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ABSTRACT

This collection of activities related to women chemists and physicists is designed for use in cooperative groups of three students each. Each of eight activities consists of a written account of the career and life of an historical woman scientist and four writing activity suggestions. The writings from each group can then be organized into one publication that comprises a magazine about women chemists and physicists. The scientists profiled include Miriam the Jewess, Jane Haldimand Marcet, Dame Kathleen Lonsdale, Harriet Brooks, Fanny Cook Gates, Yulya Vsevolodovna Lermontova, Dr. Rachel Lloyd, Icie Macy Hoobler, and Mary Fieser. (LZ)

# Cooperative Learning Activities Related to Women Chemists and Physicists



by
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## General Directions

Ideally, these activities are set up for cooperative groups of three students each. Give each group write ups and directions for the woman scientist selected. The students should read and research about their scientists together. Then it is suggested that the teacher assign each student one of the writing activities given in the directions individually. Thus, the students can be given credit for individual work. Then the writings from each group should be organized into one publication that will comprise a magazine about women chemists and physicists. Other assignments that could be given would be to assign each group another component of the magazine to work on as a group. These could include a front and back cover design, an editorial page, and advertising. By doing this, each group could then earn group credit. It is hoped that the final product will be a magazine worth saving and displaying.

## Miriam the Jewess

Miriam, who was also called Maria or Mary, apparently lived during the first century A.D. She was an alchemist, and though little is known about her personally, she was cited as an authority in her field for over 1,500 years. Her own writings are lost, but extracts from them have survived in the 28-volume encyclopedia of scientific knowledge compiled by Zosimos of Panopolis, a third century A.D. Egyptian alchemist. Thus, she is the first woman scientist whose work survives in any form.

Miriam was most skilled in designing and making alchemical equipment, including designs for the water bath, the three-armed still, and the reflux oven. The water bath was named *balneum mariae* in her honor by the 14th century alchemist Arnauld of Villanova, and the modern French name for the double boiler is *bain-marie*. Miriam's descriptions of her designs are very precise and use quantitative measurements.

Miriam was also a skilled experimental chemist. She is most famous for her preparation of lead-copper sulfide, still used by artists as a pigment and known as "Mary's Black." Because she was an alchemist, she was preoccupied with efforts to change base metals into gold. Therefore, she did extensive work with alloys of copper, lead, silver, and gold. She developed the orange-red color significant in the gold-making process by reacting mercury and sulfur to produce mercury(II) sulfide.

Miriam's quest for the "philosopher's stone", necessary for transmuting lesser metals to gold, reflects an attitude typical of ancient alchemists. Her Jewish heritage is also reflected in her attitude toward hard work and hopefulness. Her training in alchemy was as a student of the alchemist Ostanes, and she later founded her own school of alchemy. She, therefore, learned the basic tenet of alchemy and passed this on to her students. This was strict secrecy about the alchemical processes that could be passed on to only a small group of students. This secrecy coupled with Miriam's Jewish heritage was not fortuitous. Ancient Judaism held alchemical activities as sinful and felt that these practices were often passed on by wicked women, but Miriam still used many expressions reflecting her Jewish background in her writings.

Herzenberg, Caroline L., et. al., "Women Scientists and Physicians of Antiquity and the Middle Ages," *Journal of Chemical Education*,1991, 68: 101-105.

DIRECTIONS

1. Read thoroughly the description of Miriam the Jewess and any areas of the text that relate.

2. Assume that you are Miriam and write a journal entry or letter to a friend describing in detail one area of her work.

3. Compose an entry describing Miriam's work for the 28 volume encyclopedia of scientific knowledge compiled by Zosimos of Panopolis.

4. Write an article for a modern-day newspaper or magazine describing how Miriam's work is significant today.

## Jane Haldimand Marcet

Jane Haldimand Marcet (1769-1858) was born in London to a prosperous Swiss family. At the age of thirty, she married Alexander Marcet, a physician and chemist. She often entertained her husband's friends who included J.J. Berzelius, Sir Humphry Davy, the botanist Augustin de Candolle, the mathematician H.B. de Saussure, the writers Harriet Martineau and Maria Edgeworth, the political economist Thomas Malthus, the physicist and naturalist Auguste de la Rive, and the chemists Pierre Prevost and Marc Auguste Pictet. Marcet, therefore, had access to the newest ideas in the field of chemistry as well as in other areas. She translated these social connections into a long and productive writing career. Her first book was *Conversations on Chemistry*, published in London in 1806.

