The Radium Girls: A Light Amidst Tragedy

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The Radium Era

By 1902, Marie and Pierre Curie were finishing up their research on a newly discovered element called radium. Their results suggested that radium could be used to treat cancer. Entrepreneurs, eager to capitalize on this, claimed the element was a miracle cure and began to sell radioactive elixirs and curatives, as well as products containing radium such as watches, toothpaste, and toys for children. By the early 1910s, Sabin von Sochocky, one of these new businessmen, was hiring young women as radium watch dial painters for his company, the Radium Luminous Materials Corporation (RLMC), without warning them of the dangers of radium despite his knowledge of the element's risks. Neither he, nor the corporation, issued safety standards for their painters. "We used to paint our eyebrows, our lips, and our eyelashes, and then look at ourselves in the darkroom-just for fun… They never said anything; they never stopped you".[1] As employees began to fall ill the company refused to acknowledge that the debilitating health conditions were caused by radium exposure including arthritis, cancer, and necrosis. The tragedy of the Radium Girls led to advancements in science, significant changes in occupational safety laws and practices and the recognition of the fundamental rights of workers.

An Element is Born

For more than five years, Marie and Pierre Curie devoted themselves to continuing the research begun by Henri Becquerel on a perplexing substance that emitted its own energy.[2] Their work led to the discovery of a new element which Marie Curie named radium.[3] By 1901, Pierre Curie suggested that radium could be used to eradicate tumors after finding evidence that it

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[1] John Bradley, *Learning to Glow: A Nuclear Reader* (Tucson: The University of Arizona Press, 2000), 113.
[2] Franz Himstedt, "Radioactivity." *Annual Report of the Board of Regents of the Smithsonian Institution* (Smithsonian Institute, 1907), 118, https://library.si.edu/digital-library/book/annualreportofbo1906smitfo. (accessed December 7, 2018).
[3] Eve Curie, *Madame Curie,* Translated by Vincent Sheean (New York City: Pocket Books, 1937), 173.

destroyed human tissue.[4] Scientific communities embraced Curie's hypothesis and went into action. At this time, knowledge of radium was mostly limited to scientists because of its rarity. However, that changed when the Curies and Becquerel jointly won the 1903 Nobel Prize for Physics.[5] Their win spread information about radium across the world, and the resulting curiosity gave newspapers something to write about. Scientists, doctors, manufacturers, and hucksters exaggerated the wonders of radium until it became known as a miracle cure that could fix all ailments.[6] The craze grew as entrepreneurs put radium into common household products such as toothpaste, makeup, and foot warmers (see Appendix A).[7] The public's view of radium quickly moved from a scientific phenomenon to a gift from the earth. There soon came a point where even the possibility that radium could be harmful seemed preposterous to most Americans.

Radioactive Profit

The Radium Luminous Materials Corporation (RLMC) opened in 1914 under the ownership of Sabin von Sochocky and George S. Willis.[8] It produced a glowing paint made with radium which they marketed under the name "Undark".[9] They began by hiring painters for their watchmaking branch in Newark, New Jersey. These employees were to paint the dials on clocks and watches with the glowing paint. Since the watch faces were extremely small, the majority of the employees hired for the job were women who had smaller fingers than their male

[4] Denis Brian, *The Curies:* A Biography of the Most Controversial Family in Science (Hoboken: John Wiley and Sons, Inc., 2005), 66.
[5] Brian, 80.
[6] Matthew Lavine, "The Two Faces of Radium in Early American Nuclear Culture," (Bulletin of the History of Chemistry, 2014), http://acshist.scs.illinois.edu/awards/OPA%20Papers/2015-Lavine.pdf. (accessed October 10, 2018).
[7] Kate Moore, *The Radium Girls: The Dark Story of America's Shining Women*, (Naperville: Sourcebooks, 2017), 6.
[8] Moore, 16.
[9] Sabin A. von Sochocky "Can't You Find the Keyhole?," (The American Magazine, 1921), 24-27, HathiTrust, https://hdl.handle.net/2027/mdp.39015056072385. (accessed December 6, 2018).

counterparts.[10] The job was highly desired because of the free time and great pay. "The median income for women around this time was about $15 dollars a week. The average full-time employee at the Orange studio might draw about $20 a week painting about 250 watches a day."[11]

The women believed that the paint was healthy as was the claim in flyers nationwide--most of which were produced by the radium dial companies.[12] "The method of pointing the brush with the lips was taught to us, to give the brush an exceedingly fine point."[13] This technique caused them to ingest bits of paint as they worked.

