Marie Curie

The luminescent scientist who defied all odds and sparked modern science

Rachel Norton
Junior Division
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"You cannot hope to build a better world without improving the individuals. To that end each of us must work for his own improvement, and at the same time share a general responsibility for all humanity, our particular duty being to aid those to whom we think we can be most useful."[1]

Marie Curie

In the Latin Quarter of Paris, the Panthéon rises; the domed building dedicated to the 'great men' of France. On April 20, 1995, the remains of Marie Curie were laid to rest there and the French President, Francois Mitterrand, stressed in his speech that she was "the first lady in our history honored for her own merits."[2] Marie Curie, a Polish scientist, was successful at a time when sexism was rampant in the streets of Paris. Her research led to great advancements in the fields of physics and chemistry, which in turn affected other branches of science. France's post-mortem recognition of her contributions to modern society shows that she overcame the adversities of her time. She came to be a successful and respected scientist in a time where success and respect for women in any endeavor was nearly impossible to come by.

An Unquenchable Thirst for Knowledge

Marie Curie, then known as Marie Sklodowska, spent nearly her entire life thirsting after knowledge and a better understanding of the world around her. Her first lessons in physics and chemistry were from her father[3], who was a math and physics

[1] *Pierre Curie* (1923), as translated by Charlotte Kellogg and Vernon Lyman Kellogg, p. 162
[2] "Marie Curie Enshrined in Pantheon." *The New York Times*. The New York Times, 20 Apr. 1995. Web. 10 Feb. 2017.
[3] "Marie and Pierre Curie and the Discovery of Polonium and Radium". *Nobelprize.org*. Nobel Media AB 2014. Web. 24 Feb 2017.

instructor.[4] However, as a result of Poland's recent rebellion against Russia, her education was poor due to the enforced use of only the Russian language in Polish schools.[5] This, plus her family's poor financial status, prevented her from receiving a higher education until she was 24-years-old. In 189?, when she finally did attend the University of Paris -- better known as the Sorbonne -- she was eager to continue her pursuit of knowledge. She wrote in her journal, "It was like a new world opened to me, the world of science, which I was at last permitted to know in all liberty."[6]

Despite the perks, it wasn't a fairytale - she had grown up in Russian-controlled Poland, where she was only taught in Russian. Learning French to attend the Sorbonne was only one of the many difficulties she faced. Another was the sexism that plagued the society of the late nineteenth century. Out of the 1,800 students attending the Sorbonne at the same time as Marie, only 23 were female. Women in the late nineteenth century were considered weaker, both physically and intellectually, and were expected to be completely submissive to their stronger male counterparts. Because of this stereotype, women were rarely allowed an education outside the home, and were *strongly* discouraged from attending college.[7] When Marie Curie attended the Sorbonne, not only did she go against the values of many of the scientists with whom she would be working with, she was defying the dominant views of women in that era. Despite the animosity and societal trials that she faced while getting her degree, Marie Curie graduated from

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[4] "Marie Curie." *Biography.com*. A&E Networks Television, 20 Nov. 2015. Web. 26 Feb. 2017.
[5] "A History of Poland." *A History of Poland*. N.p., n.d. Web. 04 Apr. 2017.
[6] Curie, Marie. Pierre Curie: With Autobiographical Notes. Trans. Charlotte Kellogg. New York: Macmillan, 1923. Print.
[7] Balanza, Pamela. "The Role of Women in the 19th and 20th Centuries." *Aglaun*. Aglaun, n.d. Web. 27 Feb. 2017.

the Sorbonne in 1894 with top marks in her class. This triumph over the demeaning views of women in that time reflects her persistence in the face of the trials she had to face as a woman of that era.

X-rays and Radiation

In 1895, Wilhelm Röntgen had discovered x-rays.[8] This discovery is of great importance, as it sparked the research of many scientists - one such of these being Henri Becquerel. On February 26th, 1896, he conducted an experiment[9] that revealed the existence of a new ray, which he called 'uranium-rays'.[10] Now known as radioactive waves, these rays are emitted by certain elements and are highly dangerous -- long exposure to these rays can can cause cancer and scarring of tissue. But in 1896 they were simply an entirely new phenomenon, and caught the attention of a recently-wed Marie Curie.

