1 / VOL. 3, NO. 5
THE CHEMICAL EDUCATOR
© 1998 SPRINGER-VERLAG NEW YORK, INC.
ISSN 1430-4171
http://journals.springer-ny.com/chedr
S 1430-4171 (98) 05249-8

Chemistry and History

Marie Anne Paulze Lavoisier: The Mother of Modern Chemistry

CASSANDRA T. EAGLE* AND JENNIFER SLOAN
Department of Chemistry
Appalachian State University
Boone, NC 28608
eaglect@appstate.edu

She refused to allow her grief, sorrows, or gender to hinder her, but instead used them as inspiration to overcome obstacles she encountered.

Marie Anne Pierrette Paulze was a significant contributor to the understanding of chemistry in the late 1700s. Marie Anne married Antoine Laurent Lavoisier, known as the "Father of Modern Chemistry," and was his chief collaborator and laboratory assistant. Marie Anne Lavoisier translated Richard Kirwan's "Essay on Phlogiston" from English to French which allowed her husband and others to dispute Kirwan's ideas. She drew many sketches and carved engravings of the laboratory instruments used by Lavoisier and his colleagues. She edited and published Lavoisier's *Memoirs* and hosted many parties where eminent scientists discussed new chemistry and ideas. As a result of her close work with Antoine Lavoisier, it is difficult to separate her individual contributions from his, but it is correctly assumed that much of the work accredited to him bears her fingerprints.

ISSN 1430-4171
http://journals.springer-ny.com/chedr
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Introduction

The late 1700s gave birth to the foundations of modern chemistry. During this time the balance was invented allowing for quantification of chemical reactions. The myth of phlogiston was disproved, paving the way for the development of the law of conservation of mass. These developments are credited to Antoine Lavoiser, hence he is considered the "Father of Modern Chemistry." Antoine Lavoisier's contributions are well known; they are presented in virtually every introductory chemistry textbook. Absent from general knowledge are the research contributions of Marie Anne Paulze (Lavoisier's wife and collaborator). This paper is intended to fill that lacuna.

Early Life

On January 20, 1758, Marie Anne Pierrette Paulze was born in the Loire province of France to aristocrats Jacques and Claudine Paulze [1]. Her family was part of the wealthy French elite. The Paulzes had four children of whom Marie Anne was the only girl. Jacques Paulze was a member of the Ferme General, a private group of financiers that collected taxes for the government. He was a parliamentary lawyer and financier and for a time served as director of the French East India Company [2]. In 1761, when Marie Anne was three years old, Claudine Paulze died; thus, Marie Anne was reared in a convent. During the 1700s, a convent or monastery was a great place for education, due to the ready availability of educational and literary materials. In the convent Marie Anne was surrounded by women who allowed her to excel scholastically.

Marriage to Antoine Lavoisier

In 1771 at the age of thirteen, Marie Anne returned home because a marriage had been arranged for her. Marie Anne was to marry the Count of Amerval, the fifty-year-old brother of Baroness de la Garde. The Count was suffering from huge financial problems. Amerval's monetary problems put him in dire need of a financially stable marriage. The Baroness manipulated Abbe Terray, Jacques Paulze's supervisor, who in turn pressured Paulze to agree to allow Count Amerval to marry Marie Anne. This marriage was not acceptable to Marie Anne. Indeed, Marie Anne called the Count "a fool, an unfeeling rustic, and an ogre" [3].

In response to Marie Anne's decision not to marry the Count, Jacques Paulze wrote to Terray and stated that he would not force his daughter to marry against her will. Going

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http://journals.springer-ny.com/chedr
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against the wishes of his boss put Paulze's job in jeopardy. Paulze needed a way to get his daughter and himself out of such a predicament. He decided to quickly make a match for Marie that would be more appropriate and thus end Terray and the Baroness's plans. His twenty-eight-year-old colleague, Antoine Lavoisier, seemed the perfect choice. Though no record of Marie Anne's or Antoine's responses are available, it is obvious that the two agreed on marriage because their engagement was announced in November. This short engagement left little time for a courtship to occur. Terray was understandably upset but, with the urging of his family, he did not seek vengeance and arranged a private chapel where Marie Anne and Antoine were married. The couple married on December 16, 1771 [3].

Marie Anne and Antoine quickly fell in love, and it is said that their marriage was "happy and harmonious, a bourgeois marriage devoid, it would seem, of anything other than mutual esteem and fidelity" [4]. Though it was rumored that Marie was pregnant, the marriage was, to their sadness, without children [5].

Their marriage began on a very financially stable foot. Paulze gave his daughter 80,000 livres over a six year period. Antoine received 420,000 from his mother and father in advance to his inheritance. Furthermore, two of Lavoisier's aunts left him money at their deaths [3].