Everything in their workplace became a source of radiation. They were covered with radium residue throughout the day. "Dust samples collected in the workroom from various locations and from chairs not used by the workers were all luminous in the dark room. Their hair, faces, hands, arms, necks, the dresses, the underclothes, even the corsets of the dial painters were luminous. One of the girls showed luminous spots on her legs and thighs. The back of another was luminous almost to the waist."[14] Incredibly, the girls would paint themselves for fun after finishing their work for the day. "The girls shone 'like the watches did in the darkroom,' as though they themselves were timepieces, counting down the seconds as they passed. They glowed like ghosts as they walked home through the streets of Orange."[15] One woman went so

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[10] Claudia Clark, *Radium Girls: Women and Industrial Health Reform, 1910-1935* (Chapel Hill: The University of North Carolina Press, 1997), 1.
[11] Clark, 14.
[12] Leonard Grossman, "The Case of the Living Dead Women," (Leonard Grossman), http://www.lgrossman.com/pics/radium/index.html. (accessed October 10, 2018).
[13] Clark, 17.
[14] Gunderman, Richard B., and Angela S. Gonda, "Radium Girls," (Radiology: February 2015) https://pubs.rsna.org/doi/pdf/10.1148/radiol.14141352. (accessed February 24, 2019).
[15] Moore, 21.

far as to paint her teeth with the radium to impress her date with a glowing smile.[16] At the end of the day, women went home literally glowing with radioactive contamination.

Many women joined the company during World War I, which began in Europe shortly after the company was founded. The United States military signed a contract with the RLMC to buy watches with glowing dials for their soldiers.[17] During the war, more than 200 women were employed by the painting sites in Orange, New Jersey, and Waterbury, Connecticut.[18] Soon, other companies entered the market using radium in their products. The Radium Dial Company (RDC) opened their doors in 1920 in Ottawa and Chicago, Illinois, marketing their paints under the brand name "Luma".[19] Hundreds of girls worked at these two sites. In 1921, Arthur Roeder replaced von Sochocky and began to lead the RLMC. The company changed its name to the United States Radium Corporation (USRC) and slowly began to lay off its dial painters to invest in other branches of the company. Although employee numbers declined, radium poisoning advanced as it spread its way deep into the girls' organs and nervous systems.

A Radioactive Tragedy

By 1920, women who had worked at radium factories several years before began to show signs of sickness. Symptoms typically started in their jaws (see Appendix B). Aching pain led to dentist visits where their teeth were pulled, often breaking their jaws in the process due to bone deterioration (necrosis).[20] Doctors believed that the girls were suffering from phosphorus

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[16] Moore, 22.
[17] Moore, 6.
[18] Clark, 16.
[19] "Luma: The Radium Lumanous Compound," (The Jewelers' Circular, April 14, 1920) 150, HathiTrust, https://hdl.handle.net/2027/mdp.39015079990282?urlappend=%3Bseq=355. (accessed January 18, 2019).
[20] DeVille, Kenneth A., and Mark E. Steiner, "The New Jersey Radium Dial Workers and the Dynamics of Occupational Disease Litigation in the Early Twentieth Century," (Missouri Law Review 62, no. 2, 1997), 287. https://scholarship.law.missouri.edu/mlr/vol62/iss2/2/. (accessed December 13, 2018).

contamination or syphilis; however, they were tragically wrong.[21] Eventually, some girls began to experience more significant problems. Their backs and hips would ache. Some showed up to work with limbs amputated from their latest tumor treatments, while others had bones spontaneously fracture, their ankles splintering under their weight. Then, they began to die.[22]

Confronting their employers, the girls were told that radium was harmless and that the shared sicknesses were merely coincidental. After all, painters had only just begun to experience health problems. If it were the company's fault, rationalized men like Roeder, the girls would have begun to show symptoms years earlier. Doctor visits became more frequent and extreme as the girls faced terrific pain and loss of their limbs. One of the doctors treating the girls found that his suffering patients all worked the same job for the RDC.[23] Feeling the need to take action, he called for an investigation into the RDC to see if one of his patients, Irene Rudolph, had contracted phosphorus poisoning from her work. Sadly, her diagnosis would be far more tragic.

Suspicions Confirmed

An investigation, conducted by the Industrial Hygiene Division did not find phosphorus; however, the dial paint was tested by Dr. Martin Szamatolski as part of the study.[24] He found the radium and suspected it was the cause of their illnesses. Under the growing suspicions and complaints filed by the employees, Roeder hired Dr. Cecil Drinker to observe the factory based in Orange to get an official opinion on radium's effect on the girls (see Appendix C). Drinker,

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[21] DeVille, 287.
[22] Associated Press, "New Cancer Data Given in Report: Possibility of Unrecognized Source of Raidoactivity Discussed." (Evening Star, October 15, 1931). https://chroniclingamerica.loc.gov/lccn/sn83045462/1931-10-15/ed-1/seq-2/. (accessed March 31, 2019).
[23] Moore, 48.
[24] Moore, 50.

his wife, Katherine, and William Castle, studied the factory and results once again concluded that radium was the cause of the girls' tragic illnesses.[25]

In 1924, Drinker recommended the company begin to implement new safety procedures to protect painters from radium. Roeder ignored his advice and threatened to sue the Drinkers if they published their studies. A colleague of the Drinkers and leader of a voluntary workers' reform group helping the girls, Alice Hamilton, found out later that the USRC had submitted their reports to the New Jersey Department of Labor with altered results claiming that every girl was in perfect condition.[26] The Drinkers ignored Roeder's threat and published their original reports.[27] After reading the paper, New Jersey's labor commissioner ruled that Drinkers' safety procedures be put into practice. The impossible task of adhering to the new rules resulted in the Orange factory's closure, but the damage had already been done.