Mrs. Marcet's characters are Mrs. B, the instructor in the conversations; Caroline, an impetuous and skeptical student more interested in explosions than in the fundamentals of science; and Emily, a serious and bright student more likely to ask important questions. Caroline and Emily were in their early teens and from wealthy, educated families. The topics discussed range through the parameters of early nineteenth-century chemistry, including geology, mineralogy, electricity, fermentation, plant respiration, animal growth, meteors, minerals, medicinal cures, and soil samples. Also included in the conversations were social and technological issues of the time.

Mrs. Marcet intended *Conversations on Chemistry* to be a guide for a female audience interested in popular science. She explained that her interest in chemistry was aroused by attendance at the public lectures of Humphry Davy, which she initially found confusing. When the basic concepts of the new chemistry were explained to her in "familiar conversations", Marcet said, she could enjoy Davy's lectures much more. Her book was written because "there are but few women who have access" to scientific friends, such as her own, willing to converse with them about theory.

The focus of *Conversations* is on theoretical and experimental chemistry. Topics discussed were simple and compound bodies, elements, living systems, light, heat, electricity, oxygen and hydrogen, sulfur and carbon, metals, attraction, acidification, decomposition, and animal production. Marcet continued to update important ideas in later editions of the book. She followed Lavoisier's scheme of classification of the elements, the caloric theory, a Newtonian, corpuscular theory of matter, and she explained chemical reactions in terms of affinity, aggregation, gravitation, and repulsion. Davy's influence on her is shown in that she did not include Dalton's atomic theory until after 1819, a reflection of Davy's skepticism about the theory.

In the United States, *Conversations* was not used as Marcet intended, but rather as a textbook for chemistry courses offered in women's seminaries, in mechanics' institutes offered for young men, and medical apprentices favored it in beginning their study of chemistry. From 1806 to 1850, American publishers produced twenty-three editions of the book. They added study questions, dictionaries of terms, guides to experiments, and critical commentaries to increase the book's effectiveness in the classroom. In addition to influencing countless American students, Marcet's *Conversations on Chemistry* has traditionally claimed historical attention for its effect on the young bookbinder Michael Faraday, who was converted to a life of science while binding and reading it.

Linde, M. Susan, "The American Career of Jane Marcet's Conversations on Chemistry, 1806-1853", *ISIS*, 1991, 82: 8-23.

DIRECTIONS

1. Read thoroughly the description of Jane Marcet and any areas of the text that relate.

2. Write a conversation between Mrs. B, Caroline, and Emily concerning one area of chemistry that was known in the early nineteenth-century.

3. Write a review of the book as it might have appeared in a newspaper in England or America in 1806.

4. Write an article for a modern-day newspaper or magazine discussing the significance of Marcet's work to today's study of chemistry.

Dame Kathleen Lonsdale

Kathleen Yardley Lonsdale was born in 1903 in Newbridge, Ireland, and she was the youngest of ten children. She enrolled in Bedford College, a small, women's college part of the University of London, at the age of sixteen. While there she majored first in mathematics and later in physics. At the age of nineteen she began her master's degree work with William H. Bragg, the 1915 co-winner, with his son Lawrence, of the Nobel Prize for Physics in the field of x-ray diffraction. While doing her master's work, she learned to use the x-ray spectrometer, studied the structure of succinic acid, and collaborated on a set of space group tables which became a popular aid to crystallographers. Kathleen received the prestigious D.Sc. (Doctor of Science) for her study of ethane derivatives.

Shortly after her marriage to Thomas Lonsdale on August 27, 1927, Kathleen began to research hexamethyl benzene in a laboratory in Leeds. The nucleus of this compound is surrounded by six methyl groups, and the compound has a crystalline structure. Using these crystals, she was able to examine the benzene ring that was the foundation of much of organic and industrial chemistry. Since benzene is a liquid at room temperature, has a high vapor pressure, and contains more than one molecule per unit cell, it was not a suitable compound for study at this stage of the development of crystallography. However, by using hexamethyl benzene crystals, Dr. Lonsdale concluded that the hexamethyl benzene molecules were flat and lay in parallel layers. Further calculations showed definitely that the benzene ring was flat and not puckered like diamond as had been previously suggested by Bragg. Benzene was first discovered by Michael Faraday in 1825. It was known to be made of six carbons joined into a ring, as was proposed by Kekule' in 1865, but until Dr. Lonsdale's discovery little else was known about its structure.

