129-130.
[33] Priestley, *Autobiography*, 130.
[34] Priestley, *Autobiography*, 128.
[35] Schofield, *Lunar Society of Birmingham*, 318.
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[37] Schofield, *The Enlightened Joseph Priestley*, 326.
[38] Schofield, *The Enlightened Joseph Priestley*, 326.
[39] Schofield, *The Enlightened Joseph Priestley*, 340-1.
[40] Schofield, *The Enlightened Joseph Priestley*, 348.
[41] Priestley, *Autobiography*, 134.
[42] Priestley, *Autobiography* ,133.
[43] Priestley, *Autobiography* ,118.
[44] Priestley, *Autobiography*, 118.
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[46] Schofield, *Lunar Society of Birmingham* , 200.

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[48] Priestley, *Autobiography,* 126.
[49] James G. Crowther, *Scientists of the Industrial Revolution: Joseph Black, James Watt, Joseph Priestley [and] Henry Cavendish* (London: Cresset Press, 1962), 226.
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[52] Schofield, *Lunar Society of Birmingham,* 151-2.
[53] Matthew and Hanson , 358.
[54] Priestley, *Autobiography,* 130.
[55] F. W. Gibbs, *Joseph Priestley: Adventure in Science and Champion of Truth* (London: Thomas Nelson and Sons Ltd., 1965), 212.
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[57] Joseph Priestley, *Rudiments of English Grammar* (London, 1761).
[58] Crowther, 196.
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[63] Joseph Priestley, *A Familiar Introduction to the Study of Electricity* (London, 1768).
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[65] Schofield, *Lunar Society of Birmingham* , 196.
[66] Crowther, 214
[67] Schofield, *Lunar Society of Birmingham,* 199.
[68] Joseph Priestley, *Observations on Different Kinds of Air* (London, 1772).
[69] Crowther, 221.
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[71] Joseph Priestley, *Observations on Respiration and the Use of Blood* (London, 1776).
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[74] Joseph Priestley, *Additional Experiments and Observations Relating to the Principle of Acidity, the Decomposition of Water, and Phlogiston* (London, 1788).
[75] Schofield, *Lunar Society of Birmingham,* 151-2.
[76] Schofield, *Lunar Society of Birmingham,* 193.
[77] Schofield, *Lunar Society of Birmingham,* 289.
[78] Schofield, *Lunar Society of Birmingham,* 289.
[79] Schofield, *Lunar Society of Birmingham,* 269.
[80] Schofield, *Lunar Society of Birmingham,* 202.
[81] Schofield, *Lunar Society of Birmingham,* 202.
[82] Schofield, *Lunar Society of Birmingham,* 267.
[83] Schofield, *Lunar Society of Birmingham,* 92, 188.
[84] Schofield, *Lunar Society of Birmingham,* 207.
[85] Schofield, *Lunar Society of Birmingham,* 251.
[86] Schofield, *Lunar Society of Birmingham,* 251.
[87] Schofield, *Lunar Society of Birmingham,* 251.
[88] Schofield *Lunar Society of Birmingham,* 253
[89] Schofield, *Lunar Society of Birmingham,* 253.
[90] Joseph Priestley, *Considerations on the Doctrine of Phlogiston, and the Decomposition of Water* (London, 1793).
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Chapter 3- James Watt: Engineering the Future

Joseph Priestley was a man with immense talents, especially within the sciences and these skills flourished while a member of the Lunar Society. James Watt was very gifted with science but his best work and discoveries were in the area of technology and the applied sciences, and thus quickly found their way into use within the public sphere. James Watt had a very different career path and scientific personality than Joseph Priestley. Watt was a very methodical and capitalistic instrument maker while Priestley was an educated minister, yet both of these members found their place within the Lunar Society of Birmingham. Priestley more often focused on gaining knowledge while Watt was more interested in applying this new information immediately in order to make money. Despite these differences between the two, the Lunar Society tolerated and eventually benefitted both members greatly and in fact, the two members worked together on numerous projects many different times throughout their Lunar careers.

Before the life and achievements of James Watt can be fully appreciated, they must be put into historical context. Such is the case because he was born into a very dynamic and rapidly changing society that was drastically different from that of the intellectuals before him. The roots of these changes within the intellectual community are traced all the way back into the sixteenth century, when Europe's economy started to change. Countries such as England started to take advantage of their colonies and began forming an immensely mercantilist and capitalistic economy.[1] This capitalistic economy would later go on to shape the views and goals of many members of the Lunar Society,

especially Watt, during the latter half of the eighteenth century. These new economic viewpoints revealed themselves through the entrepreneurial nature of men like Watt and Boulton, rather than the more humble views of academic men such as Priestley. Not only were individual men affected by the new economic though, but so was the economy as a whole. England was slowly transforming from a domestic, cottage style of production to a more centralized, industrial labor force.[2] Labor was no longer based on the home but rather in centralized areas such as factories and this directly affected man during Watt's time. This new style of production demanded new technologies and forms of science brought into the public, and applied, rather than kept in laboratories and periodicals. The men that led England into the Industrial Revolution were embedded into a much different England then the men that preceded them.

Not only was the economy of Europe changing, but also so were their ways of thinking. Men such as Francis Bacon and Rene Descartes spread scientific throughout England and the rest of Europe, which continued throughout the seventeenth and eighteenth centuries.[3] As time went on, the branches of philosophy and science that were so entwined during previous centuries, began to untangle and separate. This separation gave the natural sciences more credibility and interest within intellectual circles, evident with a rise of numerous intellectual societies throughout Europe that primarily focused on science. The first of these societies was the Lyncean Society formed in 1611, within Italy.[4] This was far from the most successful or popular of the intellectual societies; however, being the initial club, it remains exceptionally important. Soon after, the Royal Society of London was created and they gained the most notoriety of the intellectual groups, and meanwhile still exist to this day. Also during this period, the Académie des

Sciences was founded in Paris, as well as the Academia Naturae Curiosorum was created in Germany during 1652.[5] Throughout the eighteenth century, Russia and Sweden formed their own scientific societies to prove their own prowess to the world.[6] In the book, *Ulta, or the Progress and Advancement of Knowledge Since the Days of Aristotle*, the author makes the claim that the three most important advances were the printing press, the compass and well as the Royal Society of London.[7] One aspect that made the Royal Society so vital to England was the intention behind it; however, the group was far ahead of his time,

> "There was a practical element in Charles II's encouragement of the Royal Society. He hoped for profitable results from industry for the application of science to technology. It was, on the whole, a vain hope. Science was not yet ready, and Charles was about a hundred year out of reckoning. Yet his hopes were not unnatural, since the doctrine of experiment seemed naturally allied to the considerable growth of technological and mechanical processes.[8]

People during this period were starting to understand how science worked, but not why. Therefore, as hard as the original members of the Royal Society of London tried, their science was too advanced to be applied for normal use during their lives.

One reason that James Watt and his contemporaries were so successful during the second half of the eighteenth century was that capitalistic beliefs collided with scientific thoughts resulting in a boom of applied sciences. Science and business started to go hand in hand, "In England, natural resources became the opportunity of the powerful landed and moneyed interests. Mechanization was the keynote of industry, and finance provided the lubrication for its smooth working, since capital had long ago become a necessity for industrial development." [9] Such growth in business and science was encouraged by a

variety of fiscal developments at the turn of the century. In 1694 the Bank of England was formed, which was soon followed up by the London Stock Exchange in 1698, and in combination with the increased passion for science meant that applied science now had real financial rewards.[10] Oddly enough, this surge in applied sciences were not coming from the leading academic centers of the era, "Throughout this period, with the possible exceptions of the Scottish schools of Glasgow and Edinburgh and the German Göttingen and Halle, the universities played curiously little part in the study of the practical needs of life. Scholars seemed strangely out of touch with life in England; it was, rather the day of detached amateurs or of individual scientists."[11] These amateurs and individual scientist were the types of people that became members of societies such as the Royal Society of Arts of London, as well as the Lunar Society of Birmingham during the latter half of the eighteenth century.

When James Watt was born on January 19, 1736 in Greenock, Renfrewshire he was brought into a world that was intellectually and economically ready for him to excel. However, even if England was ripe for him, he was not immediately ready for it. James was the oldest surviving child of his parents.[12] James' mother had lost three children to childbirth before him and James appeared to be a frail child, therefore his mother kept at home and homeschooled him until he was ten or eleven years of age.[13] During his childhood, Watt often experienced intense headaches and was a chronic hypochondriac, two conditions that were constant throughout the majority of his life.[14] Finally, when Watt started going to Grammar School he took Latin and Greek, which he had a large amount of trouble.[15] A hundred years earlier, students that had trouble with the basic classical languages were considered dull, but Watt quickly helped other realize his

potential. He started to excel in mathematics at school and then found a passion for his father's workshop. Just as England was shifting from emphasizing a humanistic education to acquiring practical knowledge and skill, so was Watt, "once he left the library for the workshop, he showed that he had an intelligent hand. He took to the workshop completely. He was diligent and he persevered, making and re-making all kinds of models, from cranes to capstans."[16] Even as a child, people started to value skills differently that were not important a hundred years earlier. Therefore, simply because Watt was no proficient in the dead languages, that did not mean he was not going to be successful.