Although her husband, Pierre Curie, did not actively partake in her experimentation, he did help secure her a lab in which to work.[11] "The school of Physics could give us no suitable premises, but for the lack of anything better, the Director permitted us to use an abandoned shed… it's glass roof did not afford complete shelter against rain; the heat was suffocating in the summer, and the bitter cold of winter was only a little lessened by the iron stove… with this equipment we entered on our

[8] *The Discovery of Radioactivity*. Guide to the Nuclear Wall Chart,
[9] See Appendix I
[10] "The Discovery of Radioactivity." *The Discovery of Radioactivity*. Guide to the Nuclear Wall Chart, 9 Aug. 2000. Web. 21 Feb. 2017
[11] Curie, Marie. Pierre Curie: With Autobiographical Notes. Trans. Charlotte Kellogg. New York: Macmillan, 1923. Print..

exhausting work."[12] Despite these conditions, it was in this tiny, makeshift laboratory that Marie Curie, later with Pierre Curie, would discover and theorize some of the most brilliant and world-changing ideas of their time.

Revolutionary discoveries

Pierre Curie and his brother, Jacques, had invented the *quartz piezo-electroscope*, a device that measures very small currents.[13] Since Becquerel also found that uranium rays caused the air to conduct electricity, this was the perfect device to use in discovering which other elements, if any, gave off these uranium-rays. Armed with this invention, she tested elements systematically and soon discovered that thorium, too, emitted the 'uranium-rays' that electrified the air. As she continued to experiment further and learn about uranium waves, she discovered something curious. Two substances containing uranium - a dark powder and a yellow crystal - both gave off uranium rays proportional to the amount of radium, not the state of matter. In other words, the amount of uranium rays that a material emits depends not on its form, but on the quantity of uranium. With this evidence, she theorized that the uranium-rays came from that atom itself, not the molecular structure of the substance.

This revolutionary theory shook the very foundations of science and is one of Curie's most important discoveries. At the time, the atom was considered the very smallest particle of matter. If it could give off rays, then its structure must be far more complicated than previously realized. This theory was groundbreaking and was the first

[12] Blom, Philipp. "1903: A Strange Luminescence." *Vertigo Years: Europe, 1900-1914*. New York: Basic, 2010. 71-91. Print.
[13] See appendix II

step towards today's field of nuclear physics.[14] Despite this conclusion, plus other emerging evidence that the atom was not the smallest particle, most were still doubtful, deeply set in the standard scientific principles of the late nineteenth century.[15]

The New Elements

As Marie continued experimenting on various radioactive materials, she found that pitchblende, a uranium compound found in Bohemia, contained four times more radiation than uranium.[16] After making sure that this wasn't an anomalous reading, Marie felt it necessary to find an explanation to this abnormality as soon as possible. Interested, Pierre dropped his research into crystals to help her identify the new substance.

The refining method that they used was unique. "[It was] a new method in chemical research based on radioactivity."[17] She initially estimated that the element made up 1% of the pitchblende. In reality, it contained less than one millionth of a percent.[18] This created financial troubles for the pair that halted their progress in identifying the new element. In order to extract enough of the pure element to prove to the critical science world that the element did indeed exist, they would need to process hundreds of tons of the expensive pitchblende. As they were living off the wages of a

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[14] "Marie Curie." *Khan Academy*. Khan Academy, n.d. Web. 19 Feb. 2017
[15]"Marie Curie - Research Breakthroughs (1897-1904)." *Marie Curie - Research Breakthroughs (1897-1904)*. American Institute of Physics, n.d. Web. 20 Feb. 2017
[16]"Marie and Pierre Curie and the Discovery of Polonium and Radium". *Nobelprize.org*. Nobel Media AB 2014. Web. 24 Feb 2017.
[17]Curie, Marie. Pierre Curie: With Autobiographical Notes. Trans. Charlotte Kellogg. New York: Macmillan, 1923. Print.
[18]Curie, Marie. Pierre Curie: With Autobiographical Notes. Trans. Charlotte Kellogg. New York: Macmillan, 1923. Print.

