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Female Scientists, the Military, and Informing Policy

Colleen Coyne

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Research Seminar
Senior Thesis
Due 4/28/2013

"Female Scientists, the Manhattan Project, and Policy"

Abstract:

The Manhattan Project, which was ultimately responsible for the creation of the atomic bomb, provided previously scarce opportunities for female scientists to contribute to a large government/military research project. Although women found positions in the Manhattan Project more easily than previous or other projects, the work conducted by those women was largely perceived as having reduced significance than similar work being conducted by male scientists. In the male dominated culture, women were once again subjugated to the sidelines despite the significant contributions made by female scientists. In general, the opportunities for scientists to inform political and public policy was limited at the time, but women faced additional obstacles due to their sex. In the telling of the history of the Manhattan Project, women have been relegated to the sidelines. This essay will examine the role of female scientists, specifically physicists, in the Manhattan Project and their ability to inform policy as limited by their sex and argue that despite facing many obstacles, female scientists were able to make valuable contributions to the Manhattan Project that contributed to the overall success of the project.

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The intersection of female scientists and the military, specifically in the Manhattan Project, provides a unique perspective from which to examine the actual influence and ability to influence policy possessed by scientists working for the government. The development of an understanding of how policy is informed and how the role of women has evolved in the political action of informing policy is crucial background step to understanding the capacity of females working on the Manhattan Project to inform policy.

Women working in the military field, particularly those who have a played a role in the scientific research aspect, have scarcely had real opportunities to inform policy. This is a broad, but important topic that is coupled with the struggle for equality that has been raging for decades. Women have often been confined to the margins in the telling and remembering of history. Until the 1960's and 1970's—a period marked by the tremendous and vastly important growth of the Women's Movement and Feminism Movement— women were all but ignored in the recounting of the past. Prior to that period, history was a field that was dominated by stories of great men. Women are and have always been significant to the story, yet their story remained, in large part, untold. The same is true of women in the realm of politics or more broadly , political action. Although the number and influence of women in politics has been steadily increasing in the last 100 years, there still remain huge political barriers to be broken; the representation of women in "political" jobs, such as Governors and Congresspersons, is still disproportional to the population of women. In short, women are and have been underrepresented in the political arena. However, the underrepresentation of women is not limited to the political arena; women are also drastically underrepresented, especially historically, in the field of science. Women were discouraged from pursuing careers in the field of science by societal norms; a stigma still remains in the field, but it has been dampened by the emergence of many female intellectuals conducting significant scientific research. Despite the fact that women have been disproportionally represented in history, politics, and science, some women have been able to thrive in these fields and have earned a place in history books.

It is vitally important to explore the lives of some of these women further, especially those that worked on the groundbreaking Manhattan Project, attain more knowledge pertaining to their significance. The Manhattan project opened doors for female scientist, some of whose work has been important to an American military science research, especially in the field of physics. By establishing a general, but brief, history of female scientists working in the within the scientific community it will make evident the increased role of females. However, despite the increased role, female scientists working on the Manhattan Project did not receive full parity with their male counterparts. The story of female scientists, working for the military or in tandem with the military on the Manhattan Project is one of struggle to find a foothold of recognition in the field and a lack of acknowledgement of the contributions made to the Manhattan Project by the society at large. Through an examination of the work conducted and types of jobs done by women, it can be surmised that females working on the Manhattan Project had even further limited opportunities than their male counterparts to inform public policy. Despite the fact that female physicists were able to make valuable contributions to the

Manhattan Project, they were unable to directly impact policy due to their lack of ability to gain leadership roles and the concentration of highly skilled female physicists in Europe.

Females have been working the field of science for decades. Although many have been largely ignored or their role has been novelized, some women have been able to create work that has had lasting importance. The breakthroughs that women have made in the spheres of political influence, scientific research, and military involvement are all poignant factors that have contributed to the intricate role of females in shaping policy. Women have been scientists and women have worked for or with the military. Despite the limited general knowledge of women performing these roles, the research of women has been important; it is just a matter of figuring out who these women were and how their work made a significant impact of policy making.