Even though James Watt showed a good deal of proficiency at math, as well as in his father's workshop, he was still quite far from being either rich or successful. The year 1753 was not a good one for him or his family. During the year, James' mother passed away and his father's business started to decline dramatically, forcing James to move out.[17] The young Watt decided that he wanted to attempt to be an instrument maker and moved to Glasgow in order to pursue this career. The only belongings he took with him were "his jack and chisels and files, his ribbed stockings and ruffled shirts, his Holland nightcap and tartan waistcoat, his leather apron and his hat with its crape mourning band."[18] Watt was certainly up against many odds when he left his home in Greenock but he was up to the challenge. While in Glasgow, he stayed with his mother's relatives but soon found out that no one had the time or credentials to officially teach him the craft of instrument making. Therefore, in 1755 he moved to London in an attempt to find someone to teach him, and due to the rigid apprenticeship system that was in place such a mentor proved difficult to find. Nonetheless, after enough searching he found someone

that would teach him. During the year, Watt put in many long days, working long and hard, usually until ten or eleven each evening.[19] Often throughout the year, he got sick but he continued to work hard, and also did his best to save as much money as possible. He was very thrifty because he wanted to cost his father as little money as feasible, especially due to his failing business. Halfway through his year working in London he realized that he wanted his own business and was willing to work very hard for it.[20]

After the year, Watt traveled back to Glasgow and attempted to open his own shop. The local shopkeepers "considered him an intruder on their privileges," but "the University protected him by giving him a shop within their precincts, and by conferring on him the title of Mathematical instrument maker to the University."[21] Finally, Watt had his own instrument shop and could provide for himself, and he soon started to find his place at the university. Not only did he gain a reputation for be an excellent instrument maker but he also gained a good number of friends that respected him as a person. Dr. Joseph Black spoke very highly of a young James Watt as "a young man possessing most uncommon talents for mechanical knowledge and practice," also adding that Watt was "remarkable for the goodness of his heart and the candor and simplicity of his mind, as for the acuteness of his genius and understanding."[22] Also during this period, Watt's passion and talent for science started to reveal themselves. In fact, Watt was so passionate about science that he learned other languages in order that he could read about the leading scientific achievement at the time.[23] Specifically he learned German in order to read Leopold's *Theatrum Machinarum*.[24] Not only was Watt gaining notoriety within the sciences but was truly becoming a notable mathematician as well. He agreed to build an organ for the Masonic Lodge in Glasgow even though he had never built one before.

Despite a lack of experience, he deeply invested himself in the project, specifically with investigating the theories of harmonics and by the time he was complete his "calculations put him ahead of the best mathematicians in Europe and his Masonic organ worked perfectly.[25] By 1758, he met John Robison who was a professor of chemistry at the university and the two became good friends, their bond strengthened for an enthusiasm for science.[26] Robison was extremely important in Watt's life because he encouraged Watt's initial attempts to work with improving steam engines by making them more efficient.

About this point in time, Watt's life and career started to take off for on both personal and business levels he started to achieve success. His instruments started to gain notoriety and he was so popular that he began selling some of his instruments in London. Not only were his instruments gaining fame, but also so was his prowess in other areas. While he was at the university, people constantly consulted him for scientific matters because his knowledge and expertise had expanded to matters beyond mathematics and instrument making. On looking back on when he first met Watt, Dr. John Robison commented on the respect that the scientific community gave Watt at the time,

> All the young lads of our little place that were in any ways remarkable for Scientific predilection were acquaintances of Mr. Watt, and his parlour was a rendezvous for all of this description. Whenever any puzzle came in the way of us we went to Mr. Watt. He needed only to be prompted, everything became to him the beginning of a new and serious study, and we knew that he would not quit it till he had either discovered its insignificancy or had made something of it. No matter in what line, Languages, Antiquity, Natural History, nay Poetry, Criticism and works of Taste.[27]

Not only was Watt one of the most respected scientific minds at the University of Glasgow but he was highly regarded in many other areas of study, even though he was not a professor in any subject. Such respect is an outstanding feat, especially considering he was a graduate of neither any university nor a professor at the University of Glasgow. Watt started indulging in pottery making as well as chemistry.[28] In addition, Watt always found the body fascinating and thought about becoming a doctor, but realized he was too squeamish, therefore stayed with his instrument making.[29] Ironically, even though Watt worked at a university he never found time to go to any of the classes, "In spite of the close relationship between Watt and some of the leading scientists at the University, there was quite a sharp division between Watt and the academic life. He was so busy with his various jobs that he never sat in at any of the university lectures."[30]

Watt was never interested in electricity, potentially because he did not see the practical applications and left it for the other members of the Lunar Society, especially Priestley, to deal with.[31] His lack of interest in electricity, which was very popular at the time, could have been due to his personality. For example, "Watt was often overly cautious, and it is interesting in this respect that, unlike Boulton, Darwin and Priestley, he was never interested in electricity," and therefore potentially "One feels that perhaps it was too sudden and explosive for him – he wanted to harness the simmer, not the lightning."[32] No matter the reason for Watt's disinterest in electricity, England and the world eventually benefited from Watt's passion for steam engines. Even though parts of his life were becoming successful, he still needed some money to continue to perform his experiments. During June 1763, he took out a £150 loan from Joseph Black that Watt did not completely repay until February 1774.[33]

James Watt's successes did not stop with his flourishing instrument making shop and reputation for being knowledgeable in the sciences; on 16 July 1764, he married his cousin Margaret Miller.[34] Additionally on the business areas of his life, Watt started to tap into his entrepreneurial side and started some new ventures. After his marriage to his cousin and then the birth of his first daughter in 1767 Watt decided, he needed to make more money and started a surveying business.[35] He also invested in the Delftfield Pottery Company at Glasgow while also expanding his surveying business and started to perform work with canals all over England.[36] In addition, during this period, Watt continued his work on improving steam engines and he entered into a business partnership with the previously successful John Roebuck. Watt was a very cautious man, and nowhere near aggressive as his future business partner Matthew Boulton, however, he always felt the pressure to provide for himself and his family so was always on the lookout for methods to increase his income. Most influential intellectuals during this period were set on supplementing their income, "Priestley's writing helped to add to his income, while Small and Watt, desire their intense, absorbed and often frustrating researches, always had an eye to possible money-making schemes. So did Darwin, up to a point."[37]

Watt work with the steam engine finally started to show promising results in 1769. On 5 January 1769 Watt received his patent for "James Watt's new invented Method of lessening the Consumption of Steam and Fuel in Fire Engines."[38] This became a big step for Watt because he finally had the rights to an improved steam engine, which made his partnership with Roebuck a step closer to being profitable. The majority of his later patents were based off this first patent as well. In addition, this vague patent meant

Watt had the rights to a large amount of criticism from people who felt that he had too much control of the steam engine market. Watt receiving his first patent was far from the most beneficial aspect of that trip to London in 1769. During the trip, he stopped in Birmingham and visited with Boulton. Watt actually ended up staying a full two weeks in Birmingham to talk to Boulton and to examine his facilities at Soho.[39] Watt also took notice of Boulton's skill as a businessperson and his extremely entrepreneurial nature, all of which in time would benefit the both of them. However, much was in the way before Watt and Boulton could form their successful partnership.