The Collaboration Begins

Soon after their wedding, Marie Anne began to take interest in the work of her husband. In 1775 Lavoisier received a letter from Jean Hyacinthe de Magellan in which Marie is referred to as Lavoisier's "philosophical wife." Her interest in Lavoisier's work led her to study chemistry and laboratory skills, which better enabled her to assist him. In 1777 Jean Baptiste Bucquet, who was a collaborator and follower of Lavoisier, began tutoring Marie Anne in chemistry. Marie Anne also mastered English during this time, which allowed her to translate many English chemical works into French for Antoine and his colleagues [5]. As a result of Marie's tutoring, Bucquet and Lavoisier began writing a book on how to best study chemistry; however, the book was never finished [6]. In 1775, after Louis XVI's coronation, Lavoisier was appointed as one of four directors of the Gunpowder Administration. This administration was a royal office charged with managing gunpowder and regulating how it was made and its composition. These duties explain why a chemist was chosen

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http://journals.springer-ny.com/chedr
S 1430-4171 (98) 05249-8

as a director. As a consequence of this appointment, Antoine and Marie Anne moved to the Paris Arsenal [7]. They built a chemistry laboratory in the Arsenal where the majority of their research was conducted [1]. Marie Anne studied painting with the famous Jacques Louis David. She used her painting skills to make sketches for Lavoisier's books. Madame Lavoisier also did engravings and designed plates for her husband's books. She engraved thirteen plates in her husband's very popular *Elementary Treatise on Chemistry*. These plates contain detailed drawings of the apparatus used by the Lavoisiers in their research (see below). The engravings are essential to the understanding of the text written by her husband. Marie Anne was her husband's chief collaborator, laboratory assistant, and secretary—his right arm [5].

Antoine's new position with the Paris Arsenal opened up many opportunities for the Lavoisiers. During one such opportunity in October of 1786, Antoine and his colleagues traveled to observe the making of a new type of gunpowder. As Antoine's co-worker, Marie Anne was included on the trip. This is but one example of how she was able to see chemistry in action and to be a vital participant [8]. In September 1787, the Lavoisier's went from Paris to Orleans, the administrative capital of the region. At the provincial assembly for Orleans, Antoine was selected as the representative of the district of Romorantin. At the conclusion of the assembly, the Lavoisier's hurried away to see Jacques Louis David who painted their portrait (Figure 1). This portrait can be seen today in the New York Metropolitan Museum of Art [9].

The Lavoisier's were highly involved in the political scene of the day. They constantly held intellectual and scientific conversations and parties at their home. Marie Anne made many prestigious acquaintances at these parties. Guests at these gatherings included such luminaries as Benjamin Franklin, Joseph Priestly, James Watt, and Arthur Young, as well as many people from the Academy of Sciences [10]. Arthur Young was very impressed with Marie Anne when he visited the Lavoisier's on October 16, 1787. Young declared that Madame Lavoisier was a good cook, a hospitable hostess, and a beautiful lady, but that it was her conversation that impressed him most [11]. These parties allowed her to be immersed in scientific conversation where she gained new information and a better understanding of chemistry. It is said that at the weekly meetings in their home "she proved an indefatigable promoter of the 'new chemistry' and her husband's renown" [12].

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FIGURE 1. PAINTING OF MARIE ANNE PAULZE AND ANTOINE LAVOISIER BY JACQUES LOUIS DAVID, 1788. (REPRINTED WITH PERMISSSION OF THE METROPOLITAN MUSEUM OF ART, PURCHASE, MR. AND MRS. CHARLES WRIGHTSMAN GIFT, IN HONOR OF EVERETT FAHY, 1977. (1997.10) ©1989 BY THE METROPOLITAN MUSEUM OF ART.)

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TABLE 1. Description of Plates engraved by Marie Anne Paulze Lavoisier for *Elementary Treatise on Chemistry*.

PLATE NUMBER	PLATE DESCRIPTION
I	Petri dishes, files, and graters
II	Funnels, flasks, and other filtration apparatus
III	Heating apparatus and vessels for crystallization
IV	Distillation equipment and mercury apparatus
V	Water apparatus
VI	Ice calorimeter
VII	Apparatus used in recomposition and decomposition of water
VIII	Balance for weighing reactants and products of reactions
IX	Open combustion apparatus
X	Fermentation reaction apparatus
XI	Oil apparatus
XII	Combustion apparatus, glass siphons, jars and pitchers
XIII	Furnaces

Marie Anne's Contributions

Marie Anne made some contributions to chemistry that we can directly attribute to her. One of Marie Anne's most notable contributions appears in Lavoisier's *Elementary Treatise on Chemistry*. All the laboratory instrumentation and equipment used by the Lavoisiers for *Elementary Treatise on Chemistry* are drawn in the thirteen plates prepared by Marie Anne (Table 1) [13]. An example of her exacting attention to detail is found in Figure 2.

Madame Lavoisier created many sketches and drawings of instrumentation and experiments that occurred in the laboratory. One drawing is of a large chemical balance that Lavoisier had his instrument maker produce [14]. Her sketches are some of the best and are helpful in dating laboratory equipment and techniques [15].