Although the factories themselves declined in productivity and ceased to operate, the poison in the girls persisted. They continued to suffer from anemia, spontaneous, crippling bone fractures, disfiguring tumors, and necrosis. Many became isolated from their friends, became bedridden, and accepted their impending tragic deaths.[28]

The Painters Strike Back

Few women attempted to seek justice through the courts. The occupational laws in the early 1920s required victims to name their injury, state who gave the injury, and be denied a fix or cure by the person responsible for the injury before taking legal action.[29] Many painters were

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[25] Amy Roeder, "Deadly Occupation, Forged Report," (Harvard, 2013), https://www.hsph.harvard.edu/news/magazine/centennial-radium-forged-report/. (accessed December 7, 2018).
[26] Roeder, "Deadly Occupation, Forged Report".
[27] Roeder, ¨Deadly Occupation, Forged Report¨.
[28] Clark, 212.
[29] "Email Interview of Leonard Grossman, Jr." Son of Lawyer Leonard Grossman. By Rebecca Busche. April 13, 2019.

unable to fulfill those requirements because the dangers of radium were largely unknown. "The statute of limitations also ruled out legal action for many girls. Plus, with the girls very sick and not wanting to stir up trouble, nor sure their work had actually hurt them, legal action was not a priority for them all."[30] Even so, two dial painters filed lawsuits. Roeder responded to the lawsuits with a press release announcing there was no correlation between their varying health problems and radium.[31] He successfully swayed public sentiment, making it much harder for the painters to find attorneys to take their cases. The attorneys who did accept often charged their fees in advance due to the painters' low chance of success. To sustain their deception, the USRC hired someone named Fredrick Flinn to pose as a doctor to examine the girls and testify they were healthy. His reports stated that all of his examinees were in good health, further deterring them from seeking legal aid.[32]

In the mid-1920s, after several painters filed lawsuits for large amounts of money, the public began to show interest in their plight. Journalists were now interviewing the painters, giving them names like the "Society of the Living Dead" or the "Five Doomed Women". The girls used the interviews to gain public support and to spread awareness (see Appendix D). The horror of their stories was finally revealed, and the public outcry pressured the USRC to settle the cases properly and the New Jersey legal system to add mesothorium and radium necrosis to New Jersey's list of nine compensable laws in 1926.[33]

The first to win through litigation was Irene F. LaPorte's family. Irene had already died of radiation poisoning from her work at a dial painting factory, but her family received $1,000

[30] "Email interview of Kate Moore." Author of *The Radium Girls: The Dark Story of America's Shining Women.* By Rebecca Busche. February 5, 2019.
[31] DeVille, 288.
[32] DeVille, 299.
[33] DeVille, 284.

dollars in compensation. In 1926, three cases were settled for $9,000, $3,000, and $1,000 respectively, in favor of the dial painters.[34]

Alice Hamilton mentioned the painters were unable to find legal counsel to the National Consumers' League, convincing a lawyer named Raymond Berry to help five Radium Girls named Grace Fryer, Katherine Schaub, Edna Hussman, Albina Larice, and Quinta McDonald. This became the most famous Radium Girl lawsuit. Berry sued on May 18, 1927. The five women settled out of court under the promise to receive $10,000 each. Additionally, the USRC had to cover all future medical expenses and pay each woman a $600 annuity. Several subsequent winning Ottawa cases were given to Attorney Leonard Grossman for his "reputation as an outstanding Worker's Compensation attorney".[35] Grossman's work with the Radium Girls garnered more compensation and other girls followed collecting their own settlements to ease their deaths and pay their funeral expenses (see Appendix E).

Aftermath

Although some Radium Girls received compensation, it would not cure them. Several took up an offer to be studied by researchers from Argonne National Laboratory led by Dr. Robley Evans in hopes that one would be found.[36] The Argonne did not fulfill their hopes and many girls abandoned the studies early on because the scientists and doctors studying them refused to tell them their results.[37] However, Argonne's research remains a useful source of information regarding the effects of radium on humans. The amount of radiation the girls

[34] DeVille, 284.
[35] Grossman, "Email Interview".
[36] Rowland, R. E, "Radium in Humans: A Review of U.S. Studies," Argonne National Laboratory (1994), https://apps.orau.gov/cedr/pdf/hist-docs/1198.pdf. (accessed January 15, 2019).
[37] Moore, 391.

received made these studies unreplicable due to the radium safety laws these women brought about preventing further tragedies.

