Maria Salomea Skłodowska-Curie (Physicist, Chemist, Radiation Pioneer)

November 7,1867 – July 4,1934

When you ask a person on the street to name a famous woman scientist, the answer will surely be Marie Curie. Maria Salomea Sklodowska Curie AKA Marie Curie - also sometimes called Madam Curie to distinguish from her husband Pierre Curie - is the most famous female scientist in history! This distinction is quite deserved considering that she is the first woman to win a Nobel Prize, the first person to receive a Nobel Prize twice, and the first person to win Nobel Prizes in two different scientific fields – that is, Physics and Chemistry. Although she was twenty-five years younger than Ellen Richards, there are many similarities between these two women. First, they were born in a family that values education. Both parents of Marie were teachers just like the parents of Ellen Richards. Both wanted to go to college to further their education, but both were hindered because there were so few schools that accepted women. Both worked to save money for their college education: Ellen taught, tutored, and cleaned houses while Marie worked as a governess. Both married supportive husbands who were also scientists. Both were rejected in their goals early in life. Ellen did not receive the PhD from MIT even though she studied for it just because MIT did not want a woman to be the first recipient of a PhD from MIT. Marie was not elected to the French Academy of Science because of jealousy and doubts about her scientific creativity. Too many people would not believe that she was an equal partner/researcher with her husband. They said that all the important discoveries had been made during Pierre's time. There had never been a woman elected to the French Academy of Science. Some said it would be an "audacious precedent" if they accepted a woman. Both women were highly intellectual, practical,

and supported causes that are dear to them. Ellen advocated for clean water and air, good nutrition, and scientific education for women while Marie always supported her beloved Poland's fight for independence from Russia. She also raised funds to create the Radium Institutes both in Paris and in Warsaw.

Her science journey began when Maria Salomea Sklodowska was born in Warsaw, Congress Poland on November 7, 1867. Congress Poland, a creation of the Congress of Vienna, was called the Kingdom of Poland but was de facto a part of the Russian Empire. Maria was named after Mary the Patroness and Protector of Poland, also known as the Black Virgin of Czestochowa or the Black Madonna of Czestochowa. Her parents were both born from minor nobility in Poland, descendants of Catholic landowners, whose family lost all its possessions during the Polish nationalist uprisings. Her father Władysław Skłodowski was a teacher in mathematics and physics and her mother Bronislawa Sklodowska was the headmistress of a private school. In Poland the girl's last name ends in "*a* "and the boy's last name ends in "*i".* Thus the family is known as the Sklodowskis. Her mother died from tuberculosis in 1878 when she was 10 years old, and her older sister Zosia died of typhus in 1876 two years before her mother. These two deaths greatly affected the young Maria. She has always been the smartest one in the family and inherited her passion for mathematics and physics from her father. Both parents of Maria valued education for their son and 4 daughters. They enrolled their daughters in Madam Jadwiga Sikorska school. Not only were the children taught reading and mathematics, but also, they were surreptitiously taught the history of Poland, the Polish language, and geography. The latter subjects were taught out of sight of unsuspecting Russian inspectors.

Maria and her sister Bronia (named after their mother Bronislawa) wanted to go to college in Paris but they did not have the funds to go to school at the same time. There were no colleges that would accept women in Poland. Their brother Josef was already in medical school at Warsaw University. Maria and Bronia hatched a plan where Maria would work as a governess while supporting Bronia in medical school. Then when Bronia was finished she would pay for Maria's education in Paris. The plan worked well until Maria fell in love with the oldest son of her employer Kaziemierz Zorawski who was a student in mathematics at Krakow University. Alas, their romance got no support from the Zorawski family. They felt that their son could do better than marrying a governess. Broken-hearted, Maria gave herself one last chance with Kaziemierz. She enrolled in the Flying University in Warsaw and used the laboratory of her cousin Josef Boguski. He had returned from studying in St. Petersburg under Dmitri Mendeleev, the Russian chemist best known for formulating the periodic table of the elements. In the late

1800s, The Flying University clandestinely offered an education to women in ever changing locations, often private houses throughout the city.

After Maria's several attempts to reconcile with Kaziemierz Zorawski, Bronia told her to really get her act together, forget about Zorawski and go to Paris. Later Kaziemierz Zorawski received his doctorate in mathematics and became a prominent mathematician and full professor at the Warsaw University of Technology. As an old man, after he retired and became a professor emeritus, he would be seen sitting contemplatively before the statue of Marie Curie that has been erected in 1935 in front of the Radium Institute at the University of Warsaw. He died in 1953.