After Watt received his first patent, he remained very busy with all of his engineering efforts. Not only did Watt still have a large amount of work to do on his steam engine patent but he also became very active as a canal surveyor. Working as a surveyor was very stressful for Watt and he constantly looked to his friends for support, especially Small.[40] Watt published few articles during his career, but his first one came in 1770 concerning a canal in Scotland. The work titled "A Scheme for Making a Navigable Canal from the City of Glasgow to the Monkland Coalierys*"* and this new canal was supposed to reduce the price of fuel.[41] Watt then followed that work up with a new one concerning improvements to the Glasgow port.[42] He intended making transportation more efficient because that would benefit industry and the economy of Scotland. During this period, members of the Lunar Circle were also doing impressive work with canals,

> Almost all the Lunar men owned canal shares, and Boulton had a lucrative sideline supplying metal parts, locks, bolts, brass valves for pistons, copper boxes, taps and rings. Wedgwood was the king, but Small's interest was also substantial as he gradually bought transfers from other shareholders. He and Boulton even began to dream of

> working canal boats by steam. And he carefully kept abreast of developments elsewhere through a new friendship, with James Watt.[43]

Not only were members of the Lunar Circle working on similar projects to Watt, but also they kept in contact with him. Through his work with canals, Watt gained an understanding of hydraulics and engineering, knowledge that benefited him later on with his experiments. However, the most important aspect of the Lunar Circle's work was their willingness to share their information, "There was a real sense of bartering, tit-for-tat swapping of knowledge – an exhilarating, companionable sharing of interests."[44] These men lived in an increasingly capitalist age but were willing to share this information and collaborate for the betterment of others.

Starting in 1772 and continuing through 1773, John Roebuck started to run into some financial troubles and could no longer completely support Watt and their steam engine business.[45] After a depression had hit in 1772, the Scottish banking house Neale, James, Fordyce and Down collapsed, causing Roebuck to almost become broke and no longer had the ability to pay for Watt's engine experiments.[46] In addition, while Watt was away surveying a canal, his wife went into labor with one of their children and eventually died while giving birth before James arrived home.[47] Even thought Watt went through a very difficult period that set the stage for his future success.

Ever since Watt stopped by Soho on his way to and from getting his patent, his scientific skills caught the eye of members of the Lunar Circle. Even though Watt did not attend meetings of the Lunar Circle, he corresponded with many members. He kept them abreast of his work, as if he was a member, "From 1767 to 1774 there continued a stream of correspondence and an occasional meeting between Watt and other members of

the Lunar group. Little was done by Watt or any one of the others without the knowledge of all the rest."[48] Watt coordinated a lot of his work from 1769 until 1774 with other members of the Lunar Circle. For example, many members of the Lunar Circle were invested in improving modes of transportation on the ground, especially with carriages. Darwin became consumed by this pursuit, mostly because he had the most use for it, because he traveled a lot for his patients and needed to carry a large amount of medical supplies.[49] Boulton and Edgeworth were very active with wagons, so much in fact that it sparked the spirit of competition within Watt.[50] Some members had fantasized that one day steam engine could be applied to carriages and that this too would be of great benefit to transportation.

During this period, Watt worked on many smaller projects with various members as well. For example, during the time that Priestley was working on his *History and Present Discoveries relating to Vision, Light and Colours* Watt, Darwin and Small were all making improvements to telescopes. Also before his time at Birmingham, Watt was doing work in geology, "Over the next few years, the identification of minerals and their properties would become one of the most fruitful areas for the work of the whole group, including Watt."[51] This spark in geological interest came from Watt's experiences with canals and digging up the earth. Not only was Watt's interested in geology but due to the publications of Priestley's chemistry findings, Watt discovered a new topic of interest. The chemistry expert was helpful to Watt, "At the end of 1772, Priestley published his first account. Soon his work was common knowledge and a source of continuing excitement. The following spring, Small's correspondence with Watt was full of chemistry – of making ether, or producing phosphorus from bones, of the new 'acid of

Tartar,' of a London chemist who had found that powdered tin exploded when added to copper nitrate."[52]

1774 was a very important year for James Watt. Boulton proved to live up to Watt's expectations of being an excellent entrepreneur and received Roebuck's portion of the business when he ran into money troubles. Therefore, Boulton fully supported Watt financially in his continued quest in perfecting his steam engines.[53] This had been a long awaited achievement for Boulton, who as early as the summer of 1768 was excited about the prospect of Watt's "fire Engine."[54] Also in 1774 Boulton suggested that Watt pack up and move to Birmingham. Once Watt moved to Birmingham, Boulton gave him his old home and this proved to be a very successful arrangement. In Boulton and Watt's new partnership, Watt became in charge of the diagrams, calculations and the corresponding portions of the operation.[55] In fact, during the early period of the company most of the parts were not made at Soho but were contracted out, and after production, were brought to Soho.[56] Relying on the work of other sometimes frustrated Watt who was "a craftsman, a perfectionist" and "nothing maddened him more than bad workmanship."[57] Also during this period, Watt became very involved and worried about people infringing on his patent. Watt's approved patent was very vague and he thought that many parties were infringing on his patent, a theme that was constant throughout most of his business venture with Boulton. Finally the first of Watt's steam engines was ready for commercial which possessed 7,5000 horsepower.[58] Steam engines produced today can have over a hundred times more horsepower, but again at the time these steam engines were relatively efficient compared to any other engines produced during this period.

After Watt's move to Birmingham, both his personal and professional lives started to take a turn for the better, achievements that can be attributed to his membership within the Lunar Society. Now that Watt became situated in Birmingham he finally was able to attend the meetings of the Lunar Society. As a result, the years from 1775 until 1785 were by the far the busiest and most stressful years of Watt's life, and throughout this period, he became troubled by headaches, stomachaches and depression.[59] Also during this period, he remarried to a strict disciplinarian, in 1776. Even though she was very strict, she respected his studies and experiments, often leaving him along when he was wrapped up in his experiments.[60] This second marriage also put a lot of stress on his finances during this period.

Despite the headaches and complaining, Watt and Boulton's business and stated to take off. The two made an interesting set of business associates, "The contrast between the two partners could not have been sharper. Watt was pale, round-shouldered and anxious, thrifty and full of fears; Boulton robust and ruddy and loud, extravagant and incorrigibly hopeful. Yet the odd alliance worked: together, despite the battles, the conquered Cornwall."[61] By 1780, the profits for the company started to roll in and this slightly lessened Watt's money worries. Nonetheless, he was still paying off various debts to Black in 1781. Some of the debts were as far back as 1772, and Watt expressed regret at taking so long to pay his friend back, but explained that "I could not avoid with without putting myself to some inconvenience as our Business never defrayed its own current Charges until last year and the product of that was swallowed up in a very large pay[men]t: several P[aymen]ts we were obliged at Christmas. I have therefore been always in debt to the partnership but am now clear or nearly so."[62] Watt had a very

capitalistic view of labor and only when his employees worked hard he given them their wages.[63] The two of them ended up producing 449 engines during the twenty-five year patent for a variety of industries. First, many of the engines went to companies that were in the mining business but Watt and Boulton had many ideas of industries that could one-day use steam power, such as the textile business. In addition to selling engines in England and Scotland, Watt's engines were shipped off to all parts of Europe including Russia, France, Germany, Italy, Sweden and the Netherlands.[64] 1785 was a good year for both Watt and Boulton for they were elected to the Royal Society of London, along with other Lunar Society members, Withering, Keir and Galton.[65]

Furthermore, during this period the Lunar Society was quite busy with projects that involved Watt as well. For example, Watt was extremely helpful to Priestley when working with his experiments involving dephlogisted air.[66] Wedgewood's achievements with his thermometers assisted Watt and Priestley in their phlogiston air as well.[67] Watt also did work in addition to what Priestley was doing and actually deduced that water was a compound material. While performing his experiments with water and collaborating with other scientists he proposed a universal system of weights and measures.[68] Watt's work with Priestley and dephlogisticated air led Watt to publish two papers on the topic during 1784. The first work was titled "Thoughts on the Constituent Parts of Water and of Dephlogisticated Air; With an Account of Some Experiments on That Subject" and the second article was a sequel.[69] Both articles were published in the *Philosophical Transactions*, as well as a third article that concerning the tests to determine the presence of alkalis and acids in certain chemical mixtures.[70] In addition,

throughout this period the Lunar Society was constantly trying to conquer geology and "Watt's own geological skills had grown since his early surveying days."[71]

During the 1790's the business of Watt and Boulton transformed immensely. Starting in 1790 Watt became particularly mindful of people that were potentially infringing on his patent, especially because the patent was slowly about to expire and he usually worried about money. For example on December 5, 1790 in a letter to Dr. Black he says, "We are going on well enough in our business, but are attacked on many hands, and among the rest of our invaders are our *good friends* John Wilkinson and William Reynolds. The former acts avowedly for his own interest, the letter from a purer motive, the good *of the public,* and the preventing our being paid for our merit more than we deserve."[72] Watt also goes on to express other issues he was encountering at the time, "These and other things together with the failure of my own headpiece, make business exceedingly irksome to me, yet my health is much better than it has been, my headaches are less painful though more stupefying, so as frequently to render me unable to think."[73] Therefore, due to the constant sense that people were out to use his engine designs, he set out to prosecute those that he felt were copying his ideas. Consequently, because his patent was quite vague, he felt threatened by many other engineers and companies.[74] Conversely, also due to the fact his patent was so vague, many of his competitors complained that Watt had a monopoly on steam engines and this upset a good number of entrepreneurs during the period. Also during the 1790's many changes were made at Soho. For example, Boulton installed a foundry and the company started to make more of their own parts for Watt's steam engines rather than contracting them out to other companies. This helped to increase the profitability of the company.