The RDC shut down in 1936. Its owner Joseph Kelly immediately opened an identical business called Luminous Processes, Inc. that continued production until the late 1970s, closing shortly after the United States placed a complete ban on radioactive paint.[38] In the 1980s, homes in Orange were found to have high levels of radon, a gas made from decayed radium. The investigation found that the sand used around the properties contained residue from USRC.[39] The radioactive debris produced at these sites placed them on the Environmental Protection Agency's Superfund list as more than 10,000 tons of contaminated soil had to be moved from the Ottawa plant alone.[40]

The tragedy of the Radium Girls later inspired safety procedures implemented in the Manhattan Project. While working with plutonium, nuclear chemist Glenn Seaborg remembered their story and established safety precautions – the use of gloves and hoods – for his lab that were later extended to the Manhattan Project itself. Without them, "the project's management could have reasonably rejected the extreme precautions that were urged on it and thousands of workers might well have been, and might still be, in great danger".[41] While most laws created and revised by then stayed within the region that they lived such as New Jersey's addition of

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[38] EPA. "Ottawa Radiation Areas Ottawa, Il." https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.Cleanup&id=0500634#bkground. (accessed January 3, 2019).
[39] Laura Lee Carter. "Glow in the dark tragedy: fatally poisoned by the glowing paint they used on the job, the 'Radium Girls' challenged workplace safety rules and helped shed light on the unseen dangers of radioactivity." (American History, October 2007) http://link.galegroup.com/apps/doc/A212276085/UHIC?u=lsc&sid=UHIC&xid=49108b0a. (accessed February 24, 2019).
[40] Environment Protection Agency. "Ottawa Radiation Areas Ottawa, Il.," https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.Cleanup&id=0500634#bkground. (accessed January 3, 2019).
[41] Moore, 378.

mesothorium and radium necrosis to their list of nine compensable diseases in 1921 and the extension of time added to their statute of limitations, they affected laws on a national scale. The Atomic Energy Act of 1954 and some of its future revisions took some inspiration from the painters' tragedies in mind. Their story remains along with the radium embedded in their bodies. In 1978, researchers dug up the grave of Margaret Looney, one of the dial painters from Ottawa, and found more than 1,000 times the amount of radium considered safe in her bones.[42] Many known Radium Girls donated their bodies to science in hopes that good would come to someone else even though it was already too late for them. In her final years, Grace Fryer, one of The Five Doomed women said, "My body means nothing but pain to me, and it might mean longer life or relief to the others, if science had it. It's all I have to give." As corporations today reflect on their treatment of workers and their compliance under federal guidelines, we can look to the Radium Girls, who in their moment of tragedy, fought triumphantly to correct workplace wrongs forced upon them under the glowing backdrop of radium.

[42] Moore, 392.

Appendix A

A radium advertisement from 1918 placed in the *New York Tribune*. The brand Radior sold soaps, creams, face powders, and other beauty products by advertising the radium used in their ingredients.

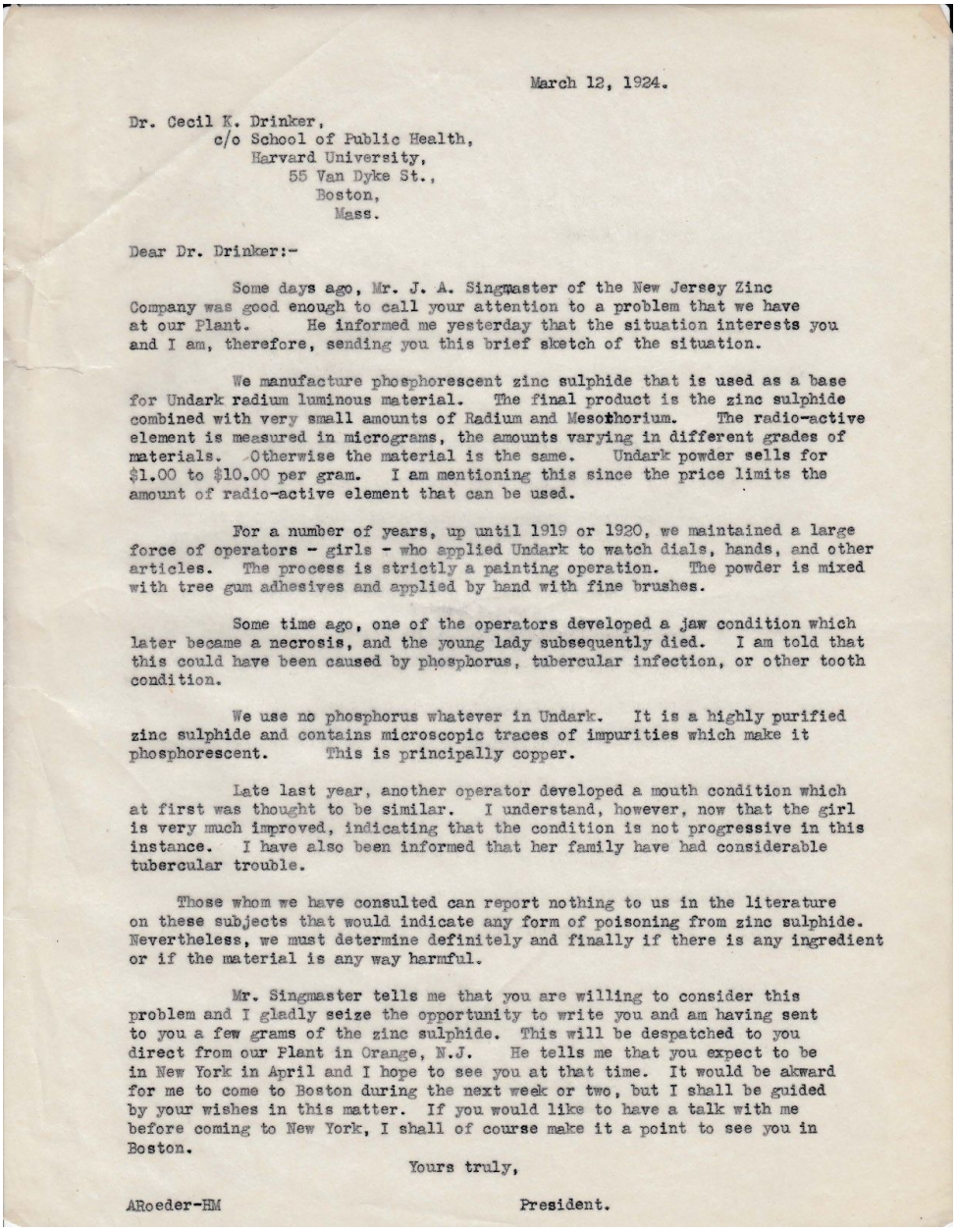
New-York Tribune. [New York N.Y] (New York, NY), Nov. 10 1918. Accessed November 12, 2018. https://www.loc.gov/item/sn83030214/1918-11-10/ed-1/.