Policy:

To begin , a brief introduction into how policy is made, how is policy informed, and why is it important to know how policy is informed. Policy is an intentional course of action by a governmental agency is reaction to a problem or matter of future concerns.[1] Policy making is a fluid process; in America, the interactions of constitutional rights and public mood play a role in policy making. The process is incremental; slowly changing over long periods of time. For example, take the struggle to develop environmental policy. The initial phases of American environmental policy only aimed to protect

[1] Leslie R. Alm et al. *Turmoil in American Public Policy: Science, Democracy, and the Environment.* (New York: Praeger, 2010).

wildlife, but in recent years the policy has been shifting gears to focus on the prevention and reversal of global warming processes[2]. However, policy questions that deal in large part with science and scientists differ from regular policy questions. Technology has the capability to inflict rapid and complex change. Many new technologies plague policy makers with dilemmas over irreversible consequences.[3] The influence of military science presents an interesting case though. Take, for example, the Manhattan Project. The development of the Atomic bomb allowed military strategists to make the decision to drop two bombs on Japan and end the war in a quicker fashion than would likely have been possible with conventional forces. Whether to drop the bomb or not was a political decision, made by politicians. What informed the decisions of those politicians was a complex mixture of factors, but at the core was science. Did politicians take the research presented by scientists seriously? What ramification was dropping the bomb going to have on the environment and human welfare? Were those consequences acceptable? Science has the ability to produce knowledge that is more effective in informing policy than any other knowledge type, but policy making requires decisive and quick action when it comes to military technology, meaning that policy is often enacted before scientists have time to compile all the knowledge that should ideally be used in the informing of policy[4]. The research of the Manhattan project is just one example of how the work of scientists plays a vital role in how policy is made, whether or not the role is direct or indirect.

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[2] Leslie R. Alm et al. *Turmoil in American Public Policy: Science, Democracy, and the Environment.* (New York: Praeger, 2010).
[3] Ibid.
[4] Ibid.

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Background Information on Female Scientists and the Manhattan Project in General:

Predating the Manhattan Project, female scientists found little opportunity to pursue meaningful work in the scientific arena. World War II brought on a wave of pro-female scientist rhetoric; female scientists appeared to be in high demand, but many still struggled to find real opportunities in their perspective fields at high levels. Many female scientists served simply as niche, temporary employees until men could return to work after the war closed. From 1942 to 1946, there was an over one hundred and thirty percent increase in female scientists working in the Physics departments in universities across America.[5] It was not clear whether these positions were to become permanent or if these females would be pushed out of work after men began to return. Regardless, the employment of women in the scientific arena in such a significant way marked a departure from the pre-war years. Perhaps the most underrated development of the early nineteenth century was the introduction of females into higher education settings. Up until and even well into the early eighteen hundreds, the education of females in formal academic settings was considered a threat by many members of society.[6] Women might become less obedient if they had received higher education; they might even become political radicals that advocated for equal rights. Perhaps the most threatening aspect of undertaking the education of females was that they might then become "masculinized"

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[5] Margaret W. Rossiter , *Women Scientists in America: Before Affirmative Action 1940-1972 (*Johns Hopkins University Press, 1998.)

[6] Margaret W. Rossiter. *Women Scientists in America: Struggles and Strategies to 1940* (Johns Hopkins University Press, 1982.)

and take over jobs that had once been reserved solely for men.[7] Despite the societal backlash, a few females did manage, in the early years of female education, to become scientists. Over the next century, females slowly found their way into the class room. By 1910, universities, in the United States and Germany, had begun to grant degrees in the sciences to females.[8] However, possessing a degree in the sciences was far from a guarantee of work in the sciences for women. When graduates did not wish to return to the household immediately, lower level jobs began to become available to women.[9] As the "big sciences" developed, service type positions in the sciences opened up that were well suited the feminine skill sets. Sexual segregation, in many scientific fields, was in many ways more than commonplace, it was institutionalized. Segregation grew out of the belief that females pursuing education were simply doing it in order to become better wives or mothers or to find meaning in otherwise aimless lives. Very few women found employment opportunities that employed the scientific skill sets they possessed at a level equal to their training. Even within scientific societies, women seldom found acceptance. Then came World War II and things began to change for female scientists.

In late 1942, General Leslie Groves was offered a position as head of the military effort of the American atomic program; the prospects did not excite him, but he knew the work was crucial to winning the war and doing it quickly.[10] That effort came to be known as the Manhattan Project. The outcome of the project was an awesome weapon,

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[7] Ibid.
[8] Ibid.
[9] Ibid.
[10] General Leslie R. Groves, *Now It Can Be Told: The Story Of The Manhattan Project.* (Da Capo Press, 2009.)