In addition, Boulton had installed a mint at Soho that helped to standardize currency throughout England, another great example of the vision and passion that Boulton possessed.[75] However, by the second half of the 1790s Watt started to be involved less and less in the business and started to let his son take over portions of the business.[76] As Watt's involvement in the business began to decline so did the health of many of his friends. By 1805 Josiah Wedgewood, Dr. Joseph Black, Joseph Priestley and John Robison had all passed away.[77] However, the biggest loss occurred in 1809 when Boulton died.

Watt's life after the steam engine business was quite different from his earlier days. Watt had considerably less problems than in his earlier years, "As his old friends dropped off one by one, Watt seemed to cheer up distinctly. He had no money worries now. His health was better than it had been all his life, though he did get a little confused, dropping asleep while talking or wandering into unconnected anecdotes. His old thrift and anxiety vanished."[78] Watt bought a variety of land in Scotland as well and took many vacation trips to Scotland to visit his homeland. The man who had been a workaholic began to take holidays and visited many spa towns throughout Scotland. Even though Watt was less involved in the sciences, he was still gaining fame. For example, the French Academy made him an honorary associate, even though his scientific accomplishments were relatively at a standstill.[79] Even after his death in 1819, Watt continued to gain fame for his scientific exploits. Some of this fame can be contributed to the fact his family carefully promoted his works soon after his death.

The life of James Watt helps to emphasize the how England and the rest of Europe had transformed and how new thought processes were developing. First, the way

people were taught to think became different. Up until the eighteenth century, humanistic educations were very important and going to a top-tier university was the way to prominence. However, the men in the Lunar Society of Birmingham proved this was no longer the case. Joseph Priestley did indeed have a large amount of education in areas the classical languages and theology, but he did not earn his degree from a top-tier university and he also did not have much of a formal background in science. Watt was even more of an extreme case, he did not even go to university; for many years he was a man whose father could not afford to have him around and who made his living through making instruments. In fact, James Watt's career represented the rise of applied sciences and studies, "The ground shifted in the late seventeenth century with the new fashion for demonstration and experiment. Mathematics achieved dignity," and "Precision instruments now commanded more respect."[80] Even a hundred years earlier, craftsmen were not in positions to help countries industrialize the way that Watt did. Humanistic educations were less important because England and other European countries were rewarding people who possessed practical knowledge and could turn a profit out of it.

James Watt was not only different from his predecessors because of his background but also the way he applied his method of thinking to the sciences. Watt was very inquisitive and smart but experiments were not satisfying enough for him, the experiments had to have meaning. He loved puzzles and the steam engine was the ultimate puzzle, "He had a craft background, and was not afraid of getting his hands dirty, but he was no on-site experimenter, working by trial and error. He was concerned with the principles of his subject, the laws of hydraulics and hydrostatics, the findings on variable temperatures and pressures, the application of mathematical theory."[81] Again

not only did Watt want to solve the puzzle to satisfy his intellectual curiosity, but finding an answer to the puzzle would reap great financial rewards as well. Watt did not look at engineering as purely a crafts or academic pursuit but as a mixture of both, potentially because of his background of being surrounded by both. At this point Europeans saw real applications for the sciences they were exploring,

> Chemistry and botany were studied in their relation to medicine, astronomy and meteorology as aids to the science of navigation, and a lively interest was taken in the technical problems of industry and agriculture. This connection between theory and the application of theory, this co-operation between the men of science and the men of business, between the professional and the amateur, who were destined to grow closer as time went on, and bore precious fruit in the eighteenth century. [82]

At this point in England, men were giving real meaning to all the abstract experiments and knowledge that they had been assembling for centuries previously.

As a member of the Lunar Society, Watt both benefitted from being an associate, as well as contributed immensely. Even though his career was thriving before his move to Birmingham, he became more successful with the support and assistance he received from the Lunar Society. The new scientific style of the group that included such large amount of scientific communication benefitted Watt immensely. The knowledge of the other members complimented his work well and through his assistance of others, Watt felt accepted, further allowing his work to flourish. For Watt, being part of such a social, supportive group went beyond scientific publications and accomplishments.

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Chapter 4- The Man Who Cured 18th Century Medicine: William Withering

If one was to take the formal education of Joseph Priestley and the attention to detail and the technique and method of James Watt that would produce a very methodical, intelligent individual, named Dr. William Withering. William Withering was a physician, scientist and famous botanist who was an integral part of the Lunar Society of Birmingham, as well as the greater scientific community in England. Withering is famous for his discovery of the usefulness and appropriate dose of the heart drug, digitalis. However in reality, what makes this discovery so important is the method in which he discovered the positive effects and correct dose of the drug. Similar to the way in which James Watt had transformed the field of engineering to the highly technical and practical field as it is known today, William Withering changed the way which the human body was to be studied. In addition, his approach to medicine took the field to a whole new level of sophistication and application. Similar to the way that James Watt's steam engine was not the first or last in its field, the importance behind it was what it meant to the industrial revolution and for the applied sciences. The same is true of Withering's accomplishments in the fields of botany and medicine. Transforming the field of medicine is just a topic that gained the attention of men like those who were members of the Lunar Society. William Withering's attention to detail and ability to apply his scientific knowledge and findings led to a seat within the Lunar Society and a place infamy.

William Withering was born on the 17th of March, 1741 in Wellington, Shropshire as the second child to his parents, Edmund Withering and his wife Sarah Hector.[1] William Withering's father was an apothecary and his extended family contained numerous physicians, which included his uncle Brooke Hector.[2] At the time,

apothecaries received no formal education and learned their trade through an apprenticeship. Therefore, despite no formal education, William's father Edmund had become quite successful as an apothecary.[3] Not much is known about William's early education but he was profoundly influenced by his parents at an early age. For a short period William was placed in an apothecary apprenticeship and spent some time in as an apprentice to his uncle Brooke Hector while spending many summers in London hospitals.[4] In addition he was taught in the classical subjects by Revered Henry Wood of Ercall until in 1762 he was admitted to Edinburgh to study anatomy and chemistry in order to become a doctor.[5] While at Edinburgh, William made many friends, became a Freemason and also joined the Edinburgh Medical Society.[6] On Sundays, William would go to Church and then meet with Professor Cullen in order to discuss philosophy and science. William was a good student and was "very industrious, and spent his evenings in transcribing his lectures notes, many written folios and quartos, illustrated by neat drawings, testifying to his diligence."[7] Another aspect of note was his ironic dislike for the field of botany at the time. As he stated about the subject of botany, "An incitement of this kind is often productive of the greatest emulation in young minds, though, I confess, it will hardly have enough to banish the disagreeable ideas I have formed of the study of botany."[8] Despite his dislike for botany he graduated from the University of Edinburgh with a medical degree in 1766.[9]

After his graduation from the University of Edinburgh Withering spent some time abroad and ended up in Paris for a short while. On his return to England he established himself in Stafford, Staffordshire and set up a private practice.[10] The practice was very meager and Withering only brought in £100 a year in salary, but made sure that he saw

poor patients daily while not charging them any money, a practice which he continued throughout his career as a doctor.[11] Also during this period, he spent some time bowling and was known for his participation in amateur dramatics within the community as well as his musical talents. However, one of the most important aspects of his time at Stafford and the Stafford Infirmary was the development of his passion for botany. This interest blossomed after he treated one of his patients, Helena Cooke, who happened to have a deep curiosity in drawing plants. The couple married during September of 1772 and the two of them proceeded to have three children throughout their marriage.[12]

Shortly after William Withering got married, his scientific career took off. In 1773 Withering had some work published in the *Philosophical Transactions of the Royal Society* about minerals in his local area. His work titled, "Experiments upon the Different Kinds of Marle Found in Staffordshire", was not necessarily important from a content perspective, but rather the practicality of his work was the significant aspect.[13] His attention to detail was the most important aspect of the work, "Withering's results are more qualitative then quantitative and it is to be doubted that they were very useful in the form reported, but the paper shows an interest in the practical application of chemical knowledge to the problems of the agriculture and would, therefore, be attractive to members of the Lunar circle."[14] Withering brought this passion for details into his next publication.