Even though the period from 1929 to 1934 saw the birth of her three children, Dr. Lonsdale continued to work on crystal structures and on the space group tables. In 1934, Kathleen returned to the Royal Institution in London to work once again with Professor Bragg. There she continued to work with benzene compounds and developed an interest in two new fields, thermal vibration of molecules and natural and man-made diamonds. In December 1946, she founded her own crystallography group at University College, London. While there she was made professor in 1949 and professor emeritus upon her retirement in 1968. She was made a Dame of the British Empire for her scientific work in 1956. In December 1970, she became ill with cancer and died on April 1, 1971.

Science was not the only area of interest in Kathleen Lonsdale's life. During World War II Dr. Lonsdale was required, with others of course, to register for fire-watching duties. Because of her profound belief in Quakerism, she refused to do this because she felt it would be positive participation in the war. She was then fined two pounds, but she refused to pay the fine and was sentenced to serve one month in Hollaway Prison for Women. This experience led to her active involvement in penal reform. She was also actively interested in world peace and in banning the use of nuclear weapons. Dr. Lonsdale served as a positive role model for the advancement of women in science and made many contributions to the scientific world as well as to society at large.

Julian, Maureen M., "X-ray Crystallography and the Work of DameKathleen Lonsdale",
*The Physics Teacher*, 1981, 19: 159-165.

DIRECTIONS

1. Read thoroughly the description of Dame Kathleen Lonsdale and any areas of the text that might relate.

2. Write a letter from Dr. Lonsdale to Professor William H. Bragg discussing her work with hexamethyl benzene.

3. Write a magazine or newspaper article as it might have been published after Dr. Lonsdale's discovery of the planarity of the benzene ring in 1928.

4. Write a magazine or newspaper article for a modern-day publication discussing the significance of Dr. Lonsdale's work to today's society.

## Harriet Brooks and Fanny Cook Gates

Harriet Brooks and Fanny Cook Gates were both pioneer nuclear scientists. The work of both of these women has been almost completely overlooked. These women were only two of at least fourteen others who published work in the field of nuclear science between 1900 and 1915. No one has drawn attention to these female pioneers. However, it is important that we recognize that early nuclear science was not the male bastion (except for M. Curie) that has been the traditional view.

Harriet Brooks was born on July 2, 1876, in Exeter, Ontario, Canada, went to school at Seaforth Collegiate Institute, Seaforth, Ontario, and entered McGill University in 1894. In 1898, she graduated with a degree in mathematics and natural philosophy. In 1898, after Ernest Rutherford moved to McGill from England, she became one of his first research students. She initially worked on electricity but later studied emanation from radium. She later worked with J.J. Thomson in the Cavendish Laboratory but rejoined Rutherford's research group in 1903. In 1905 she accepted a position as tutor in physics at Barnard College. In 1906 she became engaged to a professor of physics at Columbia University, but because Barnard officials felt that marriage would interfere with her teaching she was asked to resign when she married. Brooks strenuously objected to this action and the engagement was subsequently broken off. During 1906-1907 she worked in the Laboratorie Curie in Paris on radioactive transformations. In late 1907, Brooks decided to terminate her physics research and marry Frank Pitcher, who had been a laboratory demonstrator at McGill University while she was a student. She died on April 17, 1933, possibly from a radiation-related disease. Rutherford mentioned Brooks more often than his other students at the same time period, and much of his early work on radioactive decay and particularly on radon was performed by Brooks. She did significant pioneer work in nuclear science, but one reason she has been overlooked is because it was not until years later that the significance of her experimental work was realized.