Another important contribution was Marie Anne's translation of Richard Kirwan's "Essay on Phlogiston" from English to French. This essay discussed the existence of

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http://journals.springer-ny.com/chedr
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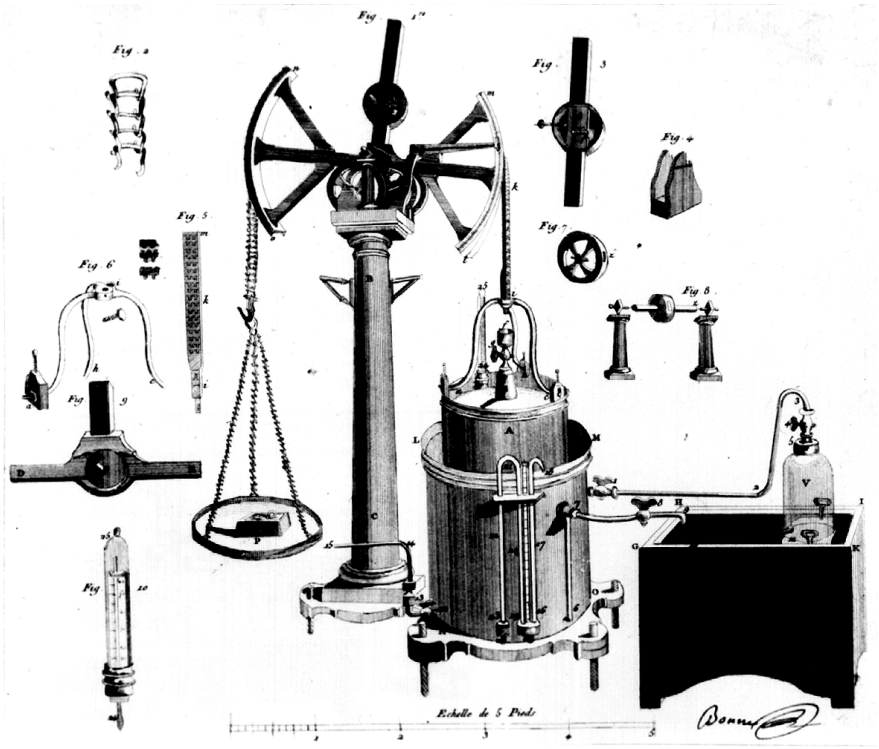

FIGURE 2. PLATE VIII FROM *TRAITE ELEMETAIRE DE CHEMIE* ENGRAVED BY MARIE ANNE PAULZE LAVOISIER. NOTE MARIE ANNE'S INITIALS IN THE LOWER RIGHT CORNER (MADAME BONNE). FROM: HOLLISTER, S. C. *ANTOINE LAURENT LAVOISIER: AN EXHIBITION*; THE CORNELL UNIVERSITY LIBRARY, 1963; THIRD UNNUMBERED PAGE AFTER P 12. (REPRINTED WITH PERMISSION OF THE DIVISION OF RARE AND MANUSCRIPT COLLECTIONS, CORNELL UNIVERSITY LIBRARY.)

phlogiston, which Kirwan popularized, especially throughout Sweden and Germany. Phlogiston was commonly believed to be a substance present in all substances which burn and was thought to escape during combustion leaving an ash substance called calx. Marie Anne, unlike her husband, was fluent in Latin and English; thus, she was able to translate the essay. Lavoisier and his colleagues were enabled to respond to Kirwan's arguments and to eventually "drive phlogiston off the stage" [16]. Lavoisier and Kirwan wrote volumes and volumes of responses to one another's arguments, and in 1791, after much discussion, Kirwan denounced his idea of phlogiston, too [17]. Lavoisier named the "phlogistated air" oxygen [18].

After Antoine's death, Marie Anne edited and published his *Memoirs* in which she included an introduction she authored [19]. Antoine had planned to make his *Memoirs* into an eight volume set; however, he was not able to finish his project. Antoine finished his first volume before his death. Madame Lavoisier undertook the publication and completion of her husband's *Memoirs*. The first volume contained

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http://journals.springer-ny.com/chedr
S 1430-4171 (98) 05249-8

their work on heat and the formation of liquids. The second volume dealt with the ideas of combustion, air, calcination of metals, action of acids, and the composition of water.

Collaborations of Marie Anne and Antoine Lavoisier

The majority of Marie Anne Lavoisier's contributions to science occurred during her marriage to Antoine Lavoisier. She was Antoine Lavoisier's laboratory assistant, library assistant, collaborator, scientific confidante, illustrator, editor, and translator of scientific papers [20]. As a result of her close work with Antoine Lavoisier, it is difficult to identify her individual contributions, but it is commonly believed that much of the work credited to him bears her fingerprints. The Lavoisiers are credited with bringing order to the science of chemistry. They listed thirty-three elements, disproved the idea of phlogiston, explained combustion, developed the law of conservation of mass, and studied transpiration and respiration.