1775 was a monumental year for Withering because this was the year that he moved to Birmingham and thus joined the Lunar Society of Birmingham. Withering did not end up in Birmingham by chance, for after the death of their dear friend Dr. Small the member of the Lunar Society were looking for a man to take his place.[15] Many

members, especially Erasmus Darwin persuaded Withering to move to Birmingham in order to take up Dr. Small's practice. Darwin knew that Withering was highly interested in the fields of chemistry and botany, two fields which other members of the Lunar Society were interested in as well.[16] After the Lunar Society had set their sights on Withering they decided they would do what it took to convince Withering to join them in Birmingham. Darwin figured out that Dr. Small had been making £500-600 and persuaded Withering he could make at least that much.[17] Also after they encouraged Withering to apply for the position, interestingly enough the other considered physicians took other positions. Due to the economic pressure of having a wife and family, Withering agreed to take the position and moved to Birmingham. Quickly after his move to Birmingham, both his medical and scientific career took off.

During 1776 Withering published his *The Botanical Arrangement of All the Vegetables Naturally Growing in Great Britain* and this work became the standard English botanical work for many years to come.[18] This was because he "was the first to delineate systematically in English the flora of Great Britain, using and extending the Linnaean system of classification."[19] Again, Withering's success came due to his obsessive note taking and organization, an extent to which very few people before him had taken in the field of botany. Withering lived during a period where ordering, classifying and naming all were aspects that helped such scientific achievements.[20] His *Botanical Arrangement* was a practical endeavor that helped many scientists for years to come. Even though Withering was a doctor and knew many of the medicinal benefits of the plants he classified, but he left the medical uses out of *Botanical Arrangement* because he was afraid that people would misuse the information if untrained. During this

period in history, medical consultation was very expensive and so was medicine, therefore many common people tried to get free medical advice through books that were in publication rather than consulting a physician.[21]

A good portion of Withering's work on the *Botanical Arrangement* was complete before his arrival at Birmingham, but that did not mean that he did not benefit from being a member of the Lunar Society. At the time that the job at Birmingham became available for Withering, the Lunar Society greatly was in need of a man with Withering's knowledge and talents. The death of Dr. Small brought a large social and scientific void in the Lunar Society and Withering attempted to fill it. The Lunar Society was changing, due to "The death of Small, and the arrival of a new, 'philosophically inclined' young doctor, as well as the realization that their work and their politics threatened to make them drift apart, all prompted them to decided to weld the group together."[22] In fact, the Lunar Society had their eye on Withering much before he was offered a position at the Birmingham General Hospital in 1775 and as early as 1766 he had their attention. On December 11, 1766 both Withering and Boulton were attending a lecture at the Royal Society of London as guests, and in 1771 Withering was in close contact with Wedgewood because he was ordering "ware" from Wedgewood.[23] As previously mentioned Darwin was very interested in Withering and Boulton needed a physician due to the death of Dr. Small so they both assisted in the attempts to entice Withering to Birmingham.

The scientific achievements of Withering would continue while a member of the Lunar Society of Birmingham. In 1778 Birmingham experienced an outbreak of Scarlet Fever and sore throats which Withering documented and then published a year later in

1779. As with all of his other works he took very careful notes and was very methodical, however due to the speed at which he published the work, he cautioned his readers of the possibility of errors.[24] His next scientific publication came during 1782 with the help of Joseph Priestley. The two friends published a work in the *Philosophical Transactions* called "An Analysis of Two Mineral Substances, viz. the Rowleyrag-Stone and the Toad-Stone."[25] Throughout the research for this publication, he worked and closely coordinated with Joseph Priestly. In return, Withering would often help Priestly with his phlogiston theory, however, Withering did not actually believe the theory that Priestley did, but still supported Priestly through financial means.[26] Despite Withering's belief about the phlogiston theory, he continued to work with Priestley on a number of projects which included Priestley's *The Principle of Acidity, the Decomposition of Water and Phlogiston* in 1788.[27] The Lunar Society was extremely obsessed with chemistry and the theory of phlogiston. At any one point, at least a couple members of the Lunar Society discussed one of the relevant scientific topics of the time. Also during this period, Withering worked at the Birmingham General Hospital. When practicing medicine, Dr. Small spent considerable time at the hospital and Boulton had a lot to do with starting the hospital.[28] Again, these are excellent example of two Lunar members working together, over a common topic to produce results. Minerals were a topic that often was an area of interest to members of the Lunar Society.

Contrary to the expectations of the Lunar Society, Withering did not completely fill the void of Dr. Small. Firstly, their intellectual interests of the two men were quite different and this led the Lunar Society into a different direction when Withering joined, "Withering did not have Small's interests in clocks, optics or astronomy and these

subjects soon disappeared from the serious Lunar Society investigation."[29] The group tended to turn their new interests to the fields of chemistry, botany and geology, which, in time, were areas the group became quite successful. Secondly, Withering did not have the same type of personality that Dr. Small had and was more irritable than many other members, and thus took some time to get acclimated to the group. For example, "Withering was stubborn, ambitious, reserved and wary. He bristled at interference, held jealousy to his own line, and was unforthcoming in company. In the Lunar circle only the broad-shouldered charm and generosity of Boulton really managed to break down his defenses."[30] Withering was not as personable as some of the other members of the group but that did not mean he was not important to other members in the group. It simply took some time before Withering felt fully welcomed into the group and reached his full potential. Again, his arrival really sparked the interest in botany within the group, especially for Darwin. Darwin had a tendency to be wrapped up in the subject matter of new members of the Lunar Society, "Just as Whitehurst's interested had fired a passion for geology, and Keir's arrival made him an instant chemist, now botany became his new obsession."[31] This new obsession with botany would cause some issues later down the road for the Withering as well as the rest of the Lunar Society, but in the short term the group became fascinated with the field.

Withering's passion for botany and medicine paid off. Again it was not the imagination of Withering that brought about his success but rather his attention to detail and scientific thinking. Withering's greatest success coincided with the Lunar Society's golden era as well. For in 1785 Withering published his *An Account of the Foxglove and some of its: Medical Uses: with Practical Remarks on Dropsy, and other Diseases*, which

became wildly successful in the medical community.[32] However the road to success was not a very short one, and took over ten years to gather the data and the project started in 1775. Before Withering, foxglove was used for treatment of a variety of diseases throughout the ages including epilepsy.[33] Even though foxglove had been used by a variety of physicians and apothecaries for ages, William Withering first started working with it for medical reasons in 1775. In his work Withering describes the beginning of his study, "In the year 1775, my opinion was asked concerning a family receipt for the cure of the dropsy. I was told that it had long been kept a secret by an old woman in Shropshire, who had sometimes made cures after the more regular practitioners had failed."[34] The remedy was found to include 20 different ingredients, but which Withering quickly reduced to one effective ingredient, the foxglove. However, even though he found the active ingredient he still had a long way to go before such a remedy could be ready for a more practical use by doctors.

The next step for Withering was to figure out an appropriate method to administer the drug, as well as the best dose. Withering quickly deduced that the best way to administer the foxglove was to crush the roots into a powered form and administer that, rather than a decoction, which is a preparation made by boiling the plant in water.[35] One reason the power was used was that it was the easier substance to produce a standard amount and therefore less to fewer overdoses. Withering's scientific, methodical reasoning that he used throughout his study was quite impressive. He did not believe in superstition or chance and believed, "we shall sooner obtain the end proposed if we take up the subject as altogether new and, rejecting the fables of the ancient herbalist, build only upon the basis of accurate and well considered experiments."[36]

The accuracy of the technique was essential for the next portion of his study where he investigated the right dosage to prescribe to his patients. Throughout his career as a physician, Withering prescribed a minimal amount of medicine for his patients.[37] He did this in an attempt to avoid a potential overdose, as well as the fact medicine was very expensive during the period and therefore attempted to save his patients money. Such a practice did not make Withering very popular with the local apothecaries; however, he was looking out for his patients, not the apothecaries. Withering started to use a variety of doses on his patients and eventually deduced that "it was moreover of consequence not to repeat the doses too quickly, but to allow sufficient time for the effects of each to take place, as it was found very possible to pour in an injurious quantity of the medicine, before any of the signals for forbearance appeared."[38] In other words he realized that previously many people were experiencing an overdose of the drug because people were being given doses every two to four hours, when in reality they should have been given doses only once or twice a day.[39] By 1782 Withering had started taking his own advice and was prescribing doses once or twice a day and "From this protracted study he realised, for the first time, the paramount importance of dose, and also that a brisk diuresis of several quarts of urine often heralded the patient's recovery."[40] Giving multiple doses a day easily allowed the body to be toxic because foxglove only slowly leaves the body.