Maria arrived in Paris in November 1891. She then changed her name to Marie. Bronia married another doctor named Kaziermierz Dluski, a Polish physician and social and political activist. Marie enrolled at the Sorbonne and began her studies in physics, chemistry, and mathematics. She was one of 23 women out of class of 1825. One of her mentors was Gabriel Lippman, Nobel Prize winner in 1908. Here again we see the importance of having good mentors. As Ellen Richards was mentored by Maria Mitchell and Charles Samuel Farrar, Marie was mentored by Gabriel Lippman. In 1893 Marie passed the license exam in Physics, a step beyond a bachelor's degree. She ranked first in her class. As she realized the importance of mathematics in physics and chemistry, she went to school for another year and passed the license in Mathematics. This time she ranked second in her class.

Marriage to Pierre Curie

While still a student finishing her mathematics degree, Marie was hired to study the magnetic effects of various steels by the Society for the Encouragement of National Industry. But her workspace was so limited that she started looking for a bigger laboratory. She met some old friends from her governess years who were visiting Paris for their honeymoon, a Polish physicist Josef Kowalski and his wife. Josef Kowalski knew a physicist in Paris who may have had some room to share. His name was Pierre Curie. The honeymooners were probably trying to become matchmakers also. After that disastrous romance with Kaziermierz Zorawski left her broken-hearted, Marie had declared that she would never marry. Pierre on the other hand had lost his first love when she died at 20 years old. Pierre had decided to live a monastic life and never get married. These two broken-hearted scientists met at the right time and sparks flew on their first meeting. Pierre was surprised how much they have in common even though she was a Polish woman. Pierre had written in his diary before he

met Marie that it was hard to find a “woman of genius”. “Women of genius are rare”. Obviously, Pierre thought Marie was a rare woman of genius.

At this time, Pierre Curie was 34 years old and a professor at the Ecole de Physique et Chimie Industrielles (School of Industrial Physics and Chemistry). Pierre was the son of Eugene Curie and Sophie-Claire Depouilly. Both sides of Pierre’s family had scientists and inventors. Sophie -Claire’s father and brothers were commercial inventors and Eugene and his father were both physicians. Through his paternal grandmother, Pierre was also a direct descendant of Jean Bernoulli, an important Swiss mathematician, through his son Daniel Bernoulli, famous for the Bernoulli’s principle and Bernoulli’s equation in fluid dynamics. Pierre was home schooled by his father. In 1875, at 16 years old, he received his bachelor’s degree in mathematics. Two years later he received his license in physical sciences at the Sorbonne also known as the University of Paris. In 1895 he received his doctorate in physics; then he became a physics professor in 1900.

In 1880, Pierre and his older brother Paul-Jacques invented the piezoelectric quartz electrometer to demonstrate that an electric potential was generated when crystals were compressed. Pierre was very comfortable collaborating with Marie at the Laboratory because he used to collaborate with his older brother on many experiments and inventions.

Pierre asked Marie to marry him but Marie’s love for Poland took precedence. She returned to Poland after graduation. During the summer of 1894, they exchanged many letters with Pierre asking Marie to come back to Paris and move in with him and marry him. Finally, Marie relented and came back to Paris.They got married on July 26, 1895 at the Sceaux, France Town Hall. Their reception was held at the house of Pierre’s parents in Sceaux. Bronia’s mother-in-law wanted to give Marie a wedding dress. Marie asked Mrs. Dluska to not give her a white wedding dress but instead give her a simple blue suit so Marie could later use it as a laboratory uniform. Pierre and Marie went on a bicycle trip through Brittany for their honeymoon.

Discovery of Polonium and Radium

In January 5,1896, William Roentgen discovered X-rays. Antoine Henri Becquerel who was doing research on phosphorescence became interested in the connection between phosphorescence and these X-rays. He thought that phosphorescent materials might emit penetrating X-ray-like radiation when illuminated by bright sunlight. He used various phosphorescent materials including some uranium salts for his experiments. His experiments also included non-phosphorescent uranium salts. In May 1896 he correctly guessed that the penetrating radiation came from the uranium itself, without any need for excitation by an external energy source. He had discovered spontaneous radioactivity.

Marie was looking for a topic for her doctoral thesis. Becquerel's rays interested her. But if Marie were to experiment with them, she would need a suitable laboratory. So Pierre asked the director of the school where he was was teaching, and Marie was given the glass-in room downstairs for free. The room was damp and humid in the summer and bitterly cold in the winter. This is typical of laboratories given to women for research in those days. Somehow you would have to possess "nerves of steel" to endure them. This is just like the basement classroom at MIT that Ellen Richards endured during her first year at MIT.