the atomic bomb. The science that went into the creation of the weapon spawned political debate that has continued to influence the shape of international politics well after the projects dismantling.[11] In 1938, Lise Meitner and Otto Frisch, while reviewing the work of Otto Hahn and Fritz Strassmann, discovered what she termed "nuclear fission."[12] Nuclear fission is the splitting of uranium nuclei into two pieces; this process creates enormous amounts of energy. Scientists in the United States quickly realized that the potential energy that could be generated from nuclear fission was tremendously more significant than the amount of energy that might be acquired from atom-atom reactions. Military developers were immediately taken with the idea of creating an explosive weapon; scientists in the United States and England instituted a ban on literature about the research being conducted in order to protect military interests.[13] It was determined, by a group of physicists from the United States, that a fission chain reaction was possible, but that it would require massive industrial capability. As early as 1939, Enrico Fermi believed that a nuclear reaction was eminent. Leo Szilard, a physicist and refugee from Hungary that had fled Hitler's power reach, advised President Roosevelt of the tremendously terrible weapon that might come from nuclear research and that Germany might already be well into the process of developing the weapon. Szilard was concerned that there was not enough correspondence between scientists working on the problems related to the advancements in nuclear physics and members of the cabinet formulating

[11] Ruth H. Howes and Caroline L. Herzenberg. *Their Day in the Sun: Women of the Manhattan Project*. (Philadelphia: Temple University Press, 1999.)
[12] Ibid.
[13] Ibid.

policy in reaction to the possibilities of a atomic bomb.[14] In response to the push from the scientific community, Roosevelt funded the Uranium Advisory Committee, which became a sub-committee of the National Defense Research Committee. Einstein had been one of the forerunners, pushing Roosevelt to fund a project based around the projected capability of nuclear fission.[15] Over the next year, large grants went to universities around the United States advancing the research of multiple physics fields all related to the potential exploitation of nuclear fission as a weapon. [16] The system of research set up became the Manhattan Project.

Groves' management style caused conflict with many scientists; he was a military man and he attempted to run the Manhattan Project as if it was a military mission. However, Groves was responsible for many of the most inspired decisions that lead to creation of the bomb, transforming the project from a research effort into a full-scale industrial endeavor. The research being conducted at universities was, however, subject to strict regulations that bogged down the researchers abilities to perform basic research without high level approval.[17] By the end of the war, over 130,000, people were employed by the Manhattan Project, which was worth over two billion dollars. The

[14] Albert Einstein to Franklin D. Roosevelt, March 25, 1945. Miscellaneous Historical Documents Collection. Harry S. Truman Library. http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/index.php
[15] Albert Einstein to Roosevelt, August 2, 1939. Miscellaneous Historical Documents Collection. Harry S. Truman Library. http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/index.php

[16] Ruth H. Howes and Caroline L. Herzenberg. *Their Day in the Sun: Women of the Manhattan Project*. P.8
[17] Notes of Meeting of the Interim Committee, July 19, 1945. Miscellaneous Historical Documents Collection. Harry S. Truman Library. http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/index.php

project spawned North America and was present at almost all major American universities. The Manhattan Project had successfully spawned an atomic bomb by 1945. General Groves described the bomb: "for the first time in history there was a nuclear explosion. And what an explosion!"; the bomb was more capable of destruction than anyone had anticipated and put tremendous power at the finger tips of the political leaders of the United States in the midst of a treacherous war in the Pacific.[18] After the project had produced the bomb and scientists saw the effects of the bomb on the Japanese population, many scientists were reluctant to return to work on the bomb or any bomb in general.[19]

Literature Review:

Females working on the Manhattan Project have rarely received significant recognition in the literature written about the work that lead to the bomb. The absence of females in the literate is due, in part, to their roles in lower level jobs as well as the tendency to give credit to project leaders. In interviews and subsequent literature, many of the female scientists and technicians that worked on the project praised their role as part of a collective; focus was on the results of the project rather than the individual contributions. One female chemist working on the project later said in an interview:

[18] Leslie. R. Groves to Henry Stimson, July 18, 1945. Research Material, Lamont Papers. Harry S. Truman Library. http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/index.php
[19] Memo of conversation with Dr. J. Robert Oppenheimer and Dean Acheson, September 25, 1945. Miscellaneous Historical Documents Collection. http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/index.php

> "I think one of the remarkable things also from a broad point of view…was the idea that this enormous project was going to go forward with determination and earnestness. I said to myself 'Good heavens, are we really going to do all that?' And we did it."-Friedell, Chemist [20]

The tendency to attribute success to group leaders, whom were all male, meant that women virtually disappeared from Manhattan Project histories. Some books and articles have made an attempt to discuss females involved with the project. Those works focus, almost entirely, on the aspects of domestic life rather than scientific work. Meaning that instead of asking "what did women contribute, as far as scientific merit, to the Manhattan Project?" historians have asked "how did working on the Manhattan Project alter the home lives of females involved with the project?". The relegation of females to the domestic or "private sphere" is not uncommon; in actuality, the relegation of females to the home was a common occurrence leading up to the Women's Movement. In recent years, there has been an emergence of important literature focused on female scientists working on the Manhattan Project; these new works are focused on the scientific and academic roles played by women rather than the domestic ones.