Not only did Withering determine the appropriate method for prescribing foxglove, but he also determined the appropriate dose and the actual side effects of the drug. In the past, due to the high rate of overdose other side effects were associated with the drug. However, "for the first time, he described clearly the important side-effects of

Digitalis which included nausea, vomiting, diarrhoea and green/yellow vision," and suggest that "The onset of side-effects should lead to an intermission of dose followed by restarting at a lower level."[41] The side effects also included anorexia, drowsiness, dizziness, confusion, and dementia.[42] Also Withering's experience with foxglove led him to make the recommendation that it be used for the treatment of epilepsy. Doctors continued to use foxglove for the treatment of epilepsy all the way until the twentieth century. Overall, "Withering's specific contribution was to place *Digitalis* on a proper scientific footing, and thereby eliminate much of its folklore and superstition. He established that the dried powdered leaf of the plant was five times as effective as the fresh leaf. The powder was also better than a decoction, as boiling seemed to destroy some of the active principle. He then went on to study 163 patients with dropsy, and recorded his results carefully"[43] Again, "the *Treatise on the foxglove* was a notable advance based entirely on careful clinical observation and it changed the face of medical practice forever."[44]

Throughout the history of the Lunar Society of Birmingham only two serious arguments surfaced, both of them involving William Withering. The first argument was between Withering and Darwin. Originally Darwin had wanted to help Withering with his book *Botanical Arrangement* and gave Withering a number of suggestions, including a name for the book. Darwin made the suggestion, "The title of your book should be easily remember'd, and easily distinguish'd from Lee etc. as 'The scientific Herbal','Linnean Herbal', 'English Botany', 'Botanologia anglica in which the science of Botany is reduced to English ect' But we'll settle all this at Mr. Boulton's with the assistance of Mr. Keir and Mr. Watt."[45] However, Withering felt threatened by Darwin

and completely rejected his title and put his own title, boldly as a whole page. This was the start of tension between the two and their personality differences did not help either, "The two doctors and botanists were sharply different. Darwin was bold and imaginative, Withering pernickety and precise – his books included instructions for readers on how to build their plant-collecting boxes to within a tenth of an inch, and provided little spaces to fill in meticulously when a specimen was spotted. He seemed more interested in bagging the species than the plants themselves."[46] This rivalry over botany would continue over the years and at times it appeared, "Botany had become the arena for Lunar competition rather than cooperation."[47] Such competition reached its pinnacle when Withering produced his writings about his experience with foxglove and his application in his practice. Darwin claimed that he in reality was the first of the two to use foxglove into his medical practice, but Withering's publication claimed differently. Unfortunately, this rift between the two men had quite an effect on Darwin, who rarely attended Lunar Society meetings after Withering's publication.

Also during his period within the Lunar Society, Withering did do work in other scientific areas that just botany. For example, his practice became quite successful and by 1776 his practice brought him over £1000 a year, and by 1780 he was making over £2000 a year.[48] This income included him seeing two to three thousand poor patients free each year as well. Withering had established the largest practice outside of London, even while maintaining his charity work. Rough estimations of Withering's travel have placed him as having traveled over 6,000 miles in a year to see his patients, and because most carriages only travel at eight miles an hour, that means he spent a lot of time seeing patients. William Withering also spent time working at the "New Hospital" in

Birmingham as a doctor. The New Hospital in Birmingham often was associated with members of the Lunar Society, which Boulton had helped start in 1765 but did not really become meaningful within the community until 1775.[49] Working on the New Hospital helped Withering work on his various studies, especially those that participated in his study involving digitalis. In fact, his book included a whole section that contained case studies on the patients that he treated in the hospital.[50]

As time went on, other members of the Lunar Society of Birmingham worked closely with Withering on a number of topics. Wedgwood, Withering and Priestley worked on "the dangerous substance 'Black Wadd', also known as the Derbyshire Mineral, and now known to be manganese dioxide (or pyrolusite), a very strong oxidising agent capable, when mixed with other substances, of spontaneous combustion," as well as some projects revolving around lightning and arsenic.[51] What made the Black Wadd so dangerous was that it induced spontaneous combustion. Besides his work with the Black Wadd, Withering performed significant work was his discovery of "terra ponderosa aerate." In fact, "His paper on the terra ponderosa is probably Withering's most significant contribution to mineralocial chemistry; it contains the first clear identification to and analysis of native carbonate of barium and for this reason, the German geologist, Wener, gave the mineral the name Witherite by which it has since been known."[52] That discovery of the mineral was one of his few original discoveries and not just an advanced classification and organization of a subject. Also Withering "had wide scientific interests besides medicine and botany, and was an active member of the Society for Promoting the Abolition of the Slave Trade."[53] Eventually Withering was recognized for his scientific achievements and was awarded fellowship to the Royal

Society of London in 1785.[54] Later on in Withering's life his work became more centered around chemistry and mineralogy, rather than botany and medicine. Not only did Withering gain praise from the Royal Society of London, but he, along with other members of the Royal Society were mentioned in the premier book on English mineralogy at the time , *Elements of Mineralogy* during 1784.[55] Overall William Withering's scientific accomplishments and notoriety rank up there with other members of the Royal Society including Joseph Priestley and James Watt.

The second serious disagreement of the Lunar Society came in 1787 with the publication of a second edition of Withering's *Botanical Arrangements*. Withering worked with one of the newer members of the Lunar Society Jonathan Stokes and allowed Stokes to borrow his material to work with. However, Stokes moved away and took all of Withering's books with him. Withering was extremely upset that his books were not returned to him. Eventually Stokes did return the books, however they were seriously damaged and missing many of the original pictures. Stokes stopped attending Lunar Society meetings, and much to the dismay of Withering, went on to publish his own series of botanical works.[56] Not everyone was detrimental to Withering's work, for example, James Watt was very helpful in Withering's effort to publish this second edition of his *Botanical Arrangements*.[57]

The 1790's started to bring out the unfortunate decline of the great William Withering. The majority of the decline was due to sickness, and much like other great scientists of the day was affected by the political turmoil that surrounded Europe and affected England as well. Withering was very close friends with Priestley and in July 1791 due to this association was target by the riots that engulfed Birmingham, but also

like Priestley, he was previously warned and hid a church during the riots.[58] Despite the fact Withering was not present, the rioters still attacked his house and "A pitched battle took place in and around the house between Withering's men, servants and hired prizefighters and the incendiarists, who numbered about 30. After several hours of hard fighting the rioters were driven off and went to seek an easier target. Withering had remained, in safety, at his other house in the city."[59] The political turmoil was placing considerable stress on many of the businesses owned by the other members of the Lunar Society and they were turning their efforts towards that rather than their Lunar meetings. However Withering did not want to give up, "Withering could be prickly, pompous and intransigent but those who knew him well were very fond of him and he tried hard, if hopelessly, to keep some of the Lunar spirit going."[60] One potential reason that Withering was still striving to keep the Lunar Society going was that he had already become very financially well off, therefore did not have the many concerns that other members had and still wanted focus his efforts on the scientific pursuits of the group.

As early as 1776 Withering starting experiencing irregular fevers and sickness, making the winters very difficult for him and up until his death he experienced "attacks of coughing, breathlessness and fever."[61] This sickness, which was eventually diagnosed as tuberculosis, shaped much of the last decade of his life. In an attempt to soothe his harsh winters, starting in 1793 Withering started to spend his winters in Portugal.[62] The medical effects were not as beneficial as he hoped for, but good did come out of his time in Portugal. The government asked him to analyze the waters of Caldas da Rainha and his work was eventually published. In addition, Withering became "a foreign corresponding member of the Portuguese Academy of Science in 1795."[63]

The only other notable scientific achievement of Withering after 1795 was his publication of a third edition of his botanical work in 1796, named *An Arrangement of British Plants*.[64] This third edition was his best botanical work and even though he did not publish much during this period, he did correspond with some of the other famous botanists of his day.[65] Due to his battle with consumption, his medical career ended as well, by 1792 he had stopped working at Birmingham General Hospital and had also given up his private practice.[66] With the help of Boulton and Watt the three men attempted to make Withering's home hospitable during the winter months with his condition, however the efforts largely failed. Throughout this period Withering did interact with other members of the Lunar Society, nonetheless this cannot be considered Lunar activity, but rather friends individually helping each other out. Personally, Withering's connection with other members of the Lunar Society lasted right up until his death. During the beginning of October,1799, Withering moved into Joseph Priestley's old house, but then died a few days later on October 6, 1799.[67]

Withering's greatest scientific accomplishment during his lifetime was his discovery of the use of foxglove in treating the heart condition known as dropsy. What led to the discovery was Withering's attention to detail, accuracy and the methodic way that he went about prescribing and recording his prescriptions. He was described as "by nature, a methodical, organised man, often deliberate to the point of obsessionalism. He was polite to his colleagues but insisted that they gave him proper recognition."[68] In fact, the majority of Withering's scientific work was based on his ability to classify and categorize rather than an ability to truly create original work. However, this does not meant that Withering should be regarded any less important than other members of the

Lunar Society should. The methods in which he went about his studies transformed two monstrous industries of medicine and botany. Even to this day, the method that Withering used in his study of foxglove greatly influenced the way in which physicians today use the drug as well as the basis for establishing a standardized method of establishing and prescribing other medications. William Withering was just as important and progressive as the other member of the Lunar Society even though he did not have the creativity or imagination of some of the other bright minds of the era.