First, Marie tried different materials to see which ones emitted radiation. She discovered after testing that thorium produced rays similar to uranium.She also discovered that the rays emitted depended solely on the amount of uranium present. She had successfully demonstrated that radiation was not caused by an interaction between molecules but that radiation was an atomic property, proportional to the amount of radioactive substance being measured.

She determined that pitchblende (in 1789 another chemist Martin Heinrich discovered that pitchblende contained uranium) was four times as active as uranium and chalcocite two times as active as uranium. She concluded that these two must contain substances other than uranium. Some scientists speculated that she made an error in the experimentation. Marie then realized she would have to convince these skeptics by isolating these unknown substances emitting radiation. She decided to grind up the pitchblende and dissolve it in acid. Then she broke in down in different components using standard chemical techniques such as fractional crystallization and spectroscopy. At this point Pierre had given up on his own research and started helping Marie with her experiments for these unknown substances. They added hydrogen sulfide to a a solution of bismuth nitrate and found that the resulting precipitate was 150 times more active than uranium. They were now convinced that they have discovered a new element which they called Polonium in honor of Marie's beloved country Poland. Marie coined the term radioactive to describe the behavior of these materials that behave like uranium. Then they discovered that the remaining liquid after they remove the bismuth and polonium precipitates was still radioactive. They named this second element Radium. It was more radioactive than polonium and 900 times more radioactive than uranium.

Now Marie had to convince the other chemists by getting the atomic weight of polonium and radium. She needed to isolate the new elements. She would need lots of pitchblende material. Once they were able to buy the pitchblende and have it delivered they had to find a place to store it. They found an abandoned shed with a dirt floor formerly used as a dissecting room of the medical school of the university. The shed was used for analytical work and the yard for storage. In summer it was very hot and in the winter it would sometimes freeze - not the best conditions for first rate research!

By 1901, the research was divided into two parts, first the isolation of radium and second the study of rays emitting from radium. Marie became the chemist and Pierre the physicist. After treating a ton of pitchblende residues, Marie was able to isolate one tenth of a gram of pure radium. After announcing the results in her own name, Marie wrote her doctoral thesis *"Researches on Radioactive Substances*". She defended her thesis on June 25, 1903 amidst a big crowd, not a usual thing for people defending their doctoral thesis but in the audience sat her family, friends, colleagues, and curiosity seekers. Marie was awarded the degree of Doctor of Physical Science at the University of Paris with the added accolade of *tres honorable* (equivalent to modern day magna cum laude). She would become the first woman to get a doctorate in France

Nobel Prize Winners

In 1903, Henri Becquerel and Pierre Curie were nominated for the 1903 Nobel Prize in Physics. Pierre Curie was nominated by four members of the Academie completely leaving out Marie Curie. The male scientists considered her as working as an assistant to Pierre. If we consider that Marie led the research because she had chosen it as a doctoral thesis topic, and she did all the isolation of radium, it's almost a slap on the face to say that Pierre would be the lone person to receive the award. One of the prize committee members, Gosta Mittag-Leffler, a great supporter of women scientists, wrote to Pierre and gave him a heads up. Pierre told the

committee he would not be willing to receive his prize if his wife is not included. The year before Marie had received two votes for the Nobel Prize (it was a very new prize, only started in 1901). One of these votes was declared to be valid for 1903, so Marie got the nomination on a technicality, as we would call it nowadays. I guess it was also a way for the Nobel Prize committee to save face. Becquerel attended the ceremony but the Curies did not go to Sweden, telling the committee that their classes prevented them from attending. Thus Marie became the first woman to receive a Nobel Prize, a prize so elusive that as of today in May, 2024, only 5 women have received the Nobel Prize in Physics: Marie Curie (1903), Maria Goeppert-Mayer (1963), Donna Strickland (2018), Andrea Ghez (2020) and Anne L'Huillier (2023). In 1905, the Curies finally made it to Stockholm to receive their Nobel Prize and award money. Pierre delivered the lecture and Marie who had done much of the work Pierre was describing in his lecture sat in the audience, giving the audience the impression that Pierre was the more important scientist.