Appendix B

This woman was one of the radium dial painters from the 1920s. Radium caused the sacroma in her jaw.

Carter, Laura Lee. "Glow in the dark tragedy: fatally poisoned by the glowing paint they used on the job, the 'Radium Girls' challenged workplace safety rules and helped shed light on the unseen dangers of radioactivity." *American History*, October 2007, 32+. *U.S. History in Context* (accessed February 3, 2019). http://link.galegroup.com/apps/doc/A212276085/UHIC?u=lsc&sid=UHIC&xid=49108b0a.

Appendix C



March 12, 1924.

Dr. Cecil K. Drinker,
c/o School of Public Health,
Harvard University,
55 Van Dyke St.,
Boston,
Mass.

Dear Dr. Drinker:-

Some days ago, Mr. J. A. Singmaster of the New Jersey Zinc Company was good enough to call your attention to a problem that we have at our Plant. He informed me yesterday that the situation interests you and I am, therefore, sending you this brief sketch of the situation.

We manufacture phosphorescent zinc sulphide that is used as a base for Undark radium luminous material. The final product is the zinc sulphide combined with very small amounts of Radium and Mesothorium. The radio-active element is measured in micrograms, the amounts varying in different grades of materials. Otherwise the material is the same. Undark powder sells for $1.00 to $10.00 per gram. I am mentioning this since the price limits the amount of radio-active element that can be used.

For a number of years, up until 1919 or 1920, we maintained a large force of operators - girls - who applied Undark to watch dials, hands, and other articles. The process is strictly a painting operation. The powder is mixed with tree gum adhesives and applied by hand with fine brushes.

Some time ago, one of the operators developed a jaw condition which later became a necrosis, and the young lady subsequently died. I am told that this could have been caused by phosphorus, tubercular infection, or other tooth condition.

We use no phosphorus whatever in Undark. It is a highly purified zinc sulphide and contains microscopic traces of impurities which make it phosphorescent. This is principally copper.

Late last year, another operator developed a mouth condition which at first was thought to be similar. I understand, however, now that the girl is very much improved, indicating that the condition is not progressive in this instance. I have also been informed that her family have had considerable tubercular trouble.

Those whom we have consulted can report nothing to us in the literature on these subjects that would indicate any form of poisoning from zinc sulphide. Nevertheless, we must determine definitely and finally if there is any ingredient or if the material is any way harmful.

Mr. Singmaster tells me that you are willing to consider this problem and I gladly seize the opportunity to write you and am having sent to you a few grams of the zinc sulphide. This will be despatched to you direct from our Plant in Orange, N.J. He tells me that you expect to be in New York in April and I hope to see you at that time. It would be akward for me to come to Boston during the next week or two, but I shall be guided by your wishes in this matter. If you would like to have a talk with me before coming to New York, I shall of course make it a point to see you in Boston.