The Lavoisiers discovered and created a systematic nomenclature for elements. L.B.G. de Morveau believed that nomenclature needed to be changed as a result of Antoine's new chemistry. Lavoisier agreed and presented the ideas of Lavoisier and Morveau to the Academy of Sciences in 1787. Later that year, Lavoisier and his colleagues wrote papers discussing the basis for the new nomenclature. The ideas they championed are still the basis for our present-day chemical nomenclature [21]. The Lavoisiers listed thirty-three elements which at that time could not be broken down or decomposed. Some of the elements listed were: light, matter of fire (caloric), oxygen, hydrogen, carbon, sulfur, phosphorus, sixteen known metals, organic radicals (acidifiable bases), and the alkaline earth oxides and alkali metals oxides (These have now been decomposed into alkaline earth metals, alkali metals, and oxygen.). Lavoisier is also credited with the definition of an element as anything that cannot be broken down. His definition was correct though some of his "elements" have since been identified as compounds. Lavoisier also came up with a principle for naming elements which stated that a name should reflect the elemental composition of a compound. This idea provided some clarity for naming that had not been previously present. Lavoisier is credited with the naming of oxygen from the Greek word meaning "acid maker." Lavoisier believed, though incorrectly, that all acids contained oxygen. Lavoisier said that salts formed from acids would have an *-ate* ending; thus, salts formed from sulfuric acid would be called sulfates. The following are some other naming rules that

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Lavoisier and his colleagues developed: *-ic* ending for oxygen saturated acids (for example, phosphoric acid or carbonic acid), *-ide* ending for compounds not in acid state and indicated oxides of the metals (for example, mercury oxide), and *-ite* ending for salts of *-ous* acids (for example, nitrite for nitrous acid) [18].

The Lavoisiers worked in a time of scientific revolution, and their work is "primarily the application of the scientific method to chemistry." One of the Lavoisiers' most important contributions was an understanding of combustion. In old chemistry gases and products of combustion were very confusing, but the Lavoisiers devoted much of their lives to understanding the reactions and products of combustion. The observation that diamonds heated in air disappeared first drew Lavoisier's attention to this subject. Lavoisier decided to pack a diamond in powdered charcoal and then heat it in air. This experiment resulted in the diamond being unaffected by the heat because the charcoal excluded the air. Lavoisier thus wrote his first paper on the subject of combustion and presented it to the Academy of Sciences in France [22]. Assisted by a young mathematician, Pierre Simon Laplace, the Lavoisiers designed a combustion apparatus in which "streams of two gases, each stored in a pneumatic chest, could be brought together in a double nozzle and burned together." In June 1783, Antoine Lavoisier presented this apparatus to the Academy of Sciences and it was quickly put to "historic" use [23]. Through the burning of "inflammable air" (hydrogen) and "vital air" (oxygen), Lavoisier observed and recorded the formation of water. The quantification of heat and the understanding of this reaction allowed Lavoisier to confirm combustion [24]. Marie Anne sketched (Figure 3) and documented the use of the combustion apparatus [24]. Between 1775 and 1778, Lavoisier clarified and expanded his ideas of combustion in two books [22]. Lavoisier and Laplace also developed the first known apparatus used to measure the amount of heat given off by a body, which they called the ice calorimeter. An engraving of the ice calorimeter, done by Marie Anne, was published in Lavoisier's best known book, *Elementary Treatise on Chemistry* [25].

The law of conservation of mass is put forth in *Elementary Treatise on Chemistry*. Lavoisier's work with fermentation coupled with his combustion reactions involving mercury and oxygen led Lavoisier to the realization that the total mass in a reaction remains constant. Lavoisier measured the amount of mercury and oxygen prior to reaction. Then, he burned the mercury and oxygen and weighed the products. He found that the mass of the reactants equaled the mass of the products; therefore, proving his

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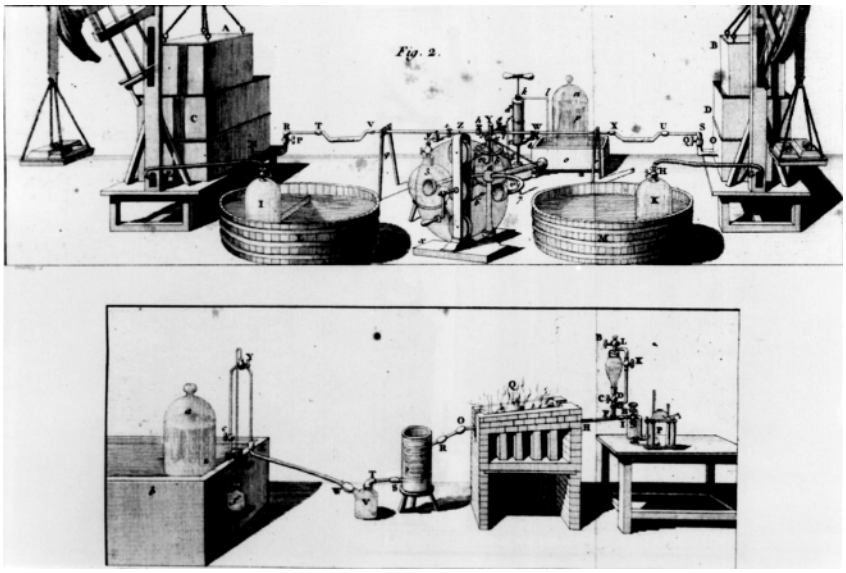

