Lesson Plan
Outcasts and Opportunities: The Effect of World War II on the Careers of Female Physicists

Lise Meitner and Otto Hahn working with equipment in their laboratory at the Kaiser Wilhelm Institute in Dahlem, Berlin, Germany. Photo courtesy of AIP Emilio Segre Visual Archives.

Grade Level(s): 9-12	**Subject(s): History, Physics**

In-Class Time: 55-75 minutes	**Prep Time: 10-15 minutes**

Materials

- Copies of Discussion Questions Handout (found in the Supplemental Materials)
- Student internet access for research
- A/V equipment- to project tables (found in Supplemental Materials)

Objective

Students will learn how World War II impacted women's careers in science, including the Manhattan Project and beyond. They will research the work of some women scientists who achieved success during and after the War. However, students will come to understand that these stories were the exception to the norm, and that many women were stuck in low-level, temporary positions. Finally, students will debate whether women should have retained their status in science and industry after the War's end.
Note: It is recommended that this Guide be used after completing the AIP Teacher's Guides:

- Chien-Shiung Wu: Chinese Nuclear Physicist,
- Marietta Blau: Austrian Particle Physicist,
- Lise Meitner: Austrian Nuclear Physicist
- Leona Woods Marshall Libby: American Nuclear Physicist

Introduction

America's entry into World War II in 1941 drastically changed the nation's social structures. Thousands of men were conscripted into the military, and industries scrambled to produce the food, tools, machinery and equipment required for the war effort. Women had traditionally been excluded from these industries, but manpower shortages and unprecedented demand caused the defense companies to begin encouraging women to join their workforce and engage in scientific study (notably chemistry and physics).

While more women entered science during the war years, they were usually relegated to lower-status positions than their male counterparts.[1]. A majority of women were hired as assistants or aides, while women with extensive scientific training or degrees were usually ignored by the National Defense Research Committee's (NDRC's) National Roster of Scientific and Specialized Personnel, which documented and organized scientists for the war effort. In fact, one of the largest outlets for women in science during the war was on college and university faculties, where their representation more than doubled across the fields.[2] Some women physicists, like Chien-Shiung (C.S.) Wu and Leona Woods Marshall Libby, were recognized and valued by their peers in the scientific community. Out of necessity, American women had been allowed to enter the sciences. However, their typical assignment to menial and clerical tasks both continued and strengthened the male-dominated, exclusionary scientific culture of the time.

In this lesson, students explore how the war affected women in science. After they research some women who achieved more long-term success from World War II, the teacher will explain the exceptional nature of their stories. It is important that students understand that the increase of women's involvement in science was actually slight, and that in general, the positions they were afforded were low-level. Teachers will foster a debate (assigning sides if necessary) in which students voice support or denial of how women were largely dismissed from science and industry after the War, acknowledging the context and social expectations of the time.

[1] Jordynn Jack, *Science on the Home Front: American Women Scientists in World War II* (Urbana and Chicago: University of Illinois Press, 2009), 3.
[2] Margaret Rossiter, *Women Scientists in America: Before Affirmative Action, 1940-1972* (Baltimore and London: The Johns Hopkins University Press, 1995), 1-26.

Instructions/Activities

Engage: 10-15 Minutes

Students will contemplate gender relations and social structures of 1940s America. The teacher will then project a series of graphs (with accompanying questions below) and the students will evaluate them.	
What is the teacher doing? Have students consider the prevalent social structures of 1940s America, specifically gender relations. Ask them to hypothesize what some "socially acceptable" positions for women would have been at the time (i.e. teachers, secretaries, nurses, etc.) To help students grasp how World War II affected women in science, project the series of tables and graphs from Margaret Rossiter's book, *Women Scientists in America: Before Affirmative Action, 1940-1972* (found in the Supplemental Materials). Lead the class through the charts, posing the following questions while doing so: • *How can we account for the drastic rise of women on science faculties? What disciplines saw the largest growth?* • *How did the percentage of women scientists change from 1941-1945?* • *What happened to the percentage of women in various scientific disciplines during the immediate post-war years?* • *Compare the rates of women and men earning degrees, and explain what this reveals. Also, how can we account for sudden or rapid increases or decreases in the numbers of degrees earned?* Note: these questions are also found on the PDF, below the graphs they pertain to.	**What are the students doing?** Think about gender relations in 1940s America. Consider what would have been viewed as acceptable positions for women at this time. Observe the tables and graphs. Consider and answer the questions posed by the teacher, using the statistics provided in the charts. Be sure to note which scientific disciplines had employed lowest and highest percentage of women, and how this changed after the war. When viewing the final graph, consider what social/cultural events could have led to dramatic rises or drops in doctoral degrees (i.e. the G.I. Bill, the *Brown v. Board of Education* decision, etc.).