Yours truly,

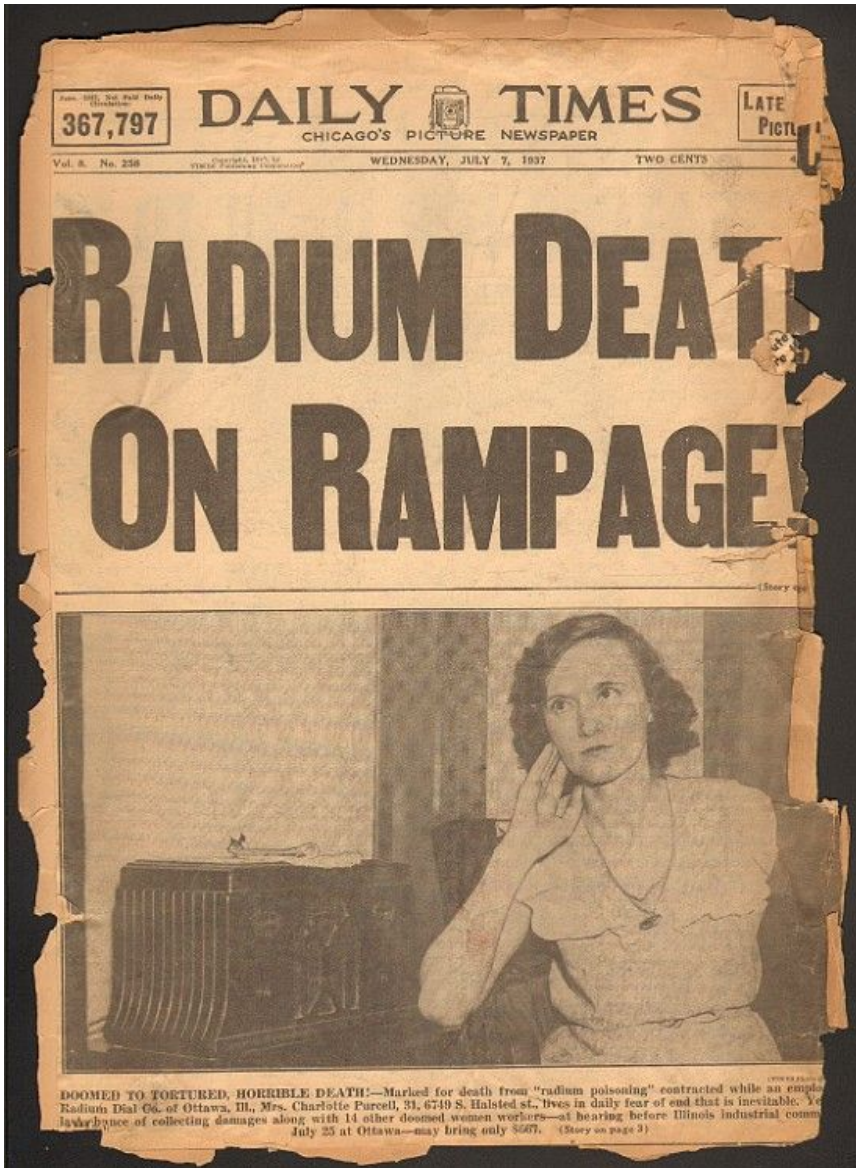
ARoeder-HM

President.

In this letter, Arthur Roeder asks Dr. Cecil Drinker if he would be willing to study the cause of the painters' deaths. At this point in time, Roeder was still convinced that radium was not the cause of their illnesses.

Roeder, Arthur. "Letters Sent to Cecil K. Drinker, March 12, 1924." United States Radium Corporation. National Archives (75718727). Accessed December 6, 2019. https://catalog.archives.gov/id/75718727.

Appendix D



367,797

DAILY TIMES

CHICAGO'S PICTURE NEWSPAPER

Vol. 8. No. 258 WEDNESDAY, JULY 7, 1937 TWO CENTS

RADIUM DEAT

ON RAMPAGE

DOOMED TO TORTURED, HORRIBLE DEATH!—Marked for death from "radium poisoning" contracted while an emplo Radium Dial Co. of Ottawa, Ill., Mrs. Charlotte Purcell, 31, 6749 S. Halsted st., lives in daily fear of end that is inevitable. Y lawsuit of collecting damages along with 14 other doomed women workers—at hearing before Illinois industrial comm July 25 at Ottawa—may bring only $667. (Story on page 3)

The Radium Girls became a topic for news articles while awaiting for their postponed trial to address their health claims. Some of the women, such as Charlotte Purcell (featured above), accepted interviews to gain public support conveying to the nation the tragedies they experienced due to their exposure to radium.

Grossman, Leonard. "The Case of the Living Dead Women," Leonard Grossman. http://www.lgrossman.com/pics/radium/index.html. Accessed October, 10, 2018.

Appendix E

OTTAWA, ILL., SATURDAY, FEBRUARY 12, 1938.

VICTIMS OF "RADIUM POISONING" AT HEARING

Catherine Donahue, one of the Radium Girls that filed a lawsuit, was too sick to leave her house for her testimonial. Instead, the case was brought to her home where she told her story from bed.

Grossman, Leonard. "The Case of the Living Dead Women," Leonard Grossman. http://www.lgrossman.com/pics/radium/index.html. Accessed October, 10, 2018.

Annotated Bibliography

Primary Sources

Associated Press. "New Cancer Data Given in Report: Possibility of Unrecognized Source of Raidoactivity Discussed." *Evening Star*, October 15, 1931, p. A-2. Library of Congress (83045462). Accessed March 31, 2019. https://chroniclingamerica.loc.gov/lccn/sn83045462/1931-10-15/ed-1/seq-2/.

This was written as the deaths of the girls were starting to be released to the public and details the kinds of ailments some women from the New Jersey plant were suffering. It was used to provide the exact problems the women faced.