The Physicists:

Although very few female physicists worked on the Manhattan Project, those that did made immensely valuable contributions. Below are two of the finest examples of

[20] Friedell. Advisory Role in the Early AEC Biomedical Program. DOE Openness: Human Radiation Experiments: Roadmap to the Project. http://www.hss.energy.gov/healthsafety/ohre/roadmap/histories/0466/0466e.html

women that helped make great strides in physics. The first is Lise Meitner; although Meitner never played a direct role in the Manhattan Project, she is, in part, responsible for the discovery of nuclear fission, which was a major factor in the conception of the Manhattan Project. The other is Leona Woods Marshall. Marshall worked in several areas during her time on the Manhattan Project, including Fermi's lab in Chicago where Chicago Pile 1 reached criticality.

Female physicists contributed some of the most important findings to the physics field prior to the conception of the Manhattan Project, meaning that a few of the most prominent female contributions to the Manhattan Project, happen to predate the project. In the 1930s, the most advance work being done in the arena of physics was happening in Europe. At every turn, that work was challenged and hindered by Hitler's relentless trek across Europe in search of power and domination. Many of the brightest scientists had been pushed out of Germany due to their ethnicity and found themselves as refugees in places like Cambridge, England—where they were able to find low level scientific work. [21] Many of those refugees, such as the famous physicist Leo Szilard, never found a true home in England and went on to work on the Manhattan Project.[22] World War II was characterized, in part, by the increased use of aerial bombardment on civilian populations. As the bombing of civilian populations all over Europe with increasingly terrifying weapons became a common place military practice, refugee scientists came to discover the power of the atomic nucleus that would later be used to the same effects. Austrian physicist, Lise Meitner, had been pushed out of Berlin in 1938 because of her

[21] Andrew J. Rotter. *Hiroshima: the World's Bomb*. (Oxford: Oxford University Press, 2008.)
[22] Ibid.

Jewish Heritage. Meitner had already established herself among the scientific community, conducting work on par with that of Enrico Fermi. Working in Sweden after her departure from Germany in 1938, Meitner began a scientific review of the work of fellow physicists Otto Hahn and Fritz Strassman. Hahn and Strassman had used new chemical techniques to identify radioactive barium in bombarded uranium.[23] Surprising by that result, the duo contact Meitner for assistance. Lise Meitner spent the Christmas holiday of 1938, carefully studying the work conducted by Strassman and Hahn. With her nephew, Otto Frisch, Meitner concluded that the radioactive barium came from a process in which a heavy nucleus broke into two roughly equal halves, naming the process "fission."[24] In a letter to the academic journal *Nature*, written by both Meitner and Frisch, the two postulated that the process of fission would create tremendous amounts of energy.[25] Meitner later refused to work on the Manhattan Project, wanting nothing to do with the bomb, but the work to which she so vigorously dedicated herself was a vital part of the conception of the bomb and allowed for the project to come into fruition. Her work, along with that of her fellow physicists, indirectly, gave American policy makers the opportunity to drop two atomic bombs on Japan and end the war in the Pacific. Meitner was perhaps the only female physicist in the world that was qualified enough to gain a position of leadership in the Manhattan Project; her refusal to join the Manhattan Project contributed to the total lack of females filling group leader positions.

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[23] Richard Rhode. *The Making of the Bomb.* (New York: Simon and Schuster, 1986).
[24] Lise Meitner and O.R. Frisch. "Disintegration of Uranium by Neutrons: a New Type of Nuclear Reaction." *Nature* 143, p. 239.
[25] Lise Meitner and O.R. Frisch.

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The disdain felt by Lise Meitner for the Manhattan Project and the bomb in general, was not one commonly held by all women alike. Many women found the opportunity of working on the project tantalizing. One such woman, whom would go on to become a renowned physicist, was Leona Woods. As a graduate student at the University of Chicago, Leona Woods (later Woods Marshall and then Woods Marshall Libby), had a profoundly intricate role in the work being done by Enrico Fermi's team. [26]Woods Marshall was responsible for the construction of boron trifluoride neutron detectors, which were used to measure the flow of neutrons in the experimental atomic piles.[27] Woods Marshall's contribution the Chicago Pile 1, which ultimately yielded the first self-sustainable chain reaction, was the detector, inserted in the fifteenth layer.[28] The measurements derived from Woods Marshall's detector would determine how large the pile needed to be in order to reach "criticality" and be self-maintaining. On December 2nd, 1942, as her fellow scientists removed rods from the pile, releasing neutrons, Woods took notes on the procedure and called out the readings from her detector.[29] The pile soon reached critical. Fermi described a chain reaction as the "burning of a rubbish pile from spontaneous combustion" with small piles lighting until the whole thing was up in flames.[30] Eugene Wigner, a refugee theoretical physicist, pulled out a bottle of Chianti

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[26] Denise Kiernan. *The Girls of Atomic City: The Untold Story of the Women Who Helped Win World War II.* (New York: Simon and Schuster, 2013).

