

In 2011 we mark the centenary of Marie Curie's second Nobel Prize. The Royal Society of New Zealand is holding a series of lectures around New Zealand by women chemists.

Further information can be found at <http://www.royalsociety.org.nz/events>

2011 is also the International Year of Chemistry, and many events are being planned. Details are available at www.yearofchemistry.org.nz

Envisioning science: Marie Curie's journey from Poland to Paris

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All my mind was centred on my studies. I divided my time between courses, experimental work, and study in the library. In the evening I worked in my room, sometimes very late into the night. All that I saw and learned was a new delight for me. It was like a new world open to me, the world of science which I was at last permitted to know in all liberty.

(Marie Curie cited by Goldsmith 2004, p. 49)

Marya Skłodowska (nicknamed Manya), born November 1867, was the fifth and youngest child in the Skłodowski family. Her mother, Bronislava, was Director of the Freta Street School, a private school for girls in central Warsaw. The family lived in an apartment at the school. Soon after Manya's birth, her father, Władysław, was appointed Assistant Director of a Russian Gymnasium on the western outskirts of Warsaw and the family relocated (Goldsmith 2004 p. 15). Eventually, Bronislava found the travelling from the new family home, her responsibilities as

principal, and caring for five children, too difficult, and resigned her position.

By the time Manya was four her mother was showing signs of tuberculosis, the disease that would eventually claim her life. Her father assumed responsibility for the family, and evenings for the children were a combination of exercise and study, developing a love of learning and pride in the Polish nation. Manya's intellectual ability was demonstrated early, when, aged four, she read aloud a sentence from the book her older sister Bronya was reading. Often she would watch her father carefully clean and regulate the barometer in the family workroom, or stand fascinated beside a display case. Professor Skłodowski, observing her interest, told her the shelves held physics apparatus. This included glass tubes, small scales, mineral specimens and a gold-leaf electroscope (Curie 1968, p. 15).

At six and a half Manya left the Freta Street School for one closer to home, where she was placed in a class with seven and eight year olds. Madame Jadwiga Sikorska, a Polish patriot, ran

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the school. In order to deceive the Russian authorities she made a double timetable where some subjects such as Botany and German Literature were replaced with Polish history and literature. When the Russian inspectors visited the school a warning bell would ring and Russian textbooks would replace Polish ones on the students' desks (Goldsmith 2004, p. 27).

The death of Manya's mother, in 1878, followed that of her elder sister Zosia from typhus in 1874. Thus began a series of depressions that would last throughout her life. To cope with the loss, she withdrew from the world and immersed herself in books and learning (Goldsmith 2004, p. 29). In 1879, against the advice of Madame Sikorska, her father enrolled Manya in Russian Gymnasium Number Three, gymnasia being the only pathway in Poland to higher education. The education was excellent, but all aspects of Polish culture had been removed, and Manya found this an unsympathetic environment. At 15, she graduated first in her class and received the medal for being the top student in 1883. The stresses of the previous four years surfaced at this time, however, and Manya retreated to her bedroom. Her worried father sent her to live with relatives in the country, and this change to her routine brought great happiness and joy and was to last for a year.

In 1883, the year Manya graduated from the Russian Gymnasium, Polish positivists¹ established a clandestine academy to offer young women the opportunity to further their education, and within a year there were more than 200 students. Polish positivism encouraged the teaching of Polish culture, history and language, to the workers and peasants, as a means of keeping the dream of a free Poland alive until the Russians could be expelled. The academy abruptly ceased when discovered by the Russians, who sent most of the teachers into exile. To the positivists, sending the teachers into exile was a challenge, and signalled the start of 'the Floating University' with over a thousand students enrolled. Courses in anatomy, natural history and sociology were taught in homes, including that of Jadwiga Sikorska, and in institutions in Warsaw. In later life, Manya would look back at the early influence of one of the tenets of positivism on her whole career, namely that all statements and conclusions should be, '... supported by evidence which can be checked.' (Goldsmith 2004, p. 35)