B., C. I. "Radium Discoverers.: Professor and Mme. Curie are Indeed Helpmeets." *New-York Tribune*, April 19, 1903, p. 6-7. Library of Congress (83030214). Accessed March 30, 2019. https://chroniclingamerica.loc.gov/lccn/sn83030214/1903-04-19/ed-1/seq-36/.

Radium Discoverers was a short biography of the Curies that detailed their latest discoveries. This was used for background on radium.

Curie, Eve. *Madame Curie*. Translated by Vincent Sheean. New York City: Pocket Books, 1937.

After the Curies found fame, their daughter Eve Curie wrote a biography recounting her parents' discoveries and their research. This translated edition was used for background information on the history of radium and the Curies.

Fleischman, Doris E. "Radium Becoming a Household Aid." *The Sun and the New York Herald*, May 30, 1920, sec. 7. Library of Congress (83030273). Accessed March 30, 2019. https://chroniclingamerica.loc.gov/lccn/sn83030273/1920-05-30/ed-1/seq-76/.

This article listed off ways that radium was being used for the time, including paints, and explained that radium was only dangerous in great quantity. This was used for background on promotional radium stories.

Grossman, Leonard. "The Case of the Living Dead Women," Leonard Grossman. http://www.lgrossman.com/pics/radium/index.html. Accessed October, 10, 2018.

Leonard Grossman, Jr. posted the newspaper articles his father, a Radium Girls' lawyer, collected on the Radium Girls. These headliners were used to show how the Radium Girls were being treated by the media. These newspaper titles appear as Appendix D and Appendix E in the paper.

Himstedt, Franz. "Radioactivity." *Annual Report of the Board of Regents of the Smithsonian Institution* (1907): 117-30. Smithsonian Institute. Accessed December 7, 2018. https://library.si.edu/digital-library/book/annualreportofbo1906smitfo.

Radioactivity reviews the recent advancements made in the studies of radioactivity, including radium. He gave insight on both the background necessary for the project as well as the views people had on radium at the time.

"Luma: The Radium Luminous Compound." The Jewelers' Circular, April 14, 1920, 150. HathiTrust. Accessed January 18, 2019. https://hdl.handle.net/2027/mdp.39015079990282?urlappend=%3Bseq=355.

A newspaper known as the *Jewelers' Circular* frequently advertised radium dial clocks during the early 1900s. This particular article produced by the Radium Dial Corporation quickly advertised their radium paint "Luma" and provided a list of companies they partnered with in the sale of their product.

Martland, Harrison S. "The Occurrence of Malignancy in Radioactive Persons." *The American Journal of Cancer* 15, no. 4 (1941): 2435-514. American Association for Cancer Research. Accessed December 7, 2018. http://cancerres.aacrjournals.org/content/amjcancer/15/4/2435.full.pdf.

Martland published some studies he made on the dial painters. This was used to understand the tragedy the girls went through as well as the research conducted on them in an effort to understand the effects of radiation on the body.

New-York Tribune. [New York N.Y] (New York, NY), Nov. 10 1918. Accessed November 12, 2018. https://www.loc.gov/item/sn83030214/1918-11-10/ed-1/.

The New-York Tribune released several "Radior" advertisements throughout its printing. "Radior" was a makeup product containing radium that appeared as Appendix A in the paper.

Parton, Lemuel F. "Lawyers, Medicos Second Best In $1,250,000 Radium Suites." *Asbury Park Press*, June 6, 1928, p. 16. Accessed March 30, 2019. https://www.newspapers.com/clip/18014010/radium_lawsuits/.

This newspaper article revealed the results of the radium suites filed by Raymond Berry. It backed up the claim that the girls won and brought about new laws related to workplace rights.

Roeder, Arthur. "Letters Sent to Cecil K. Drinker, March 12, 1924." United States Radium Corporation. National Archives (75718727). Accessed December 6, 2018. https://catalog.archives.gov/id/75718727.

Arthur Roeder, the president of the RLMC, asked Cecil K. Drinker to inspect his company to prove it was safe in this letter. His letter was used to show his opinion on the issue and how Drinker came to investigate. This letter appears as Appendix C of the paper.

Sochocky, Sabin A. von "Can't You Find the Keyhole?" *The American Magazine*, 1921, 24-27. HathiTrust. Accessed December 6, 2018. https://hdl.handle.net/2027/mdp.39015056072385.

Von Sochocky's article advertises the marvellous uses of radium. Absurdly enough, he briefly interrupted his advertising of its curative properties by discussing its dangers and how he had lost a chunk of a finger bone to it. This primary article written by the paint's inventor himself was used to show how the company presented itself to the public.

"Undark: Radium Luminous Material." *Scientific American:* Volume 123, 1920. HathiTrust. Accessed December 3, 2018. https://babel.hathitrust.org/cgi/pt?id=mdp.39015024546411.

This newspaper article in the *Scientific American* discussed how people could use ¨Undark¨ paint made by the Radium Luminous Materials Corporation. The article contributed facts about the paint such as its name and uses in the paper in an effort to provide historical context.

Secondary Sources

Bradley, John. *Learning to Glow: A Nuclear Reader*. Tucson: The University of Arizona Press, 2000.