FIGURE 3. MARIE ANNE PAULZE LAVOISIER'S ILLUSTRATION OF THE APPARATUS FOR THE DECOMPOSITION AND RECOMPOSITION OF WATER. PUBLISHED IN THE *JOURNAL POLYTYPE* ON THE 27 FEBRUARY 1786. FROM HOLLISTER, S. C. *ANTOINE LAURENT LAVOISIER: AN EXHIBITION*; THE CORNELL UNIVERSITY LIBRARY, 1963; FOURTH UNNUMBERED PAGE AFTER PAGE 12. (REPRINTED WITH PERMISSION OF THE DIVISION OF RARE AND MANUSCRIPT COLLECTIONS, CORNELL UNIVERSITY LIBRARY.)

idea of conservation of mass. The law of conservation of mass states that the total mass in a reaction remains constant. The Lavoisiers used the balance they developed to conduct this experiment [26]. Marie Anne recorded observations and assisted Antoine in research for this experiment and others during all of their married life [5].

Another one of Lavoisier's major studies was on respiration and transpiration. He began his studies with the analysis of inhaled and exhaled air. He concluded that space occupied by men or animals must be ventilated. He also showed that during breathing, oxygen is used up and water and carbon dioxide are formed. Furthermore, he noted that moisture evaporates from the body allowing body temperature to be kept normal, and the oxygen level consumed is constant. Lavoisier wrote four papers on the subject. One discussed the need for ventilation in closed spaces where men and animals exist, and another was an analysis of the change in air during breathing [27]. Madame Lavoisier drew very detailed sketches of the apparatus used and kept very clear and specific records of the procedures they followed. She even drew herself into the pictures recording data and procedures of the laboratory [28]. In one of her most vivid drawings of their work with respiration (Figure 4), she shows one of Antoine's colleague's face covered with a mask, breathing air or oxygen [29]. Marie Anne

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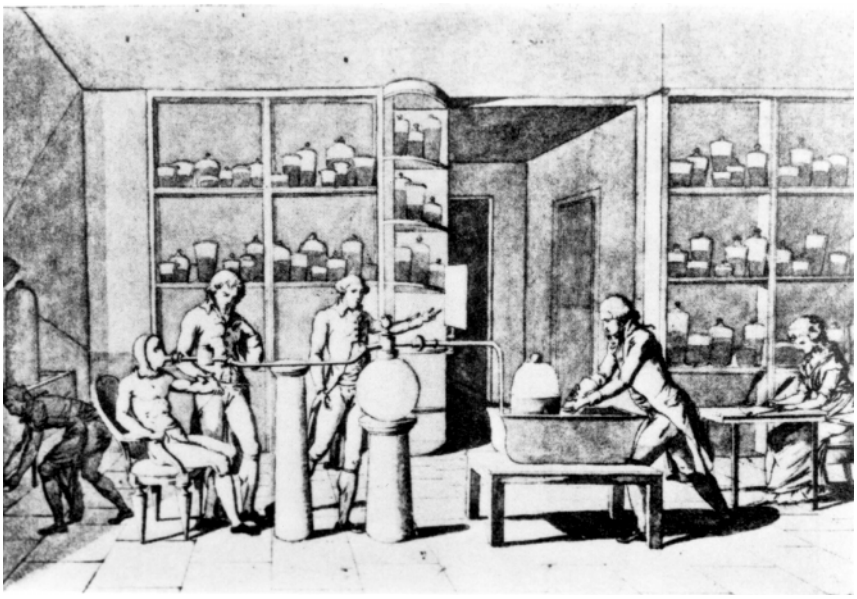

FIGURE 4. DRAWING BY MARIE ANNE PAULZE LAVOISIER OF EXPERIMENTS ON RESPIRATION AND TRANSPIRATION. FROM: GUERLAC, H. *ANTOINE LAURENT LAVOISIER*; CHARLES SCRIBNER'S SONS: NEW YORK, 1975; P 40. (REPRINTED WITH PERMISSION OF RITA GUERLAC.)

Lavoisier's records on respiration and transpiration still exist; they document the significant achievements made in these areas by Lavoisier and his colleagues. The Lavoisiers' work on respiration and transpiration is another example of how the work ascribed to Lavoisier is more accurately ascribed to the couple [30].

The Effect of the French Revolution

The French Revolution was beginning to slowly rear its head in 1789 and had a huge impact on the lives of the Lavoisiers. One of the first examples of this new regime affecting the Lavoisiers occurred in 1789. Jacques Louis David's paintings were displayed in France, but he chose not to display the painting of the Lavoisiers because they were prominent figures of the Old Regime and it might "incite public agitation." In 1793 the Terror became stricter; academics, including chemistry, were suppressed. One day as Madame Lavoisier was on her way to meet her husband and some colleagues to discuss a scientific matter, her carriage was mobbed by a group of women. These militant women forced her from her carriage and made her join them on a march to Versailles. On the march they abducted the king and his family and forced them back to Paris. This event in history is referred to as the Women's Bread March [31].