William Withering's experience with the Lunar Society was different than the other members. Part of this experience can be attributed to Withering's own scientific personality. Because Withering had his own successful practice, his motivations were less capitalistic than Watt, but sought out fame instead. Also he accomplished his two most important works mostly on his own, with only being minimally influenced by the group. In addition, he also did not appear to seek out the social support that Priestley and Watt did during their time in Birmingham. The new social patters of the scientists that that characterized the Lunar Society turned out to have a negative aspect on some parts of Withering's career when two fellow members tried to steal his work. Nonetheless, other aspects of Withering's career benefitted from the membership and friendships of the Lunar Society.

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[15] Matthew and Hanson, 880.
[16] Jenny Uglow, *The Lunar Men: Five Friends Whose Curiosity Changed the World* (New York: Farrar, Straus and Giroux, 2002), 264.
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[18]Matthew and Hanson, 881.
[19] Matthew and Hanson, 881.
[20] Uglow, 266.
[21] Withering, vii.
[22] Uglow, 264.
[23] Schofield, 124.
[24] William Withering, *An Account of the Scarlet Fever and Sore Throat, or Scarlatina Anginosa; Particularly as it Appeared at Birmingham in the Year 1778* (London, 1779).
[25] William Withering and Joseph Priestley, "An Analysis of Two Mineral Substances, viz. the Rowleyrag-Stone and the Toad-Stone" *Philosophical Transactions* 72 (1782) 327-336.
[26] Lee, 4.
[27] Lee, 4.
[28] Uglow, 248.
[29] Schofield, 125.
[30] Uglow, 268.
[31] Uglow, 269.
[32] Withering, *An Account of the Foxglove*, vi.
[33] Withering, *An Account of the Foxglove*, 237.
[34] Withering, *An Account of the Foxglove*, 2.
[35] Withering, *An Account of the Foxglove* , 4.
[36] Withering, *An Account of the Foxglove*, 4.
[37] Withering, *An Account of the Foxglove*, vi.
[38] Withering, *An Account of the Foxglove*, 229.
[39] Withering, *An Account of the Foxglove*, 229.
[40] Withering, *An Account of the Foxglove*, 229.
[41] Lee, 3.
[42] Withering, *An Account of the Foxglove*, 232.
[43] Lee, 3.

[44] Lee, 3.
[45] Uglow, 270.
[46] Uglow, 383.
[47] Uglow, 382.
[48] Matthew and Hanson, 880.
[49] Uglow, 170.
[50] Withering, *An Account of the Foxglove*, 101.
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[52] Schofield, 305.
[53] Matthew and Hanson, 882.
[54]Matthew and Hanson, 882.
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[56] Uglow, 383
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[58] Lee, 5.
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[61] Lee, 6.
[62] Withering, *An Account of the Foxglove*, 264.
[63] Withering, *An Account of the Foxglove*, 264.
[64] Withering, *An Account of the Foxglove*, 266.
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[66] Schofield, 391.
[67] Uglow, 485.
[68] Lee, 4.

Conclusion

The biggest advantage the Lunar Society of Birmingham had over other intellectual groups of the period, also presented the largest problems when researching for this paper. The informal aspect of the Lunar Society's meetings was vital to their success as scientists, inventors, entrepreneurs and friends but made researching the group very difficult. The Lunar Society did not keep formal records of any portion of their society; they did not record when the meetings were, what the meetings covered, who attended particular meetings, or even whom membership consisted of at particular portions of time. The Lunar Society or Birmingham was the complete opposite of the Royal Society of London, who recorded almost everything about their group including membership, rules and dues. Another issue of dealing with the Lunar Society was they never appeared to have a set of rules.[1] Therefore determining what, or if, any qualifications existed for membership, and what governed their meetings while in existence was quite a difficult task.

The members of the Lunar Society did not keep attendance records, making it difficult to determine precisely when certain member started showing up on a regular basis and conversely, when particular members stopped coming to meetings later on. Normally fourteen members would not be a large number to deal with, however because no formal records were kept, this became an issue. Collections of letters between members only provided limited information concerning members that were attending or not. On the contrary, the Royal Society kept very good records of whom the current members were and who were just visiting. The chronology of the group was very difficult to keep organized, especially during the early beginnings, and the later years

when the group declined. For example, when William Withering moved to Birmingham in 1775 it became difficult accurately to discern when he regularly started attended meetings and became an active member.[2]

In addition, this large number of members made determining the "golden period" of the group very difficult. Some members were publishing large amounts scientific works at a quick pace, such as Withering from 1780 until 1787.[3] At the same time, others were publishing fewer papers but they were accomplishments that defined their career, like Keir and his work with his *Dictionary of Chemistry*.[4] Yet, still other members were achieving success, which did not come in the form of published papers, such as Watt's breakthroughs with his steam engine designs during the 1780s.[5]

Another difficult aspect of this project, and studying the Lunar Society, was a lack of primary or secondary sources that directly dealt with the group. Again, no formal records of the Lunar Society existed and thus, no one recorded any part of their history. Shortly after the Royal Society received its charter, they commissioned a written history of the organization.[6] The issue with primary sources was members rarely publically discussed the Lunar Society, and while meetings were being held, except Priestley.[7] In preserved letters or correspondences, members spoke to one another about meetings, but not very often and not about all the members either. Again, the large number of members made analyzing large amount of available personal correspondences difficult. For example, when looking at some letters of James Watt, he was more concerned with the attendance and activities of some members much more than he was with other members.[8] Therefore gathering information on particular members proved to be difficult.

The primary sources concerning the Lunar Society were vast but full of dead ends, and the large number of fluctuating members could be one reason that very few secondary sources exist concerning the Lunar Society. Only two books and a handful of journal articles were ever written concerning only the Lunar Society. The other secondary sources available only covered one or two members of the Lunar Society and if the sources mentioned the group as a whole, they did so minimally. Again, a lack of secondary works made it quite difficult to establish a strong chronological order of memberships, as well as the accomplishments of the members. Therefore similar to the primary sources, a lot of extrapolation was necessary to analyze the different members.

Despite all of the issues facing a scholar studying the Lunar Society of Birmingham, some solutions presented themselves. One of the most useful documents for this study was an article by Robert E. Schofield titled "The Lunar Society of Birmingham; A Bicentenary Appraisal" published in 1966.[9] Robert E. Schofield was a historian that did a large amount of research of the Lunar Society and its members. However, what made his article particularly useful was that it helped provide the strong chronological element to my research that was lacking. In a concise manner Schofield managed to outline which members joined and when, their major accomplishments and an explanation of the decline of the group. All of these aspects of the paper were part of the foundation for this study.

One problem encountered during the study of the Lunar Society of Birmingham was a lack of primary sources directly discussing the group. After the chronology of the Lunar Society was established, primary sources then contained more value and helped establish the position of the Lunar Society within individual lives. Each of the three

members had a strong primary source that was used in analyzing the importance of the Lunar Society in their careers. The most useful primary source was Joseph Priestley's autobiography, which came in an annotated form, edited by John T. Boyer. This source was particularly useful because it gave Priestley's actual opinions and perspective, with a modern perspective from the editor. In addition, this source was particularly helpful because it contains Priestley discussing the Lunar Society, while still in existence. Priestley was the only member to refer to the Lunar Society in a publication and he does throughout this work. He also speaks about what the other members meant to him and who his close members were.[10] Naturally, this became a very important primary source in analyzing the importance of the Lunar Society, in both his personal life and career. In addition to his autobiography, Joseph Priestley published over two hundred writings, many of which were scientific and connected with his Lunar friends and interests. The writings from when he was living in Pennsylvania were very nostalgic; even in his scientific writings he discusses the Lunar members he was no longer with.[11] The other writings by Priestley served as continuations of his autobiography, contributing to make the established chronology stronger. Priestley had the highest number of scientific publications of the three members studied, which provided to be useful and why he was the first member discussed in detail.