She and her older sister, Bronya, met women who valued higher education, and planned to enrol in universities abroad that accepted female students. The Russian authorities must have been aware of the academy, but chose to do nothing. Most of the students were women, and the adverse publicity from the closure of the academy would have been embarrassing. One of the aims of the Floating University was that students would become educators and give lessons to the poor (Curie 1968, p. 54). Both the sisters spent time as tutors, but when they realised they needed fulltime employment to enable them to save for future studies, it was decided that Bronya, as the eldest, would study medicine in Paris first, supported by Manya. Then, when she was qualified, Bronya would support Manya, who wanted

to become a scientist. Manya would find a job as a governess in the country with free room and board and send half her salary to Bronya, leaving their father to contribute what he could.

A week after this decision was made Manya obtained a position with a family of lawyers, but left after a few months. She then became a governess for the Zorawski family in Szczuki 80 kilometres north of Warsaw. She was accepted as a member of the family, but found social events difficult, because she did not have money to spend on clothes, so she spent her evenings studying. In the kitchen of the Zorawski home she and Bronka, the 19-year-old eldest daughter of the family, began to teach the children from the estate to read and write in Polish. This illegal and criminal activity would have meant exile in Siberia had the girls been discovered by the Russian authorities (Goldsmith 2004, p. 38).

Casimir Zorawski, the eldest son, returned home for the spring holidays from his studies at Warsaw University, and an attraction developed between him and this governess, who spoke three languages, understood mathematics, and loved nature. At the end of the summer the two spoke of their plans to marry. However, his parents forbade the marriage and threatened to disinherit him if he married 'a penniless governess who was obliged to work in other people's houses.' (Goldsmith 2004, p. 39). Humiliated, but needing to send money to Bronya for medical school, Manya felt unable to leave. In her letters to her family it became clear that she was becoming depressed, and at Christmas 1888, she wrote: 'I have fallen into black melancholy.' (Goldsmith 2004, p. 40).

Fortunately for Manya, she did not have to suffer this situation much longer. In April 1888, her father was offered the position of Director of a reform school outside Warsaw. Though he found the job distasteful, the salary was excellent, and after two years he would retire on a modest pension. From his salary he would be able to send money to Bronya. Manya resigned and returned home in April 1889. The following July, she obtained another position and travelled to Zoppel on the shores of the Baltic Sea, returning with the family to Warsaw for the winter (Curie 1968, p. 85).

When Bronya graduated from the Faculty of Medicine at the Sorbonne, she was one of three women out of a total of one thousand students. She and her husband, Dr Casimir Dluski, who had left Poland because his socialist views opposed those of the positivists, invited Manya to live with them in Paris and enrol at the Sorbonne. However, pressing family responsibilities, and her shaken confidence in her ability to successfully study, led her to decline the offer. Bronya's attempts to change her mind were initially ineffective, but eventually they reached a compromise: Manya would stay for another year with her father, save for her studies, and then go to Paris in November 1891. Little did they realise the impact that this year would have.

Joseph Boguski, Manya's cousin, directed the Museum of Industry and Agriculture, part of the Floating University, at 66 Krakovsky Boulevard (Curie 1968, p. 89). Behind the façade was a laboratory where, for the first time, Manya was able to reproduce experiments from physics and chemistry books, and remembered the days when she gazed into her father's glass cabinet and saw the physics apparatus. It was in this laboratory she developed a taste for experimental research, and realised she could choose to realise her dream.

¹ *Positivism in Poland was a socio-cultural movement that defined progressive thought in literature and other walks of life in partitioned Poland after the disastrous January 1863 Uprising against Imperial Russia. The Positivists viewed work, not uprisings, as the true way to maintain a Polish national identity and demonstrate a constructive patriotism. [Editor]*

She left for France, and after a four-day train journey, arrived at Gare du Nord. Within the week Bronya took her to the Sorbonne, where, with her newly found 'very precious sense of liberty and independence,' she signed the forms 'Marie', the French equivalent of her Polish name Marya (Goldsmith 2004, p. 46). She was one of only 23 women students out of 2000 studying in the School of Sciences. By the age of 23 she had developed the patience and tenacity to overcome obstacles, an ability to work independently, and a determination to devote her life to science. Her experience with Casimir Zorawski, however, had left her wary of personal relationships.