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In 1793 Antoine Dupin accused the Ferme General of loyalty to the Old Regime [10]. As a direct result, on December 24, 1793, Antoine Lavoisier and Jacques Paulze were arrested for their involvement in the Ferme General. Antoine appealed to the Terror officials as a scientist, but to no avail [32]. Marie Anne requested the help of many prominent figures and scientists in an attempt to free her husband, but no one came to his aid. This was a point which Madame Lavoisier never forgave nor forgot. She informed the authorities that her husband had ended his involvement with the royalist group three years prior, but they refused to release him [10]. While in prison, Lavoisier wrote to Marie Anne. These letters show his deep love for her as well as his respect and hope for her future. His desire for her happiness is seen in the following letter.

> My dearest friend, you are beset by much pain and weariness of body and soul that I cannot share. Be careful not to sacrifice your health, for that would be the greatest misfortune. My career is well advanced and I have always enjoyed a happy life. You have made it so and continue to do so by all the signs of affection you show me. When I am gone I will be remembered with respect. My work is done, but you, who have reason to hope for a long life, must not waste it. Yesterday you appeared to be sad. Why should you be, when I accept what will happen with resignation and will consider anything that is not lost as a victory. There is also reason to hope we will be together again. Until then, your visits provide me with moments of happiness [33].

Despite the attempts made by the Lavoisiers, on May 8, 1794, Antoine Lavoisier and Jacques Paulze were guillotined because of their involvement in the Ferme General [31].

Madame Lavoisier was completely devastated by the deaths of her husband and father, and for a while she suffered from much depression and loneliness [34]. Her enemies accused her of sending her husband to death by her “denunciation of his accusers” instead of pleading for his life. [18]. Bitter and angry, she blamed her husband’s death on his colleagues who did not come to his defense. The agents of the Terror took all of the Lavoisiers’ finances and belongings, including laboratory equipment and journals; thus, Marie Anne was impoverished. She was then arrested and imprisoned for a short time, but was soon released because the Reign of Terror had finally come to an end [10]. After her release, she had nothing because her goods had been impounded in 1794. She was forced to depend on the good will of a former servant to survive. Later, she was able to recover most of Antoine’s notebooks, laboratory equipment, and her property; although her monetary assets were never returned [34].

ISSN 1430-4171
http://journals.springer-ny.com/chedr
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Marie Anne's Life After Antoine Lavoisier

Marie Anne spent much of her life working by the side of her husband; thus, she was very literate in scientific ideas. She decided after his death to publish his *Memoirs.* In the introduction she condemned those men who had not come to Lavoisier's aid while he was in prison. No one would help her produce and publish the book because of the "scathing condemnation" of the six men in the preface, so she decided to do it alone [18]. As a result it was cheaply and poorly printed. It appeared in two volumes in 1803, but it was never available for public purchase. Instead, she donated copies of the books to local libraries and prestigious scientists [35]. Antoine had said, "This theory is not, as I have heard said, the theory of French Chemists, it is mine, it is the one piece of property that I claim from my contemporaries and my posterity." This statement encouraged Marie Anne to finish the book and ensure his memory and scientific credit. In 1805, *Memoirs* was again printed, but the offensive preface was replaced with the above quote from her late husband [19].

Madame Lavoisier also wrote a "violent, but well documented pamphlet" accusing Antoine Dupin of not coming to her husband's aid when he was imprisoned. Dupin caused her husband and her father to be arrested. She wanted Dupin to retract his accusation that Antoine Lavoisier was a member of the Ferme General. The pamphlet was written in an effort to avenge Antoine Lavoisier. Dupin was imprisoned, but general "amnesty" spared his life [18].

On November 19, 1801, Madame Lavoisier met Count Rumford, also known as Benjamin Thompson. He found Marie Anne appealing and called on her frequently. He said that she was "attractive, "independent," and "one of the cleverest woman ever known and uncommonly well informed" [36]. Because Count Rumford was English he was not allowed to stay in France, so he and Madame Lavoisier communicated between countries [37]. In 1803 Marie Anne went on an extended tour of Bavaria and Switzerland with Rumford. Marie Anne's ideas and observations were requested when the two were vacationing together. When she returned to France, she persuaded the government to allow Rumford to come back into the country, and he moved to France that spring. They planned to get married, but complications with Rumford's past wife's death prevented them from doing so until October 24, 1805 [37]. Their wedding was a big event in Parisian elite society. Madame Lavoisier was strong-willed from the beginning and demanded to be Madame Lavoisier de Rumford. She refused to give up her first husband's name, and Rumford ultimately agreed [38].

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http://journals.springer-ny.com/chedr
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Rumford was similar to Lavoisier in that he is credited with many honors and contributions to science. Rumford said, “I think I shall live to drive the caloric off the stage as the late Mr. Lavoisier drove away phlogiston. What a singular destiny for the wife of two philosophers!” Indeed, Marie Anne married two great men of science [39].