[27] Ruth H. Howes and Caroline L. Herzenberg.
[28] Leona Woods Marshall. Account of December 2nd, 1942. *The Uranium People.(*NY: Crane, Russak & Company, 1979).
[29] Leona Woods Marshall.
[30] Enrico Fermi. *The Manhattan Project: The Birth of the Atomic Bomb in the Words of Its Creators, Eyewitnesses, and Historians*. Edited by Cynthia C. Kelly . (Black Dog & Leventhal, 2009.)

and the group toasted to their success. Everyone was quiet as the wine was passed around in little cups that Fermi had sent someone out to get; the group fell silent, the only thought among the group was "we did it, but hopefully we did it before the Germans."[31] The scientists present that day, including Fermi and Woods Marshall, signed the Chianti bottle's label, denoting the significance of the day.[32]

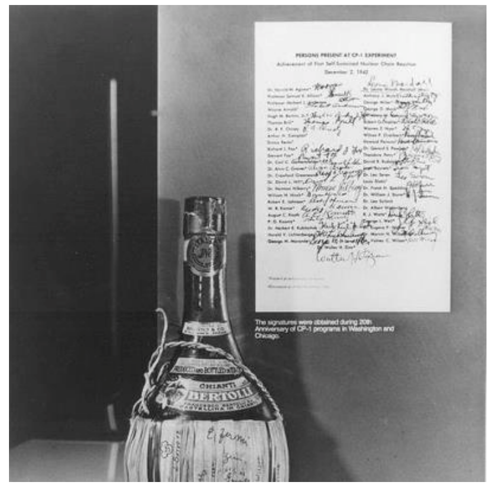

Figure 1 The Chianti bottle signed by scientists present at the CP-1 Experiment along with a list of the persons present. Leona Woods Marshalls' name is at the top of the right column. According to the list of persons in attendance, which can be seen to the right of the bottle, Leona Woods Marshall was the only female scientist present at the experiment. She was in the company of many great male scientists, including Enrico Fermi and Leo Szilard.

Leona Woods Marshall's contributions did not stop at her work with Fermi though. Woods Marshall was responsible, along with John Wheeler, took up a scientific study of the safety at the Hanford plant, where plutonium was being extracted from irradiated fuel elements.[33] Along with Wheeler, Marshall produced two reports on the amount of plutonium that should be possessed at one time. The first report, *Limiting Mass*, considers the importance of timeliness and productivity over matters of safety.

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[31] "First-Hand Recollections of the First Self-Sustaining Chain Reaction." Dept.of Energy. United States. http://energy.gov/articles/first-hand-recollections-first-self-sustaining-chain-reaction
[32] Eugene Wigner. Account of December 2nd, 1942. In "The Fermi-Szilárd nuclear reactor," by George Marx. http://sukjaro.eu/Fermi-Szilard%20pile.pdf
[33] Jordynn Jack. *Science on the Home Front: American Women Scientists in World War II.* (University of Illinois Press, 2009).

Facing the crunch of war time, Marshall and Wheeler chose to utilize short cuts when it came to the calculations, using "probable" approaches to the problem.[34]Probable approaches considered safety, but mainly insured the maximization of productivity, a notion which was very appealing to any scientists or government agency reading the report. The report states that " the chain reactions limits listed here are calculated on the most probable assumptions, rather than the most conservative ones" and that "to superpose upon the operating safety factor a calculational safety factor any more substantial than necessary might result in a serious limitation of batch size."[35] The report reflected the attitude of the Manhattan Project at large, productivity was the number one concern. On April 9, 1945, Wheeler and Marshall revised their report, only this time they used a conservative approach, which was much more likely to favor safety over productivity. [36] The first report's numbers had been skewed by the simplification of the calculations.[37] The new calculations yielded greater safety working limits designed to maximize safety and productivity. Marshall was not opposed to taking safety risks herself. She was so enthralled in her work on the Manhattan project that when she became pregnant, she concealed the pregnancy from all of her coworkers, except Fermi, and continued work.[38] Along with her husband, Marshall was involved in the design of every nuclear reactor built during World War II[39]. Marshall's technical rationality, putting the Project above her own health, is an example of the equality of the ability and