Life with Bronya and Casimir Dłuski was distractingly social and soon she moved into an attic room in the Latin Quarter, closer to the University, the laboratories and the libraries. Here she was able to study without distractions, oblivious to the social mores which governed women in French society and would have restricted her life.

Towards the end of her second year, Marie was one of only two women students sitting the examination for a degree in science. When the results of the examination were announced in order of merit, the name of Marie Skłodowska was read first.

The following year, with her name becoming known in Poland, she was awarded the Alexandrovitch Scholarship for students from Poland studying abroad. It helped to support her studies, and she obtained a second degree in mathematics, but was disappointed in only achieving second place. Some years later she repaid the scholarship, so that another student would benefit.

During 1894, Marie was introduced to Pierre Curie as someone who might be able to help with her research into the magnetic properties of various steels. Poor equipment and facilities meant she was making slow progress, and Pierre was acknowledged as an expert on the laws of magnetism. He was not able to assist with laboratory facilities, but introduced Marie to the piezoelectric quartz electrometer, which he had developed with his brother, Jacques (Goldsmith 2004, p. 52). This piece of apparatus would enable Marie to accurately measure small quantities of electricity. Marie and Pierre realised they shared many similarities in their backgrounds, families, and approach to work. Encouraged by Marie, Pierre completed his thesis: 'The Magnetic Properties of Bodies at Diverse Temperatures'. His research into the effect of heat on magnetic and non-magnetic properties of substances is still known as the 'Curie temperature' (Goldsmith 2004, p. 58). In Marie, Pierre had met the woman with whom he wanted to spend the rest of his life. Several times Marie rejected his proposals, but finally realising they were very compatible, she eventually accepted, and in 1895, at a simple ceremony in keeping with their lifestyle, they married.



Marie Curie in 1930. Image from: Steele, P. 2006. Marie Curie: The Woman Who Changed The Course Of Science. Washington, National Geographic Society.

Absorbed in their work, life for Marie and Pierre continued much as before, but flowers on the table and moving to a house with a garden were new pleasures. Marie realised they would need additional income, so she studied to become a qualified teacher, entitled to use the honorific, Professor. After the birth of their daughter Irene in 1897, Marie began her doctoral thesis. At this time, no woman in Europe had completed a doctorate (Rockwell 2003, p. 172). For her thesis topic she chose to investigate Becquerel rays, mysterious rays emitted by uranium salts. By March 1898, the initial results of her research on 'Rays emitted by uranium and thorium compounds' (Rockwell 2003, p. 172) was read at the Academy of Science by Gabrielle Lipmann, as neither Marie nor Pierre was a member.

She concluded that radioactivity was an atomic property, 'that did not depend on the chemical state of the uranium and was always proportional to the amount of the uranium

in the compound being tested.' (Rockwell 2003 p. 172). Marie introduced the concept that a new element could be discovered, if its radioactivity was different from that of a known element. Later the same year, Henri Becquerel read the paper, authored by both Curies, 'On a novel radioactive substance contained in pitchblende' at the Academy of Science. The mysterious element was too small to be detected by spectroscopy or chemical tests, so they measured the ionising activity (Rockwell 2003, p. 173). For this work, and her work on the magnetic properties of steel, Marie was awarded a prize of 3,800 francs. The Academy broke with tradition by awarding the prize to a woman. However, they confirmed the award by writing to Pierre! (Rockwell 2003, p. 173).