French professor, they had no means to go about buying that amount of pitchblende. Fortunately, the Viennese Academy of Sciences spoke to a uranium mining excavation company on behalf of the Curies and convinced them to sell their excess pitchblende to the Curies at a reasonable price. Through this transaction, the Curies were able to obtain several tonnes of pitchblende and begin extracting the new element. However, when they refined the pitchblende, they found not one, but *two* new radioactive elements. One they named polonium, after Marie's home country, and the other they named radium, derived from the Latin word for 'ray.' They publicly announced the existence of polonium in July 1898 and radium the following December. These discoveries are some of the most important discoveries in the world of radioactivity study. Marie Curie herself said "...it can be said that the task of isolating radium is the corner-stone of the edifice of the science of radioactivity."[19]

The Doubtful Scientific Community

Even though her results were groundbreaking, they turned the scientific world on its head and set it spinning. Before that time, the atom was considered the smallest particle of matter -- the word atom itself comes from the Greek word *atomos*, which means 'indivisible'. Marie Curie's theory said that the atom emitted particles even smaller than the atom. This proved that the atom's structure was even more complex than previously thought, which went completely against the principles which had developed about the atom.

[19] Curie, Marie. "Nobel Lecture." *Marie Curie - Nobel Lecture*. Web. 21 Feb. 2017.

The animosity she faced as one of the 23 female students at the 1,800 student university of Paris did not go away as she began to make new discoveries.[20] Instead, it led scientists to doubt her results. Not only was she publishing a radical idea that went against the very foundations of the small atomic science field, but she was a *woman* publishing a radical idea that went against the very foundations of the small atomic science field. Despite the disbelief and doubts that circulated around her research, Marie Curie's theories eventually took hold within the scientific community and transformed the ideas about the structure of the atom. However, some thought that it wasn't Marie Curie doing the research at all and that she was merely taking credit for Pierre's discoveries. In a society where men were expected to be the intellectuals, and women were considered inferior to their mental capacities, this conclusion wasn't a huge leap, but it was wrong.

The Nobel Prizes

In spite of the opposition faced by Marie Curie, her discoveries still led her to great success. Following her isolation of polonium and radium, and her research into radioactivity and its effects, she, Pierre, and Henri Becquerel split the Nobel Prize of Physics in 1903.[21] Thus, she became the first woman to ever win a Nobel Prize. However, it was not without its own set of trials. The Nobel Prize was first awarded to only Pierre and Henri, not Marie[22]. This blatant disregard for her work on the discoveries was not

[20] "Marie Curie." *Khan Academy*. Khan Academy, n.d. Web. 19 Feb. 2017
[21]"Marie and Pierre Curie and the Discovery of Polonium and Radium". *Nobelprize.org*. Nobel Media AB 2014. Web. 24 Feb 2017.
[22] "Marie Curie." *Khan Academy*. Khan Academy, n.d. Web. 19 Feb. 2017

unnoticed by Pierre, and he quickly remedied it, asking them to also award part of the prize to Marie.

She was not simply the first *woman* to win a Nobel Prize, she was the first person to *ever* win two Nobel Prizes.[23] She won her second Nobel Prize in Chemistry in 1911 "in recognition of her services to the advancement of chemistry by the discovery of the elements radium and polonium, by the isolation of radium and the study of the nature and compounds of this remarkable element."[24] This achievement is a testament both to her breakthroughs in the scientific understanding, and her success at challenging the social norms and expectations of women in that era.