Fanny Cook Gates was born in Waterloo, Iowa, on April 26, 1872. She graduated from Northwestern University with a B.S. in 1894 and a M.S. in 1895. She was awarded a European Fellowship for 1897-1898, and she spent part of the year at the University of Gottingen and at the Polytechnik Institute in Zurich. She spent 1898-1911 at Goucher College, Maryland, where she advanced from instructor to associate professor to head of the department of physics. She obtained leave to spend the 1902-1903 school year at McGill University, Montreal, as a graduate student with Rutherford. Her early work in radioactivity showed that it was not a standard physiochemical process as had been previously assumed. During the summers of 1904 and 1905, Gates worked at Cavendish Laboratory, presumedly with J.J. Thomson. During 1907-1908, she was a graduate student at the University of Pennsylvania where she was awarded a Ph.D. in 1909. She was a researcher at the University of Chicago from 1911-1913 and worked at Grinnell College from 1913-1916. She went on to serve as a physics instructor in several schools until her death in Chicago on February 24, 1931.

Rayner-Canham, M.F. and Rayner-Canham, G.W., "Harriet Brooks- Pioneer Nuclear Scientist", *American Journal of Physics*, 1989, 51: 899-902.

Rayner-Canham, M.F. and Rayner-Canham, G.W.,"Pioneer Women in Nuclear Sciences," *American Journal of Physics*, 1990, 58: 1036-1043.

Directions

1. Read thoroughly the selection on Harriet Brooks and Fanny Cook Gates and any areas of the text that relate.

2. Compose a dialogue between Brooks and Gates discussing their work as research assistants for Ernest Rutherford at McGill University.

3. Write a newspaper article that could have been published in 1904 discussing one aspect of either woman's work.

4. Write an article for a modern-day newspaper or magazine discussing the significance of Brooks' and Gates' work on today's society.

## Yulya Vsevolodovna Lermontova

Yulya Vsevolodovna Lermontova was the first Russian woman to receive the title of Doctor of Sciences in Chemistry. Russian universities, as well as those in many other countries, were closed to women in the 1860's. Therefore, she had to journey to Germany to Heidelberg University where she was allowed to attend some lectures and work in the chemical laboratory of Robert Bunsen. During the two years she studied there she worked on qualitative and quantitative analysis and worked on the separation of the platinum family of metals as had been suggested to her by Mendeleev.

In 1871 she went to Berlin to work in the laboratory of A.W. von Hofmann and attend his lectures. Even though she had completed sufficient work to earn a doctorate, she was unable to do so because she had never been officially admitted to the universities in either Heidelberg or Berlin. However, the University of Gottingen granted her a doctoral degree in absentia in July of 1874. Her dissertation was entitled "The Study of Methylene Compounds."

After receiving her degree she worked for one year in the Moscow University Laboratory of V.V. Markovnikov. Her work there was cut short because she contacted typhus. Upon her recovery, she went to work in St. Petersburg in the University laboratory of A.M. Butlerov. However, family matters cut short her promising career there. In 1880 she once again worked in Markovnikov's laboratory where she designed an apparatus for the continuous treatment of petroleum and reached the height of her fame as a chemist. At this time she was a member of both the Russian Chemical Society and the Russian Technological Society.

However, Lermontova's active work in chemistry soon stopped. In 1886 she moved to the family farm near Moscow where she spent the rest of her life as a farmer. She did not totally abandon science in her new career because she employed the latest agricultural methods and fertilizers. Her chemical skill served her well in her greatest agricultural success, making cheese which she sold in and around Moscow. This pioneering woman chemist died in December 1919, at the age of 73.

Steinberg, Charlene, "Yulya Vsevolodovna Lermontova (1846-1919)", *Journal of Chemical Education*, 1983, 60: 757-758.

DIRECTIONS

1. Read thoroughly the selection on Yulya Vsevolodovna Lermontova and any sections of the text that might relate.

2. Write a laboratory report as Lermontova might have done describing her work on the platinum family of metals.

3. Write a letter to a newspaper published in the 1860's attacking or defending the universities' positions of not admitting women.

4. Write an article for a modern-day newspaper or magazine discussing the significance of Lermontova's work to today's society.

Dr. Rachel Lloyd

Rachel Lloyd was one of the first women to publish in the American Chemical Journal. After her husband died in 1865, she supported herself by teaching in a private girl's school in Louisville, Kentucky. Because of an interest in chemistry she attended the Harvard Summer School from 1876-1884. In order to be able to teach in a university, she needed to receive a doctorate, but the only place where women could work on a doctorate in chemistry was in Zurich. There she was awarded her doctorate in 1886, and she is probably the first American woman to earn a doctorate in chemistry.