Explore: 25-30 Minutes

The teacher will provide students with a list of more women scientists who worked during World War II (found in Supplemental Materials). Students will split into groups and do brief research on an individual from the list, answering the Discussion Questions (found below and in the Supplemental Materials).

What is the teacher doing?	What are the students doing?
Split students into 6 small groups. Provide them with the list of World War II Women Scientists and the Discussion Questions. Assign each group a scientist from the list. Instruct groups to quickly conduct research on their assigned individual to answer the Discussion Questions. See the Required/Recommended Readings below for some suggested links for each individual. Have them prepare to share their findings with the class.	Split into 6 small groups. Receive the Discussion Questions and the World War II Women Scientists list from the teacher. After each group is assigned a scientist, answer the Discussion Questions by conducting brief research on the individual.

Explain: 15-20 Minutes

Students will share their findings with the class. The teacher will then remind students that the stories of these individuals were exceptional. A majority of women who became involved in science during World War II were relegated to low-level positions, and were generally dismissed after the war's conclusion.	
What is the teacher doing?	**What are the students doing?**
Instruct each group to present their research findings to the class. Ensure that they have completely addressed the Discussion Questions in their presentation.	As groups, present research findings to the class, incorporating the answers to the Discussion Questions.

Elaborate: 5-10 Minutes

The elaborate section of this lesson plan emerges organically during the explain section. After the students have presented their research findings, the teacher will explain that despite discrimination and restrictions, some women found success as scientists during World War II.	
What is the teacher doing?	**What are the students doing?**
After each group has presented, discuss with the entire class how women were encouraged to join the defense industries and science after 1941. Explain that vast majority of women who entered science during this time were stuck in low-status positions with little mobility. Then explain that, after the war, these women were often dismissed from their positions as the men retuned to work, and they were pushed to resume their "normal" domestic functions. Explain that some women, such as those profiled in the presentations, forged successful scientific careers during the war.	Listen and understand the teacher's explanation of how/why women were encouraged to enter into war industries and the sciences during World War II. Also understand that most women were given low-level scientific jobs, and were summarily dismissed once the war ended. Acknowledge that despite these difficulties, a few women created or continued long-term scientific careers through the war.

Evaluate:

The main opportunity for evaluation emerged during the explain section of this lesson. Teachers may choose to evaluate the students' presentations of their research, based on the thoroughness and communication of their research.

Required/Recommended Reading and Resources

The following resources provide useful starting points for student research on these scientists:

Katharine Way

- Martin, Murrary; Gove, Norwood; Gove, Ruth; Raman, Subramanian; and Merzbacher, Eugene. "Katharine Way." *Physics Today* 49 no. 12 (1996): 75. Doi: 10.1063/1.881582
- Atomic Heritage Foundation. "Katharine Way." Accessed August 4, 2016. http://www.atomicheritage.org/profile/katharine-way

Mina Rees

- Lee, J.A.N. *Computer Pioneers*. Los Alamitos, CA: IEEE Computer Society Press, 1995. Web Version. Accessed August 4, 2016. Lee's book contains a chapter on Mina Rees: http://history.computer.org/pioneers/rees.html
- Larry Riddle. "Mina Rees." Agnes Scott College, Biographies of Women Mathematicians Project. Last modified February 25, 2016. https://www.agnesscott.edu/lriddle/women/rees.htm

Elda Anderson

- "Elda E. Anderson." *Physics Today* 14 no. 7 (1961): 68. Doi: 10.1063/1.3057675
- Atomic Heritage Foundation. "Elda Anderson." Accessed August 4, 2016. http://www.atomicheritage.org/profile/elda-anderson