Ripples into Waves

Not only did she rise above what was expected of her, but Marie Curie's contributions to the scientific world sparked whole new branches of science. The prospect of entirely new concepts was as appealing to other scientists as the mysterious uranium rays discovered by Henri Becquerel was to Marie. One of these curious scientist, name Ernest Rutherford, studied the rays emitted by the atoms of radioactive elements. He soon discovered and separated alpha and beta particles, which took Marie's already revolutionary discovery to a whole new level. He distinguished these two particles and theorized that radioactive atoms break down into other atoms. If he is considered the father of nuclear physics, Marie Curie should be the mother, for it was

[23] "Marie Curie - Facts". *Nobelprize.org*. Nobel Media AB 2014. Web. 16 Feb 2017.
[24] "Marie Curie - Facts". *Nobelprize.org*. Nobel Media AB 2014. Web. 16 Feb 2017.

her research that sparked Rutherford's. Nevertheless, even today, we still credit him more than Curie.

After Rutherford's discovery, scientists realized that they could use this breaking down of atoms to measure the age of certain materials. Thus, the term radioactive 'half-life' was born. The concept that there are unstable atoms was what Albert Einstein investigated, and is part of what led him to formulate his theory of relativity.[25]

Not only did her research inspire some of the greatest scientists ever, it also directly influenced the way cancer is treated, paved the way to new sources of power and led to developments in how we kill pests[26]. Not to mention, nuclear science and theory stemmed from her extensive research into radioactive materials and the consequential understanding of the structure of an atom.

Legacy

Marie Curie is a legendary physicist, without whom much of today's modern theories, such as the famous theory of relativity and nuclear physics would not even be possible. In addition to overcoming the challenge of poverty and mastering a new language, she faced the societal challenge of being considered an oddity--a woman student of science. Nevertheless, she rose far above these trials. Her devotion to her work and her brilliant mind led to some of the greatest discoveries of her time. She has been recognized as a very important woman in the development of modern science. Despite the sexism she faced, she rose above them all; won two Nobel Prizes and

[25] "Marie Curie." *Khan Academy*. Khan Academy, n.d. Web. 19 Feb. 2017
[26] "The Many Uses of Nuclear Power." *The Many Uses of Nuclear Technology - World Nuclear Association*. N.p., n.d. Web. 05 Apr. 2017.

contributed greatly to the scientific world. Marie Curie proved herself to be an intelligent and innovative scientist at a time when the scientific world was predominately male and sexist. This defiance of the social standards of the time helped open doors to aspiring young women who also wished to rise above the restrictions society imposed on them. Without Marie's radiant discoveries, the world would be a darker place.

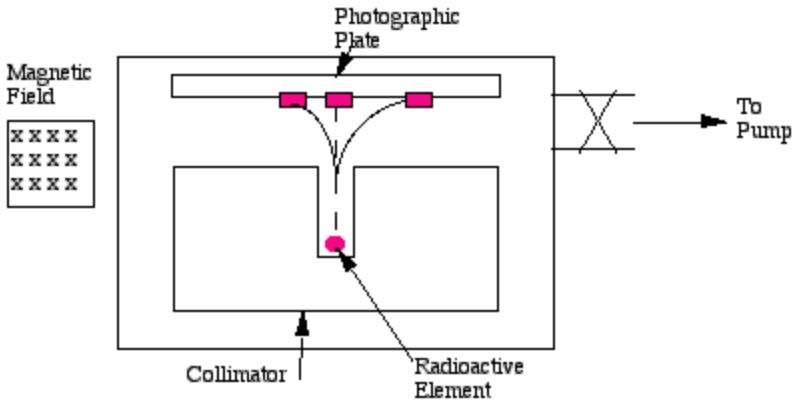
Appendix

Appendix I

A picture of Marie Curie

"Marie Curie - Facts". *Nobelprize.org*. Nobel Media AB 2014. Web. 16 Feb 2017.

Appendix II



Henri Becquerel's experiment that proved the existence of 'uranium-rays' and that they are affected by a magnetic field. This helped Marie discover radium and polonium.

"The Discovery of Radioactivity." *The Discovery of Radioactivity*. Guide to the Nuclear Wall Chart, 9 Aug. 2000. Web. 21 Feb. 2017

Appendix III

Pierre Curie and the quartz piezo electroscope - invented by his brother and him, used by Marie Curie to measure the amount of electricity in the air (caused by uranium rays)

Curie, Marie. *Pierre Curie: With Autobiographical Notes*. Trans. Charlotte Kellogg. New York: Macmillan, 1923. Print.