Dr. Lloyd joined the faculty of the University of Nebraska on July 1, 1887 at an annual salary of $1500. She also was appointed assistant chemist at the Nebraska Agricultural Experimental Station. Dr. Lloyd became a full professor in 1888 and carried a heavy teaching load. At the same time she did extensive work for the experiment station on the feasibility of sugar beets as a successful crop for Nebraska farmers.

Dr. Lloyd's work on sugar beets proved to be quite extensive. She determined percent of sucrose by weight in beets at the early stage of growth. Later analyses on the expressed juice provided specific gravity, total solids, percent of sucrose, percent of reducing sugars by using Fehling's solution, and the important factor, coefficient of purity-- the percent of sugar in total solids-- which indicated the ease with which the white sugar could be refined. These favorable results lead to the development of a successful sugar beet industry in Nebraska.

Dr. Lloyd continued as assistant chemist at the experiment station through 1891, and as a full professor at the university until 1894 when she resigned because of ill health. She died in Bevery, New Jersey, on May 7, 1900, at the age of sixty-one.

Tarbell, Ann T. and Tarbell, D. Stanley, "Dr. Rachel Lloyd (1839-1900); American Chemist", *Journal of Chemical Education*, 1982, 59: 743-744.

DIRECTIONS

1. Read thoroughly the selection on Dr. Rachel Lloyd and any sections of the text that might relate.

2. Assume you are Dr. Lloyd and write a letter of application to the University of Nebraska applying for a position as an instructor in chemistry.

3. Write an article for a farm journal published in 1890 describing Dr. Lloyd's work with sugar beets.

4. Write an article for a modern-day newspaper or magazine discussing the significance of Dr. Lloyd's work to today's society.

## Icie Macy Hoobler

Icie Macy Hoobler was born in 1892 in Davis County, Missouri. Her parents had little formal schooling but were dedicated to providing the best education possible for their four children. Because of her father's wishes, Icie first earned an AB degree in music in 1914 from Central College for Women in Lexington, Missouri. However, her increased interest in science led her to the University of Chicago where she earned a BS degree in 1916. She received her MS degree in 1918 in physiological chemistry from the University of Colorado. One of her professors, Robert C. Lewis, suggested she continue her education at Yale with Lafayette B. Mendel, one of America's leaders in biochemical nutrition. Lewis suggested this because he felt that a woman would have more career opportunities in nutrition-related chemical science.

After receiving her doctorate in 1920, Dr. Hoobler worked at the West Pennsylvania Hospital in Pittsburgh as the staff biochemist where she taught urinalysis and hematology to interns. She later became a part-time teacher in the Department of Household Science at the University of California at Berkeley. In 1923 she accepted the directorship at the Merrill-Palmer School, an establishment for educating young mothers in Detroit. She held this position until her retirement in 1959, but she continued to work as a consultant for them until 1974. She remained active in scientific studies until her death in 1984.

A lecture by Mendel during Dr. Hoobler's studies at Yale provided the inspiration for much of her research work. He mentioned that little was known about the chemistry of human milk. Consequently, Dr. Hoobler's most significant scientific accomplishments center on this area. She developed methods for testing human's, cow's, and goat's milk for composition and comparative value; she studied the metabolism of women and children and the growth of infants and children; she studied the influence of certain dietary factors on nutrients in mother's milk. She also investigated the amino acid composition of milk and animal tissues and their variation in foods; she conducted gastrointestinal studies of children, and bone development studies. Her research group also did tests on the amount of vitamin C in orange juice. They also investigated the composition of human blood cells and examined the addition of iodine to salt. As a result of this work, many dietary standards were set for children at various stages of development, for pregnant and lactating women, and for daily vitamin requirements for all adults.

Kopperl, Sheldon J., "Icie Macy Hoobler: Pioneer Woman Biochemist", *Journal of Chemical Education*, 1988, 65: 97.

## DIRECTIONS

1. Read thoroughly the selection on Icie Macy Hoobler and any sections of the text that might relate.

2. Write a letter from Dr. Hoobler to her parents describing her work at Yale with Lafayette B. Mendel.

3. Write an essay discussing why Dr. Hoobler might have had greater career opportunities in nutrition-related chemical science rather than in one of the other areas of chemistry.