Over the following years, work on purifying polonium and radium continued, and both Curies wrote many papers. In 1903, Marie submitted her thesis and was awarded the degree of *Docteur des Sciences Physiques* with the mention, 'tres honorable' (Rockwell 2003, p. 174). Later that year, in November 1903, Marie and Pierre received the Davy Medal from the Royal Society in London for the most important discovery of the year in chemistry. With Henri Becquerel, the Curies were awarded the 1903 Nobel Prize in Physics for their 'joint work concerning investigations of the radiation phenomena described by Henri Becquerel' (Rockwell 2003, p. 175). Marie was the first woman to receive a Nobel Prize.

They continued to live simply, and used the prize money to provide scholarships for Polish students, and for Bronya to establish a tuberculosis clinic in Poland. A second daughter, Eve, was born in December 1904.

In 1906, tragedy struck. Pierre was killed as he stepped in front of a horse-drawn wagon (Rockwell 2003, p. 175). Marie became very depressed and for a number of months was unable

to work. The Sorbonne had to make an appointment to cover Pierre's teaching responsibilities, and, unable to ignore her qualifications, appointed Marie as Head of the Department of Physics. She became the first woman to lecture at the university, and hundreds gathered to hear her inaugural lecture. In 1910, 971 pages of notes from her lectures at the Sorbonne were published in two volumes: *Treatise on Radioactivity* (Rockwell 2003, p. 163).

Marie was able to increase the number of students in her laboratory when Andrew Carnegie, the American philanthropist, bestowed a series of annual research scholarships in 1907. Potential students who would not otherwise have been able to study physics were encouraged to apply for these grants, as Carnegie was very supportive of Marie's work. They had met in Paris just after Pierre's death, and he had been impressed by her simplicity of manner and precise objectivity.

Her laboratory was dedicated to 'medical, biological and industrial research for the peaceful benefit of humanity.' (Goldsmith 2004, p. 154). She continued to work with radium and eventually discovered a method for measuring the element based on the rays it emitted. She pursued the use of radium for medical treatments and industrial uses, manufacturing products at the de Lisle factory. Both laboratory and factory provided excellent training facilities for medical technicians.

Marie's caring though demanding attitude towards her 'laboratory children,' is clear in the following extract from an account written by a Norwegian student, Mme Gleditsch:

Marie Curie came every day and spent hours and hours there ... But what was most important and most precious was the close contact between the students and the heads ... She had a thorough knowledge of the work each student was doing, and was always very interested in all the details. In the laboratory, her face, which was usually closed and slightly sad, became animated, she smiled often, and she even laughed with a fresh, young laugh ...

(Giroud 1986, p. 151)

For many years, Marie had dreamed of a laboratory where she could continue her research. In 1909, design work began on the Paris Radium Institute. Two laboratories were planned;

one would focus on biology and cancer research, and the other on the physics and chemistry of radioactive substances.

In 1911, Marie Curie became the first woman to be awarded a Nobel Prize in her own right – this time in Chemistry - and the first person to receive a second Nobel Prize. The official letter commended her for 'producing sufficient pure samples of polonium and radium to establish their atomic weight, facts confirmed by other scientists, and for her feat of producing radium as a pure metal.' (Goldsmith 2004, p. 172).

In 1933, artists and writers from different countries gathered in Madrid to debate 'The Future of Culture', believing that culture was undergoing a crisis, and creativity becoming sterile and threatened by science. Marie was asked to preside over the debate.

I believe [declared Marie] that Science has great beauty. A scientist in his laboratory is not a mere technician: he is also a child confronting natural phenomena that impress him as though they were fairy tales. We mustn't let anyone think that all scientific progress can be reduced to mechanisms, machines, gearboxes ... though these things too, have their own beauty.

(Giroud 1986, p. 270)

Marie Curie epitomised the ability to be beautifully creative. Her pioneering spirit gave her the drive to become one of the first women to gain an education, and qualifications, in the sciences. At least as admirable was her choice to both marry and continue her work and study. Finally, she combined the ultimate creativity of motherhood, and mostly as a solo parent, with the work which gained her her second Nobel Prize, and other awards, and which continued for the rest of her life.

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