Annotated Bibliography

Primary Sources

Curie, Marie. "Nobel Lecture." *Marie Curie - Nobel Lecture*. Web. 21 Feb. 2017.

This was her Nobel Lecture, given after receiving the Nobel Prize in chemistry in 1911. Hearing things phrased how she saw her work and its influence on science was enlightening and helped make my paper as true to the facts as possible

Curie, Marie. *Pierre Curie: With Autobiographical Notes*. Trans. Charlotte Kellogg. New York: Macmillan, 1923. Print.

This book was entirely written by Marie Curie, with the exception of the introduction by one of her close friends. It was invaluable in seeing what conditions she had to work in, what experiments she conducted and how exactly she came to discover the two new elements.

Secondary Sources

"Marie and Pierre Curie and the Discovery of Polonium and Radium". *Nobelprize.org*. Nobel Media AB 2014. Web. 24 Feb 2017.

This article was very detailed and supplied me with a lot of information that I otherwise would not have known. It is one that I turned to often to verify facts from other sources and helped paint a clear picture of the trials Marie Curie faced.

"Marie Curie Enshrined in Pantheon." *The New York Times*. The New York Times, 20 Apr. 1995. Web. 10 Feb. 2017.

This article was from when Marie Curie's efforts paid off even more. Even the French president made sure everyone knew that she was interred there under her own merit and because of her meaningful contributions to society. This strengthened my paper overall.

"The Discovery of Radioactivity." *The Discovery of Radioactivity*. Guide to the Nuclear Wall Chart, 9 Aug. 2000. Web. 21 Feb. 2017

This article was very detailed in exactly how Henri Becquerel discovered radioactive waves - it even included a diagram of his experiment. Overall, this helped me better understand the experiments that went into the monumental discovery.

"Marie Curie." *Biography.com*. A&E Networks Television, 20 Nov. 2015. Web. 21 Feb. 2017.

Like all articles from biography.com, this was one I could trust to be accurate and contain facts that I either didn't know, or that I could use to cross reference facts from other sources.

"Marie Curie." *Khan Academy*. Khan Academy, n.d. Web. 26 Feb. 2017

While this did talk about her life, it more focused on the scientific aspect of her work, and the effects it had on the world around her. As a scientific person myself, this was a fascinating article to read.

"Marie Curie - Facts". *Nobelprize.org*. Nobel Media AB 2014. Web. 16 Feb 2017.

This article's main purpose was to tell me how many Nobel Prizes Marie won, and under what categories. It was very useful for that, but not much else.

"Marie Curie - Research Breakthroughs (1897-1904)." *Marie Curie - Research Breakthroughs (1897-1904)*. American Institute of Physics, n.d. Web. 20 Feb. 2017

This article also focused on the scientific aspect of her work, but in a different way, that made me rethink some of the things I had learned about Marie Curie. It also was the first place that I learned that her discoveries stemmed from the discovery of x-rays, which was fascinating.

Blom, Philipp. "1903: A Strange Luminescence." *Vertigo Years: Europe, 1900-1914*. New York: Basic, 2010. 71-78. Print.

This book was especially helpful because it focused on one of the main points of my thesis, and helped me integrate little bits of evidence supporting said thesis into my paper.

"Polonium." *Today's Science*. Infobase Learning, Web. 4 Apr. 2017.

This article was very helpful in understanding polonium and its effects and uses in the scientific world today, which in turn helped me to understand the effects of Marie Curie's work on the world.

"A History of Poland." ***A History of Poland*****. N.p., n.d. Web. 04 Apr. 2017.**

This site was *extremely* helpful in understanding the Poland that Marie grew up in. It was hinted at in other thing I had read, but this stated it clear as day and really gave me a deep understanding of what was happening.

"The Many Uses of Nuclear Power." ***The Many Uses of Nuclear Technology - World Nuclear Association*****. N.p., n.d. Web. 05 Apr. 2017.**

This site was crucial to deepening my understanding of how much Marie Curie's discoveries influenced the world today - and it affected much more than I thought.