4. Write an article for a modern-day newspaper or magazine discussing the significance of Dr. Hoobler's work to today's society.

## Mary Fieser

Mary Fieser's role in the history of chemistry is a transitional one. She was able to maintain a more traditional role for women while working in an atypical field for women. Her career is closely linked to that of her husband Louis Fieser, a distinguished professor of chemistry at Harvard University for nearly fifty years. Thus, she serves as a link between women who work as housewives and women who maintain independent careers outside the home, and she gives us insight into the evolution of attiudes toward women.

Mary Fieser was born in 1909 in Atchison, Kansas, to a family that strongly believed in higher education for both men and women. Her paternal grandfather was president of Midland College, a small Lutheran school there in Atchison. Her maternal grandmother was a graduate of a ladies' seminary and educated all of her seven children at home until they were ready to attend college. Mary's mother went on to do graduate work in English at Goucher College, and her father was professor of English first at Midland and later at Carnegie-Mellon University. Mary was also exposed to working women as she grew up, and looked to the family doctor, a woman, as a role model.

Mary earned a BA degree in chemistry at Bryn Mawr College in 1930. There she met her future husband, an instructor in chemistry, who taught Mary all of her college chemistry. When Louis Fieser returned to Harvard where he had completed his doctoral work, Mary went also to do graduate work. There she earned an AM degree in organic chemistry in 1932. While pursuing her degree, Mary performed research in Louis Fieser's lab half-time and attended class half-time. Harvard at the time was not yet ready for women students. In analytical chemistry Mary was not allowed to do labwork with the rest of the class and had to do her experiments in the deserted basement of an adjoining building with no supervision.

Mary did not choose to earn a PhD, possibly because of her impending marriage to Louis. As his wife, her position on his research team would be secure whether she had a PhD or not. In addition, the more narrow-minded faculty members would look on her more favorably out of deference to her husband. Louis Fieser's intervention on Mary's behalf was indeed fortunate because many equally well-qualified women were denied admittance to Harvard as graduate students because professors refused to work with them.

Most of Mary's laboratory work was conducted during the 1930's and 1940's. This centered around two main topics, the chemistry of quinones and of natural products, especially steroids. Even though she was a skilled chemist, Mary maintained a very feminine image in the laboratory. She always wore dresses or skirts and made sure that her fingernail polish always matched her clothing.

Mary Fieser has also made many contributions to chemistry outside the laboratory. She published over 40 papers in the *Journal of the American Chemical Society* as a member of Louis Fieser's research group. In 1944, the Fiesers co-authored *Organic Chemistry*, an innovative textbook that dominated the market for over a decade. They also published a *Style Guide for Chemists* in 1960 to help chemists improve their use of English in their written work. Probably the most famous of the Fiesers' books are the multi-volume, dictionary form *Reagents for Organic Synthesis*, begun in 1967.

Together the Fiesers produced volumes 1 through 7. Since her husband's death in 1977, Mary has published volumes 8 and 9. Work is now in progress on volumes 10 and 11 of the series.

> Mary Fieser has accomplished a great deal for science as well as for women. These achievements have resulted from a desire to excel as a chemist rather than a wish to prevail as a feminist. Shaped by her childhood experiences, Mary's image of women allowed her to pursue an active professional life in close association with her husband at a time that female scientists were rare. Regardless of their circumstances, Mary Fieser's contributions to chemistry are significant and have hastened recognition of women's professional careers in science. Women today seek faculty positions of their own, and in most cases consider females equal to males. Mary Fieser's thoughts and experiences reflect changes in ideas and behaviors that gradually take place as women's roles broaden. Her success also reveals that much can be achieved by women while these changes occur.

Pramer, Stacey, "Mary Fieser. A Transitional Figure in the History of Women", *Journal of Chemical Education*, 1985, 62: 186-191.

## DIRECTIONS

1. Read thoroughly the selection on Mary Fieser and any sections of the text that might relate.

2. Write a letter from Mary to her parents explaining why she has chosen to work toward an AM degree in organic chemistry rather than pursue a PhD.

3. Write an article for a 1930's issue of the Harvard alumni journal attacking or defending the chemistry professors' positions on refusing to work with female graduate students.

4. Write an article for a modern-day newspaper or magazine discussing the significance of Mary Fieser's work to today's society.