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[34] Jordynn Jack.
[35] Leona Woods Marshall and John Wheeler. *Limiting Mass.* March 29, 1945.
[36] Leona Woods Marshall and John Wheeler. *Limiting Mass: An Application and Consideration Presented in Memorandum of the Same Title.* April 9, 1945.
[37] Ibid.
[38] Jordynn Jack.
[39] Ruth H. Howes and Caroline L. Herzenberg.

even of the work conducted by female scientists on the Manhattan Project. Marshall was a part of several key moments of the Manhattan Project, making key contributions and helping to provide for the success of the Project.

Lise Meitner and Leona Woods Marshall are two extraordinary examples of female physicists who made valuable contributions to the field of physics that directly contributed to the success of the Manhattan Project, but they were not the only female physicists that had an impact on the success of the project. In the Spring of 1943, General Groves consolidated the experts working on the bomb design to the facility at Los Alamos in New Mexico.[40] The Manhattan Project was born out of the relatively new field of nuclear physics, meaning that the nuclear physicists were by-and-large young men and women, fresh out of graduate school. Several of the female physicists had followed their husbands, also scientists, to Los Alamos and found work on the top secret project to design the bomb. Elizabeth Riddle Graves, a bright young Ph.D. out of Chicago, followed her husband, Al, to New Mexico. In Los Alamos, the majority of Graves' work concentrated on the selection of a neutron reflector to surround the core of the atomic bomb.[41] Graves was one of few physicists in the country skilled enough in fast-neutron scattering to be useful to the Manhattan Project; she had gained this experience through the work on her graduate thesis involving energy released from Beryllium, lithium 7.[42] Fellow scientists reported that Graves had a tremendous work ethic and was extremely

[40] Ruth H. Howes and Caroline L. Herzenberg.
[41] Ruth H. Howes and Caroline L. Herzenberg. P. 48 A reflector is meant to keep neutron inside the fissioning mass and speed the rapid growth of the chain reaction.
[42] Elizabeth Graves Riddle. "Energy Released from Be 9 (d, a) Li 7 and the Production of Li 7." *Physical Review* 57 (1940).

capable of independent thought. Another noted female physicist that contributed to the Manhattan Project was Mary Argo; Argo was the only female invited in an official capacity to witness the Trinity test.[43] On July 16, 1945, just after sunrise, Argo witnessed the first-ever nuclear explosion; from thirty miles away, they witnessed the explosion light up the New Mexico sky.[44] Other physicists included women like Joan Hinton, who later participated in the Chinese efforts to build a social economic policy.[45] Hinton worked under Enrico Fermi at Los Alamos, helping to build the first reactor to use enriched uranium as fuel.[46] The reactor, nicknamed "the water boiler", was designed to yield massive amounts of neutrons to be used in fission experiments.[47] Hinton had also witnessed the Trinity explosion, in a very unofficial manner: "it was like being at the bottom of an ocean of light. We were bathed in it from all directions. The light withdrew into the bomb as if the bomb sucked it all up. Then it turned purple and blue and went up and up."[48] All of these women worked on significant aspects of the Manhattan Project, but have failed to receive general recognition. This is due in part to the nature of the work they conducted in lower level jobs and due in part to the fact that many of the leading female physicists were Europeans that failed to immigrate to the United States to work on the Manhattan Project.

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[43] Harold Argo. Interview with R. Howes. (July 18, 1991).
[44] Harold Argo. Interview with R. Howes. (July 18, 1991).
[45] William Grimes. "Joan Hinton, Physicist Who Chose China Over Atom Bomb, Is Dead at 88." *Science. New York Times:* June 11, 2010.

[46] Ruth H. Howes and Caroline L. Herzenberg.
[47] Merle E. Bunker. "Status Report on the Water boiler Reactor." *Los Alamos Scientific Laboratory of the University of California.* (Los Alamos: New Mexico, February 1963).
[48] Joan Hinton. Interview with R. Howes. (December 1990).