The marriage almost immediately became troublesome. Marie Anne was very socially active and hospitable, whereas Rumford was reclusive and arrogant. Their incompatibility soon became public knowledge. Marie was knowledgeable in chemistry and science as a whole as well as a variety of other subjects. She enjoyed discussions on many topics. It annoyed her that Rumford talked of physics constantly and predominately. Madame Lavoisier de Rumford had worked with her late husband and was involved directly in his work. She was considered Antoine Lavoisier’s most valued friend and assistant. Rumford worked alone [40]. Rumford worked at his apartment alone prior to their marriage, and he expected to do the same after their wedding. She was never considered an essential part of his work as she had been with Antoine Lavoisier [41]. Though they did not work together, when Rumford was accused of plagiarism, Marie Anne ran to his defense [18]. Later, Marie Anne said of Rumford, “He would make me very happy if he would but keep quiet” [41]. Rumford stated it best when he wrote to his daughter, “In character and natural propensities, Madame Rumford and myself are totally unlike” [41].

Another dispute concerned Rumford’s dissatisfaction with the house and his desire to see it remodeled. He wanted the house to be a display case of his “contributions to modernization,” while Madame Lavoisier de Rumford did not want any changes made [41]. It is also thought that Rumford tried to “undercut” some of Antoine Lavoisier’s scientific work. This indeed infuriated Marie Anne and caused increased tension between the two [42]. By their first anniversary, it was obvious that this marriage was going to be very short lived. Count Rumford wrote a letter to a friend on their first anniversary and referred to Marie Anne as a “female dragon” [41]. Their differences continued to plague their marriage, and their disputes became much louder, more fierce, and more public. According to one story, Marie Anne was having a party one afternoon and Rumford wanted peace and quiet so that he could study. He locked the gates and refused to allow the servants to let anyone enter. Marie was so angered by her husband’s rejection of her guests that she poured boiling water all over his prize-winning rose garden [40]. She had Rumford excluded from all fashionable society in France and she attempted to persuade Napoleon to throw him out of the

ISSN 1430-4171
http://journals.springer-ny.com/chedr
S 1430-4171 (98) 05249-8

country. Rumford wrote, “I have the misfortune to be married to one of the most imperious, tyrannical, unfeeling women that ever existed, and whose perseverance in pursuing an object is equal to her profound cunning wickedness in framing it” [43]. In 1808, without any surprise to the community, Rumford and Marie Anne separated; in 1809 they were divorced. According to the divorce agreement, Rumford received a pension and Marie Anne kept the house. Despite their difficulties, Marie Anne continued to keep close contact with Sarah, the Count’s daughter [30].

Marie Anne married two excellent scientists. Count de Rumford made many significant achievements in physics during his lifetime. He pioneered in the areas of heat conduction, radiant heat, and thermometry. Rumford was the first to note the expansion of water when it cools. His most well known experiments occurred in Munich where he supervised the boring of cannon from brass blocks. During this project, he observed that large quantities of heat were being generated. The theory of the day stated that heat was a substance stored in bodies and released by friction. Rumford concluded that if this was true then the heat would eventually run out. Because this did not occur, he decided that heat is not a substance, but the mechanical product of motion [44]. Another major accomplishment was his practical work with lamps, stoves, and ventilators. He referred to his lamps as “illuminators.” He created a special “illuminator” for the table and the dining room. Another interesting apparatus created by Rumford was a portable coffee pot, though it was argued that he copied this idea from Hardot [45].

Little is known about the remainder of Marie Anne’s life other than that she continued to host parties with important guests. She continued to be a prominent and important member of Parisian society until February 10, 1836, when she died at the age of seventy-eight [30].

Conclusion

Marie Anne Paulze married the famous Antoine Lavoisier and worked vigorously with him until May 1794, when he was guillotined. After her four-year marriage to Benjamin Thompson, she continued to popularize and support chemistry for the remaining twenty-seven years of her life.

ISSN 1430-4171
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Marie Muerdac said, “minds have no sex and that if the minds of women were cultivated like those of men, and that if as much time and energy were used to instruct the minds of the former, they would equal those of the latter [46]. The life of Marie Anne Lavoisier proves this statement to be true. She refused to allow her grief, sorrows, or gender to hinder her, but instead used them as inspiration to overcome obstacles she encountered. She was trained in chemistry by a great chemist and took art lessons from a famous artist of the time. She learned and worked along side her husband, the “Father of Modern Chemistry.” Marie Anne engraved the plates for Lavoisier’s books, documented their research observations, and translated Kirwan’s “Essay on Phlogiston.” She and Antoine investigated combustion, identified elements and systematized nomenclature, developed the law of combustion, researched transpiration and respiration, and disproved the idea of phlogiston. Marie Anne Lavoisier used her education to help pave the road to new discoveries in chemistry that have laid the foundation for many aspects of chemistry today.

REFERENCES

1. Borgias, A. P. “Marie Anne Pierrette Paulze Lavoisier” *In Women in Chemistry and Physics: A Bibliographic Sourcebook*; Grinstein, L. S.; Rose, R. K.; Rafailovich, M. H.; Eds.; Greenwood Press: Westport, 1993; p 314.
2. Ogilive, M. B. *Women In Science*; MIT Press: Cambridge, MA, 1986, p 119.
3. Donovan, A. *Antoine Lavoisier*. Blackwell Science: Cambridge, MA, 1993; pp 111–113.
4. Guerlac, H. *Antoine Laurent Lavoisier*; Charles Scribner’s Sons: New York, 1975; p 65.
5. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; pp 114–115.
6. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; p 178.
7. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; pp 190–191.
8. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; p 198.
9. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; pp 237–239.
10. Borgias, A. P. “Marie Anne Pierrette Paulze Lavoisier” *In Women in Chemistry and Physics: A Bibliographic Sourcebook*; Grinstein, L. S.; Rose, R. K.; Rafailovich, M. H.; Eds.; Greenwood Press: Westport, 1993; p 315.
11. Tilden, W. A. *Famous Chemists*; E. P. Dutton & Co.: New York, 1921; pp 65–66.