Raising Children as a Working Mother

In the late 1800s it was unheard of for a woman to work as a scientist much less to also have children. Two weeks before her first child Irene was born on September 12, 1897, Marie's mother-in-law died. With her father-in-law becoming a widower, he was quite happy to move to Pierre and Marie's house and become their full time babysitter. In December 1904, their second child Eve Curie was born. Marie was your typical working mother, always tired and busy. But she also applied scientific principles in her domestic work: she would write annotations on the margins of her cookbook and recorded every detail of her daughter's Irene's life just like the way she would meticulously record observations of an experiment. She carefully noted her weight every day, her diet, and the appearance of each tooth. At that point, she was also experiencing exteme fatigue, probably from exposure to radiation from radium.

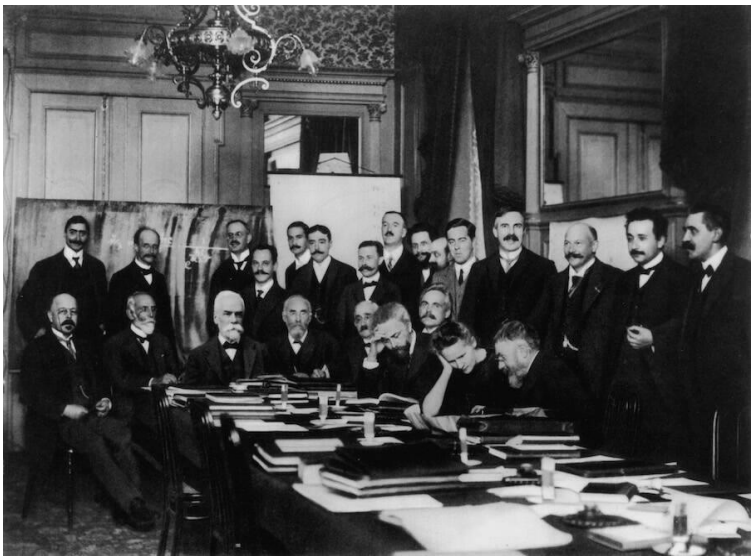
Traffic Accident

On April 19,1906, Pierre attended a meeting of the Association of Professors of the Science Faculties at a hotel. After the meeting he walked with a friend towards the Latin Quarter. Then he left his friend and walked towards the Institute Library. It was raining and Pierre walked with his head down. A pair of horses pulling a 6000 kilogram laden wagon collided with Pierre and knocked him down. The driver tried to pull the horses to the left to avoid Pierre but one of the rear wheels of the wagon rolled directly over Pierre's skull. He was dead in an instant. One of the leading scientists in the world has died in a freak traffic accident!

The Department of Physics voted to give the chair of the Physics Deaprtment and the professor of physics job that Pierre had to Marie Curie. Although she was highly qualified some of the professors in the department questioned her qualification to be chair. As a compromise she became professor but not chair of the Physics Depaartment.

Another Nobel Prize

Marie was devastated with the death of her husband but she had to go on to raise her two daughters. In December 1911, Marie, her sister Bronia, and her daughter Irene went to Stockholm to receive the Nobel Prize in Chemistry for the discovery of polonium and radium and to deliver the lecture. This time she made sure she tell the world which experiments are hers alone and which ones were done with Pierre. No doubt Pierre would have also received a second Nobel if he were alive but this time it was only Marie at the podium.



Marie attended an international Physics conference in Brussels, Belgium where she was the only woman in the group.

World War I and Petit Curie

During World War I, Marie served her country with what she knows best-science. The doctors realized that they will be able to save many lives if they can find the exact location of the bullets through X-rays. But there were no X-ray machines in the battlefront. Marie decided to help and asked a private organization, *Patronage des blesses*, to give funds so Marie could design such mobile radiography units. They became known as *petit* Curie (little Curie). The first military radiology center was in operation by late 1914 at Criel, France, 20 miles from the front line at Compiegne. The center was manned by Marie and her daughter Irene. The mother and daughter team opened 200 radiological units at field hospitals and sent 20 mobile units out into the field in the first year of the war. Irene traveled al over the front lines training doctors and surgeons in using the mobile unit. Later, Marie trained hundreds of young women to become X-ray technicians. At war's end, an estimated one million soldiers have been treated using the *petit* Curie.

Travel to America

In 1921, Marie went to the United States of America to accept a gift of I gram of radium. Marie only has less than 1 gram of radium in Paris and America possessed 50 grams. Although she initially thought of doing some sight seeing of America before accepting the gift of radium, her stay lasted longer than planned - 7 weeks. Besides appearances at public events, she received ten honorary college degrees and numerous honors and awards. On May 20, 1921 she attended a reception at the White House where President Warren G. Harding presented her with a leather case containing 1 gram of radium, a gift from America to France.