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Conclusion:

Females worked on nearly every aspect of the Manhattan Project. The females that had the greatest chance to contribute tremendous scientific findings to the project were physicists. Women, like Leona Woods Marshall, played vital roles in the success of the Manhattan Project. These women were relegated to lower level positions; no female group leaders existed during the war effort on the Manhattan Project. Scientists in general struggled to communicate with policy makers that controlled the policies being formulated about the bomb. This struggle was compounded for women because they had even less chance to fill upper level or management jobs within the project. Leo Szilard expressed, to Albert Einstein, his concern that scientists were failing to be heard by policy makers.[49] If men like Einstein and Szilard, who were considered two of the most brilliant physicists of their time, had little impact on policy, how were women like Hinton and Marshall, who had lower level jobs, supposed to impact political policy? The females that contributed to the Manhattan Project through work in the United States, were always the subordinates to men like Leo Szilard, Enrico Fermi, and Robert Oppenhiemer; in their roles as subordinates , it was nearly impossible for women to influence policy, especially because their teams leaders, again men like Szilard and Fermi, felt that they were unable to get through to policy makers. Despite the fact that many female physicists made important and vital contributions to the Manhattan Project, their ability to work to inform policy was almost entirely indirect. Only through their ability to make

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[49] Albert Einstein to Franklin D. Roosevelt, March 25, 1945. Miscellaneous Historical Documents Collection. Harry S. Truman Library.
http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/index.php

the Manhattan Project a success by working vigilantly and often without regards to personal safety, were females able to contribute to the list of factors considered by policy makers whilst deciding whether to drop the bomb. Direct contributions to policy making came through statistical safety reports, like the one produced by Marshall and Wheeler, about the best manner in which to precede experimentation and production of bomb related work. Female scientists were limited in their ability to inform policy, even further than male scientists, because they were unable to gain leadership roles and were still relatively new to the field.

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In this book, the authors lay out a general guide to how public policy is informed and how scientists are able to work to inform said policy. Although the book focuses on Environmental policy, there are several chapters that deal exclusively with the process of creating public policy. For this current work, this book will be useful because it will provide me with a general understanding of how policy is informed and created. In addition, the book serves to illustrate ways that scientists can work to inform American Public Policy.

Argo, Harold. (July 18, 1991). Interview with R. Howes.

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Grimes, William. "Joan Hinton, Physicist Who Chose China Over Atom Bomb, Is Dead at 88." *Science. New York Times:* June 11, 2010.

Groves, General Leslie R. Now It Can Be Told: The Story Of The Manhattan Project. Da Capo Press, 2009.

In this work, General Groves, whom directed the Manhattan Project, provides a general history of how the Manhattan Project came to be and how it proceeded to the culmination that was the atomic bomb. Groves gives insight into the politics of the project; he tells the story of the political, logistical, and personal problems of the project. For my work, Groves provides a baseline of general knowledge of the politics of the

project. Although his work does not focus on the science of the project, it reveals political hurdles that the project faced and it helps to provide this project with an idea of some of the obstacles faced in informing policy about the use of the bomb.

Hinton, Joan. (December 1990). Interview with R. Howes.

Howes, Ruth H. and Caroline C. Herzenberg. Their Day in the Sun: Women of the Manhattan Project. Philadelphia: Temple University Press, 1999.

In their book, Howes and Herzenberg outline the stories of a number of women that contributed to the Manhattan Project. Howes and Herzenberg actively work to dismiss the notion that only male scientists contributed to the Manhattan Project. The book provides insight into the daily struggles of females, female scientists in particular, working on the project and supplements the missing history of females in the project. This book is perhaps one of the most important sources for the current project; it provides many firsthand stories of females working on the project and is a great jumping off point for finding primary sources.

Howes, Ruth Hege and Michael Robert Stevenson. Women and the Use of Military Force. Lynne Rienner Pub, 1993.

Howes and Stevenson trace the historical roles of women in the military in this book. In chapter eight, the book focuses on the Manhattan Project and the contributions of women in general to the project. Although the chapter is brief and focuses on more than female scientists, it is a great introduction to women working on the Manhattan Project and provides context for what the average job a women was able to secure on the project was. The book also provides a good structural outline of females interactions with the military and military research.

Jack, Jordynn. Science on the Home Front: American Women Scientists in World War II. University of Illinois Press, 2009

In Science on the Home Front, Jordynn Jack argues that the very nature of the scientific communication limited women's progress in science; however, it provided opportunities for a small group of prominent female scientists to advance during the war. The book uses the experiences of these women to provide context for the broader limitations of the male centered scientific community. Like, Howes and Herzenbergs' book, Jack's book provides a good starting place for primary sources. This book will be important to this project because it highlights the struggles that female scientists faced in trying to penetrate the male dominated scientific community in a meaningful way.

Kelly, Cynthia C. The Manhattan Project: The Birth of the Atomic Bomb in the Words of Its Creators, Eyewitnesses, and Historians. Black Dog & Leventhal, 2009.