William's Withering's primary sources were less introspective than Priestley's were, but were useful nonetheless. The most beneficial of his primary sources was an edited version of his *An Account of the Foxglove and Some of its Medical Uses: with Practical Remarks on Dropsy, and other Diseases*. The editor was J. K. Aronson and this source gave an excellent account of his most celebrated achievement. The editor also

included some background of Withering's life as well as the implications of his achievements in the medical community. This greater context of Withering's achievements was very useful in assessing him and his effect of the Lunar Society. Withering did have some other primary sources used in this study; however, they were much less useful. An aspect of note was the relatively large amount of his publications published in the *Philosophical Transactions*. These publications revealed the subjects Withering was passionate about, as well as, when these interests occurred. The secondary sources associated with Withering supplemented his primary sources, but overall Withering was the toughest person to associate with the Lunar Society on a constant basis.

Initially James Watt had the most difficult primary sources to work with. Almost all of his publications dealt with highly technical topics, such as canal plans or dealt with the phlogiston theory. However, one particularly useful primary source surfaced which was a collection of letter between James Watt and his good friend Joseph Black. This source contributed some biographical information as well as some of his thoughts and feelings on numerous subjects.[12] Again one of the issues in dealing with Watt was he did not have many scientific publications, most of his time was spent in a lab or trying to sell his products rather than writing papers. The lack of published scientific papers made it more difficult to track his achievements through primary sources. Despite only one strong primary source, many secondary sources covered Watt extensively. The fame and prosperity of the partnership between Watt and Boulton have attracted a lot of attention to Watt from historians. These secondary sources were much more helpful in placing Watt in the larger context of the Lunar Society and compared to the established timeline.

Despite the difficulties of putting the lives of so many members of the Lunar Society into perspective, taken as a whole, the study produced interesting results. Overall, the Lunar Society of Birmingham was responsible for numerous scientific advancements and much innovation during its twenty-five years of existence. Different personalities found acceptance within the Lunar Society, which increased the group's scientific correspondence. What made the group unique was the variety of scientific personalities that the group accommodated. Joseph Priestley who was a minister who saw science more as hobby worked quite closely with James Watt the meticulous instrument maker that once worked at Edinburgh University but never attended a class. Watt also worked with William Withering, the temperamental physician who had a passion for botany. The achievements of its individual members can be credited in part to their intellectual abilities, but the new pattern of scientific cooperation among the Lunar members also led to their success. Suddenly scientists were no longer making achievements in isolation, but rather through collaboration and working with others. These partnerships led to synergy that propelled Britain into the Industrial Age.

Each member of the Lunar Society had different motivations and personalities but still found common ground in their scientific pursuits. This common ground and common topics led to a change in the scientific style of the period, which started to include more scientific communication and collaboration. As a whole, the group produced abundant scientific discoveries, and many of these contained actual uses and practicality, which applied to numerous industries. The paramount of the Lunar Society's scientific achievements occurred from 1780 until 1785, when the group started to decline. One example of the constant communication and combined effort of members was when

Priestley's work with gases became useful to Watt and his work with steam engines.[13] The success of the group was not simply due who attended their meetings, but rather what the members did outside of the Lunar meetings. Other informal intellectual societies were in existence during the period but few appear to have the level of teamwork and collaboration apart from the group meetings.

The three members discussed in the scope of this paper, Joseph Priestley, James Watt and William Withering each played different roles within the society and their careers each reflected such roles. Joseph Priestley's personality had a large impact on the Lunar Society. His selflessness and wide base of knowledge became quite welcome within the group, and this level of acceptance was valuable for him. He also appeared to be an effective facilitator for the other members of the Society. His published scientific work during the period was rare and the results had minimal importance or application, yet he still gained a lot through his membership in the Lunar Society in other ways. Already discussed was the large economic and social support he received from various members. However, Priestley's work during the period appeared to manifest in helping other members, especially with phlogiston projects.

The evidence of Priestley's work from the Lunar Society lies within the letters and publication of other Lunar members' works rather than his own personal gains.[14] The primary sources concerning Priestley did an excellent job revealing the social and personal impact that the Lunar Society had on Priestley, both during and after his time in Birmingham. Joseph Priestley put a lot of effort into working with, and helping others, and received a lot in return. Priestley took his expertise in both gases and electricity and readily applied his knowledge to any Lunar member that sought him out. This

collaboration of knowledge benefitted both Priestley's studies as well as other members, and this increasing synergy was what made the Lunar Society so successful. Therefore, the arrival of Priestley followed by a reinvigoration of the group is logical because of the traits and effort Priestley brought to the group.

The Lunar Society of Birmingham was a not a group of misfits but the level of acceptance within the association benefitted many members. After the King's Riots, the Royal Society alienated Joseph Priestley but the Lunar Society embraced him, which speaks volumes about how different the two scientific communities were. After he reached a certain level of acceptance, he worked more with other members on their projects that led to an increase in the amount of combined efforts by other associates. This level of acceptance led to a rejection of the previous, rigid model for science and scientists during the period.

Another man who tirelessly gave himself to the Lunar Society was James Watt. Watt was a hard worker who gave himself diligently to the group and received much in return. Watt constantly was looking towards other member of the society either for personal support or for the scientific knowledge to benefit his scientific pursuits. Despite his capitalistic characteristics, Watt was also very helpful for other associates of the Lunar Society. For example, Watt was always willing to help Priestley with his pursuits of the phlogiston theory, and in return, Priestley used his knowledge of gases and work with Watt; insuring that none of Watt's patents became infringed upon. Not all of the cooperation within the Lunar Society consisted of one member sharing their area of expertise with another. For example Watt often worked with Withering on his *Botanical Arrangements*, even though Watt was no expert on the topic.[15] A large amount of what

we know about Watt is from his massive amount of communication and correspondences with his close friends in the Lunar Society, also showing us what a huge emphasis he placed on his friends. Watt's friends were a vital aspect to his scientific and technological achievements during his career.

Finally, of the three members analyzed in this study, William Withering was probably the least active member of the group. Withering was an associate for an extended period, but did not appear to cooperate with other members quite as much as Watt and Priestley did. Nonetheless, the physician got a lot out of the group when it came to scientific matters but also experienced the downside to collaboration when other people attempted to take credit for his work. Other reasons for diminished communication were that Withering was more irritable than others were, and less open to sharing his information, based on the Darwin and Stokes episodes.[16] Again, the level of sharing and collaborating shown by the Lunar Society was impressive for its period yet Withering did not appear to embrace fully this behavior. Nevertheless, Withering was a unique scientist who was still an important member of the group who collaborated with many members, including Watt and Priestley on a matter of subject including, balloons, minerals and the phlogiston theory.

> The Lunar Society of Birmingham was unique for its period. Its most important feature was an abundance of communication and collaboration outside of the meetings. Its members redefined the social relations of eighteenth-century science, stressing joint efforts that promoted synergy. Frequent contact and correspondence led to interdisciplinary achievements whose quality and quantity were superior to that of other, contemporary institutions, such as the Royal

Society of London. Most important, the practical application of the results of their teamwork had a revolutionary impact on both Britain and the world.

[1] Jenny Uglow, *The Lunar Men: Five Friends Whose Curiosity Changed the World* (New York: Farrar, Straus and Giroux, 2002), 264.
[2]Uglow, 264.
[3] H.C.G. Matthew and Brian Hanson, *Oxford Dictionary of National Biographies* (Oxford: Oxford University Press, 2000) ,881.
[4] Robert E. Schofield, "The Lunar Society of Birmingham; A Bicentenary Appraisal," *Notes and Records of the Royal Society of London* 21, no. 2 (1966). 156.
[5] Schofield "A Bicentenary Appraisal", 156.
[6] Lyons, vii.
[7] Robert E. Schofield, *The Lunar Society of Birmingham: A Social History of Provincial Science and Industry in Eighteenth- Century England* (Oxford: Oxford University Press, 1962) ,4.
[8] Eric Robinson and Douglas McKie. eds. *Partners in Science: Letters of James Watt and Joseph Black* (Cambridge: Harvard University Press, 1970).
[9] Schofield "A Bicentenary Appraisal".
[10] Joseph Priestley, *Autobiography of Joseph Priestley*. Memoirs Written by Himself. (London : Bath, Adams & Dart, 1970), 122.
[11] Joseph Priestley, *The Doctrine of Phlogiston Established, and that of the Composition of Water Refuted* (Northumberland, 1800).
[12] Robinson and McKie. eds. *Partners in Science*.
[13] Schofield, *The Lunar Society of Birmingham*, 201.
[14] Joseph Priestley, *Autobiography of Joseph Priestley*, 126.
[15] Schofield, *The Lunar Society of Birmingham, 313*.
[16] Uglow, 270, 383.

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