Radium Institute

The Radium Insititute at the University of Paris was established in 1912 by Marie Curie to honor her husband Pierre and to have a world center for the study of radioctivity. Marie continued research in polonium and radium until her death. The Radium Institute also became an international center for measuring the radium content of various products. The Insitute provided this service to doctors and other who used radium.

Her Legacy

Marie Curie died on July 4, 1934 at 66 years old from aplastic anemia. The cause was her long term exposure to radiation from polonium, radium, uranium, thorium and other sources, all during her experiments. She was also exposed to x-rays during her work with the *Petit* Curie radiology units. Marie has been suffering from ill health which she tried to hide from her co-workers and colleagues. She had symptoms like low blood pressure, anemia and dizziness. Her eyes became clouded with cataracts. All these symptoms were related to exposure to radiation but at that time no one really knew the danger of too much exposure to radiation.

She was buried on July 8, 1934. Her coffin was lowered over Pierre's coffin in a simple ceremony at the Sceaux cemetery attended by family members. Her sister Bronia and brother Josef each brought a handful of Polish soil to sprinkle over Marie's coffin. In April 20,1995, Marie's and Pierre's remains were both transferred to the Paris Pantheon to honor their achievements. Marie became the second woman to be interred at the Pantheon and the first woman to be honored with internment in the Pantheon, France's National Mausoleum, for her own accomplishments.

Her daughter Irene Joliot-Curie and her son-in-law Frederic Joliot-Curie won the 1935 Nobel Prize for Chemistry for discovery of artificial radioactivity.

Marie founded the Curie Institute in Paris in 1920 and the Curie Institute in Warsaw in 1932.

In 1910, the curie (symbol Ci) was established as a unit of radioactivity named for both Pierre and Marie Curie.One curie is equal = 3.7×10^{10} decays per second.

She and Pierre did not patent their method of isolating radium. Both of them were adamant that science was for the benefit of mankind. They believed that an invention or discovery did not belong to the scientist and he or she should not receive material or monetary benefit from it. Marie realized that other people have enriched themselves from the processes of isolating radium that the Curies have invented and questioned whether they had made the right decision for their children and grandchildren. In the end she concluded that they made the right decision, not to profit from their invention.

In 1944, a team of scientists composed of Glenn T. Seaborg, Ralph A. James, and Albert Ghiorso intentionally made the element Curium using the cyclotron at Lawrence Berkeley National Laboratory (LBNL). They bombarded the newly discovered Plutonium element with alpha particles. The sample was sent to the Metallurgical Laboratory at the University of Chicago where a small amount of curium was separated and identified. They named the newly discovered element Curium in honor of Marie and Pierre Curie. Curium is a synthetic element with the symbol Cm and atomic number 96. It is a hard, dense, silvery metal with a high melting and boiling point for an actinide. It is paramagnetic at ambient conditions but becomes antiferromagnetic upon cooling. All known isotopes of curium are radioactive and have small critical mass for a nuclear chain reaction.

In 1997 UNESCO honored the anniversary of the Marie Curie's 130th birthday with a commemorative medal. The medal was unveiled in 1998 together with the launch of the Future Scientists Campaign of UNESCO.

When the United Nations designated 2011 as the International Year of Chemistry, the celebration was linked to the 100th anniversary of Marie's Nobel Prize in Chemistry. Google honored Marie with a Doodle on November 7, 2011, her 144th birthday.

HER SCIENCE JOURNEY:

1867- Maria Salomea Sklodowska was born in Warsaw, Poland

1876 – Maria's older sister Zosia died of typhus

1878 -Maria's mother died of tuberculosis

1883-Graduated from secondary school

1886- Worked as governess at the Zorawski household

1889- Moved to Paris and enrolled at the Sorbonne

1893 -Received degree in physics, first in class

1894 -Received degree in mathematics, second in class

1895 -Married Pierre Curie

1897 -Irene Curie was born

1898 -Discovered polonium and radium and coined the term radioactivity

1903-Received Nobel Prize in Physics with Pierre Curie and Henri Becquerel

1904 -Eve Curie was born

1906 -Pierre died in a traffic accident and Marie became the first female professor at the Sorbonne

1911 -Applied for membership to the French Academy of Sciences and was rejected

1911 -Received the Nobel Prize in Chemistry

1914- Radium Institute completed

1914-1919 – Operated the *petit* Curie radiological units

1921 -Visited the United States to receive the gift of 1 gram of radium

1929 -Second trip to US to raise funds for the Radium Insititute in Warsaw

1934 – Died of aplastic anemia

1995 -Remains transferred to the Pantheon, France National Mausoleum

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