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This book is a collection of Essays, letters, notes, and reflections from historians, scientists, politicians, and military officers all relating to the Manhattan Project. Coupled with an introduction from Richard Rhodes, the collection provides insights into nearly every aspect of the project from the politics, to the science, to the international repercussions. This collection will be helpful for this work because it provides context for the words of many of the brightest minds of the Manhattan Project as well as the politicians that dictated their actions.

Kiernan, Denise. *The Girls of Atomic City: The Untold Story of the Women Who Helped Win World War II.* (New York: Simon and Schuster, 2013).

Marshall, Leona Woods and John Wheeler. *Limiting Mass*. March 29, 1945.

Marshall, Leona Woods and John Wheeler. *Limiting Mass: An Application and Consideration Presented in Memorandum of the Same Title.* April 9, 1945.

Marshall, Leona Woods. Account of December 2nd, 1942. *The Uranium People.(*NY: Crane, Russak & Company, 1979).

Meitner, Lise and O.R. Frisch. "Disintegration of Uranium by Neutrons: a New Type of Nuclear Reaction." *Nature* 143, p. 239.

Rhode, Richard. The Making of the Bomb. (New York: Simon and Schuster, 1986).

Rossiter , Margaret W. Women Scientists in America: Struggles and Strategies to 1940. Johns Hopkins University Press, 1982.

In this work, Rossiter describes the activities and personalities of the multiple female scientists who overcame numerous obstacles to contribute to American science. In her history, Rossiter recounts the efforts that women had to take in order to establish themselves as members of the scientific community and examines the forces that inhibited their recognized participation in the scientific community. This work is helpful to my own mainly because of the context it provides about women working in the scientific community immediately prior to the American entry into the Second World War. Rossiter's book provides good background knowledge about female scientists; only several chapters apply directly to this project.

Rossiter , Margaret W. Women scientists in American: Before Affirmative Action 1940-1972. Johns Hopkins University Press, 1998.

In this second volume, Rossiter continues her mission to bring important female scientists into the master narrative of science. Rossiter emphasizes the notion that although many female scientists were able to find opportunities to conduct important work, the general public was reluctant to accept those females as important contributors. This work is helpful for this study because it demonstrates that female scientists continued to struggle for recognition despite the fact that they had successful began to fill important scientific roles. In addition, this second volume by Rossiter will be more helpful to my project because it covers the time that the Manhattan Project was actually being conducted.

Rotter, Andrew J. *Hiroshima: the World's Bomb*. (Oxford: Oxford University Press, 2008).

Selected: "The Decision to Drop the Bomb." *Miscellaneous Historical Documents Collection.* Harry S. Truman Library. http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/index.php

This collection of government documents pertaining to the decision to drop the atomic bomb yielded from the Manhattan Project provides useful insight into the feelings and motives of not only government and military personnel, but also insight into the feelings and motives of several of the lead scientists working to develop the bomb. Several of these documents serve to express the powerlessness felt by the scientists in informing policy about the use of the bomb. This collection is important to this essay because it establishes that even the group leaders, none of whom were female, were unable to effectively inform policy.

Wigner, Eugene. Account of December 2nd, 1942. In "The Fermi-Szilárd nuclear reactor," by George Marx. http://sukjaro.eu/Fermi-Szilard%20pile.pdf

The history of women in the Manhattan Project is, in large part, an oral history, meaning that the best way to determine the role of women was to read or watch firsthand accounts of the time spent working on the Manhattan Project. Many of the primary sources that were utilized in this project are transcripts or video recordings of scientists, men and women alike, that worked on the Manhattan Project. This interviews were collected by everyone from physicists to the Department of Energy, which had its founding in the Manhattan Project. These interviews, more so than any government document, provide insight into the types of work and the importance of the work being done by female scientists, specifically physicists, during their time on the Manhattan Project. These oral histories are important to this work because they often speak to the character of the women that worked on the Manhattan Project, but they also pin point key roles that these women were able to play. In addition, many of these firsthand accounts, like those of Enrico Fermi or Eugene Wigner, help to establish what the general atmosphere of the project was like.

Other important documents that were utilized in this essay were dissertations and reports that dealt with the kinds of work that the female physicists were doing on the Manhattan Project as well as the training that these females had going into the Project.

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The dissertations help to explain why some women were able to gain semi-important roles and others were not; in general, the level of experience of women in physics was lower than the level of experience of the men working in the same field. Reports, such as the two *Limiting Mass* reports produced by Leona Woods Marshall and John Wheeler, serve as evidence of the possible effects that women had on safety policy with in the Project.