ISSN 1430-4171
http://journals.springer-ny.com/chedr
S 1430-4171 (98) 05249-8

12. Guerlac, H. *Antoine Laurent Lavoisier*; Charles Scribner's Sons: New York, 1975; p 66.

13. Lavoisier, A. *Elementary Treatise of Chemistry*; Keer, R., Translator; Chicago: Encyclopedia Britannica: Chicago, IL, 1952 Plates I–XIII.

14. Guerlac, H. *Antoine Laurent Lavoisier*; Charles Scribner's Sons: New York, 1975; p 37.

15. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; pp 278–279.

16. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; p 175.

17. Hollister, S. C. *Antoine Laurent Lavoisier: An Exhibition*; The Cornell University Library, 1963; p 12.

18. Ihde, A. J. *The Development of Modern Chemistry*; Dover Publications: Mineola, NY, 1984; pp 77–79.

19. Borgias, A. P. "Marie Anne Pierrette Paulze Lavoisier" *In Women in Chemistry and Physics: A Bibliographic Sourcebook*; Grinstein, L. S.; Rose, R. K.; Rafailovich, M. H.; Eds.; Greenwood Press: Westport, 1993; p 318.

20. Brown, S. C. *Benjamin Thompson, Count Rumford*; The Murray Printing Co.: Baskerville, 1979, pp 268–269.

21. Hollister, S. C. *Antoine Laurent Lavoisier: An Exhibition*; The Cornell University Library, 1963; p 5.

22. Hollister, S. C. *Antoine Laurent Lavoisier: An Exhibition*; The Cornell University Library, 1963; pp 10–11.

23. Guerlac, H. *Antoine Laurent Lavoisier*; Charles Scribner's Sons: New York, 1975; p 96.

24. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; p 134.

25. Guerlac, H. *Antoine Laurent Lavoisier*; Charles Scribner's Sons: New York, 1975; p 32.

26. Guerlac, H. *Antoine Laurent Lavoisier*; Charles Scribner's Sons: New York, 1975; p 119.

27. Hollister, S. C. *Antoine Laurent Lavoisier: An Exhibition*; The Cornell University Library, 1963; p 13.

28. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; p 273–279.

29. Guerlac, H. *Antoine Laurent Lavoisier*; Charles Scribner's Sons: New York, 1975; p 123.

ISSN 1430-4171
http://journals.springer-ny.com/chedr
S 1430-4171 (98) 05249-8

30. Borgias, A. P. "Marie Anne Pierrette Paulze Lavoisier" *In Women in Chemistry and Physics: A Bibliographic Sourcebook*; Grinstein, L. S.; Rose, R. K.; Rafailovich, M. H.; Eds.; Greenwood Press: Westport, 1993; p 317.

31. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; p 294–295.

32. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; p 297.

33. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; p 300.

34. Donovan, A. *Antoine Lavoisier*; Blackwell Science: Cambridge, MA, 1993; p 301–302.

35. Guerlac, H. *Antoine Laurent Lavoisier*; Charles Scribner's Sons: New York, 1975; p 131.

36. Brown, S. C. *Benjamin Thompson, Count Rumford*; The Murray Printing Co.: Baskerville, 1979, p 248.

37. Brown, S. C. *Count Rumford*; Greenwood Press: Westport, 1979, pp 141–144.

38. Brown, S. C. *Count Rumford*; Greenwood Press: Westport, 1979, p 145.

39. Brown, S. C. *Benjamin Thompson, Count Rumford*; The Murray Printing Co.: Baskerville, 1979, p 255.

40. Brown, S. C. *Count Rumford*; Greenwood Press: Westport, 1979, pp 151–152.

41. Brown, S. C. *Benjamin Thompson, Count Rumford*; The Murray Printing Co.: Baskerville, 1979, pp 275–277.

42. Brown, S. C. *Benjamin Thompson, Count Rumford*; The Murray Printing Co.: Baskerville, 1979, p 281.

43. Brown, S. C. *Benjamin Thompson, Count Rumford*; The Murray Printing Co.: Baskerville, 1979, pp 289–290.

44. Laudan, L. L. In *Encyclopedia Americana*; Grolier: Danbury, 1996; Vol. 26, p 691.

45. Brown, S. C. *Benjamin Thompson, Count Rumford*; The Murray Printing Co.: Baskerville, 1979, pp 280–293.

46. Kass-Simon, G.; Farnes, P. *Women of Science*; Indiana University Press: Bloomington, IN, 1990, p 306.