Learning to Glow: A Nuclear Reader lists the uses of radium all over the United States and how it affected many different groups of people. One of Bradley's focuses were the Ottawa Radium Girls. This book provided an understanding for others affected by radium other than the radium dial painters and helped position the Radium Girls in the overarching period of radium usage in the United States.

Brian, Denis. *The Curies: A Biography of the Most Controversial Family in Science*. Hoboken: John Wiley and Sons, Inc., 2005.

Denis shows the lives of Marie and Pierre Curie. Their success was important for understanding how radium became overblown and popular enough to lead to poisoned dial painters. This source was vital for background research on the Radium Girls and provided historical context for the paper.

Carter, Laura Lee. "Glow in the dark tragedy: fatally poisoned by the glowing paint they used on the job, the 'Radium Girls' challenged workplace safety rules and helped shed light on the unseen dangers of radioactivity." *American History*, October 2007, 32+. *U.S. History in Context*. Accessed February 24, 2019. http://link.galegroup.com/apps/doc/A212276085/UHIC?u=lsc&sid=UHIC&xid=49108b0a.

Carter provides a brief overview of the Radium Girls, their legacy, and other radium products of the time. She proved that the Radium Girls brought about legal change for the workplace. A picture of one of the Radium Girls with a tumor from this text appears as Appendix B.

Clark, Claudia. *Radium Girls: Women and Industrial Health Reform, 1910-1935*. Chapel Hill: The University of North Carolina Press, 1997.

Clark explains how the *Radium Girls* tied into making workplace safety standards set by law today. This source made it easier to state that the Radium Girls were triumphant in court creating new laws for the rest of the United States.

DeVille, Kenneth A., and Mark E. Steiner. "The New Jersey Radium Dial Workers and the Dynamics of Occupational Disease Litigation in the Early Twentieth Century." Missouri Law Review 62, no. 2 (1997). Accessed December 13, 2018. https://scholarship.law.missouri.edu/mlr/vol62/iss2/2/.

Although written years after the incident, this military law review goes over the legalities the Radium Girls went through as well as how they were able to make the changes to workplace laws that they did during and after their employment.

"Email Interview of Kate Moore." Author of *The Radium Girls: The Dark Story of America's Shining Women.* By Rebecca Busche. February 5, 2019.

Conducting an interview with Ms. Moore verified research and confirmed the tragic nature of radium for the girls. The paper quoted some of what she said in the interview.

"Email Interview of Leonard Grossman, Jr." Son of Lawyer Leonard Grossman. By Rebecca Busche. April 13, 2019.

The interview with Leonard Grossman gave more details on the legal process for the Radium Girls and verified previous research. The paper used this to explain the women's triumph in court.

Environment Protection Agency. "Ottawa Radiation Areas Ottawa, Il." Accessed January 3, 2019. https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.Cleanup&id=0500634#bkground.

The EPA keeps track of biohazardous locations around the United States including the ones created by radium dial factories. Many of these places were added to the Superfund list where their conditions are kept track of. The information on the Ottawa Radiation Areas created by both the Radium Dial Corporation and its successor Luminous Processes was used to show the modern day effects of the radium factories.

Gunderman, Richard B., and Angela S. Gonda. "Radium Girls." *Radiology* 274, no. 2 (February 2015): 314-18. Accessed February 24, 2019. https://pubs.rsna.org/doi/pdf/10.1148/radiol.14141352.

This article is a short summary about the Radium Girls that contains a lot of quantitative data relating to them, such as the number of painters and the money they recuperated off of settlements.

Lavine, Matthew. "*The Two Faces of Radium in Early American Nuclear Culture.*" Bulletin of the History of Chemistry, 2014. Accessed October 10, 2018. http://acshist.scs.illinois.edu/awards/OPA%20Papers/2015-Lavine.pdf.

This article displays two contradicting ways people advertised radium products. It described newspapers as either insisting that radium was a modern scientific substance or an ancient natural remedy with the use of advertisements from the early 1900s. It was used for background on the general reception and usage of radium products.

Moore, Kate. *The Radium Girls: The Dark Story of America's Shining Women*. Naperville: Sourcebooks, 2017.

Moore eloquently portrays the history of the Radium Girls in a story-like structure. This source was used to understand the broad concept of the Radium Girls' story and provided a basis for further research.

Roeder, Amy. "Deadly Occupation, Forged Report." Harvard. Accessed December 7, 2018. https://www.hsph.harvard.edu/news/magazine/centennial-radium-forged-report/.

The false reports Arthur Roeder wrote in the name of the Drinkers were discussed in this article. The information was used to understand how the Drinkers played a role in the tragedy and how Roeder was able to temporarily ward off the legal system.

Rowland, R. E. "Radium in Humans: A Review of U.S. Studies." Argonne National Laboratory (1994). Accessed January 15, 2019. https://apps.orau.gov/cedr/pdf/hist-docs/1198.pdf.

The Argonne National Library published this review containing old records they made on the dial painters years before. This source was used to find out more about the research conducted on the girls and the effects that radium had on their bodies including necrosis and bone sarcoma.