Florence van Straten

- Ohab, John. "A Pioneer in Naval Meteorology: CDR Florence van Straten." *Armed with Science: The Official U.S. Defense Department Science Blog*. Posted March 30, 2010. http://science.dodlive.mil/2010/03/30/a-pioneer-in-naval-meteorology-cdr-florence-van-straten/
- "Florence W. van Straten Dies." *Washington Post*, March 31, 1992. Accessed August 4, 2016. https://www.washingtonpost.com/archive/local/1992/03/31/florence-w-van-straten-dies/655aad61-90b3-4b6e-970b-5b6701f0acd1/

Julia Anna Gardner

- Ladd, Harry S. "Memorial to Julia Anna Gardner (1882-1960)." *Proceedings Volume of the Geological Society of America,* Annual Report for 1960 (1962): 86-92. ftp://rock.geosociety.org/pub/Memorials/proceedings_1960/Gardner-JA.pdf

Mary Sears

- Woods Hole Oceanographic Institute. "About Mary Sears." Accessed August 4, 2016. https://www.whoi.edu/page.do?pid=7718
- National Women's History Museum. "Mary Sears (1905-1997)." Accessed August 4, 2016. https://www.nwhm.org/education-resources/biography/biographies/mary-sears/

Discussion Questions

Discussion Questions can be found as a Handout with a corresponding Answer Key in the Supplemental Materials to this lesson plan.

1. When was the scientist born?
2. What was their education?
3. What did they do before the war?
4. What did they work on during the war, and where?
5. How did their career progress after the war?

Further Reading and Additional Resources

Rossiter, Margaret. *Women Scientists in America: Before Affirmative Action, 1940-1972*. Baltimore and London: The Johns Hopkins University Press, 1995.

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

Williams, Kathleen Broome. *Improbable Warriors: Women Scientists and the U.S. Navy in World War II*. Annapolis: U.S. Naval Institute Press, 2001.

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

Extensions

Related AIP Teacher's Guides on Women and Minorities in the Physical Sciences:

- Lise Meitner, Austrian Nuclear Physicist
- Marietta Blau, Austrian Particle Physicist
- Chien-Shiung Wu, Chinese Nuclear Physicist
- Leona Woods Marshall Libby, American Nuclear Physicist
- Inge Lehmann, Danish Seismologist
- Women and the Manhattan Project

Common Core Standards

For more information on Common Core Standards, visit http://www.corestandards.org/.

Speaking & Listening	
CCSS.ELA-LITERACY.SL.9-10.1	Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
CCSS.ELA-LITERACY.SL.9-10.2	Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, orally) evaluating the credibility and accuracy of each source.
CCSS.ELA-LITERACY.SL.9-10.4	Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of

	reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.
CCSS.ELA-LITERACY.SL.11-12.1	Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11-12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
CCSS.ELA-LITERACY.SL.11-12.2	Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.
CCSS.ELA-LITERACY.SL.11-12.4	Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.
History/Social Studies	
CCSS.ELA-LITERACY.RH.9-10.1	Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
CCSS.ELA-LITERACY.RH.9-10.2	Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text.
CCSS.ELA-LITERACY.RH.9-10.3	Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.
CCSS.ELA-LITERACY.RH.9-10.4	Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social science.
CCSS.ELA-LITERACY.RH.9-10.7	Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
CCSS.ELA-LITERACY.RH.11-12.1	Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.
CCSS.ELA-LITERACY.RH.11-12.2	Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.
CCSS.ELA-LITERACY.RH.11-12.4	Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines *faction* in *Federalist* No. 10).
CCSS.ELA-LITERACY.RH.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

Subject Writing	
CCSS.ELA-LITERACY.WHST.9-10.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
CCSS.ELA-LITERACY.WHST.9-10.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
CCSS.ELA-LITERACY.WHST.9-10.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
CCSS.ELA-LITERACY.WHST.9-10.9	Draw evidence from informational texts to support analysis, reflection, and research.
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CCSS.ELA-LITERACY.WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
CCSS.ELA-LITERACY.WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research.

Next Generation Science Standards

For more information on the Next Generation Science Standards, visit http://www.nextgenscience.org/.
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