# Remembering Madame Curie

George Joseph *

*2011 marks the centenary of the Nobel Prize in Chemistry to Madame Curie. It was her second Nobel Prize, the first was in Physics in 1903 shared with her husband Pierre Curie and Henry Becquerel. The year 2011 is also declared as the International Year of Chemistry to celebrate the achievements of chemistry to the well being of humanity.*

**"Nothing in life is to be feared – it is only to be understood." — Marie Curie**

MADAME CURIE was an outstanding scientist, a role model not only for women, for men too. She was not only a great woman in science; she was a loving mother, a remarkable teacher, and above all, a noble human being steeped in the tradition of scientific outlook on life.

Manya, that was her childhood name, was born to Bronislawa and Vladislav Sklodowski, in Warsaw, Poland on 7 November, 1867. She was the youngest of the five children. Warsaw was then under the occupation of Czarist Russia. Even as a child she had experienced the repressive social environment and developed a hatred for anything unjust and inhuman.

After passing out from the school with gold medal, she wanted to pursue higher studies in science. But in Warsaw, girls were not admitted in the University, a social malady of the time. It was possible in Paris, France. Manya's family was not in a position to meet the expenditure for her study abroad. She and her elder sister Bronya

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decided to resolve it together. First Bronya would go for higher studies, while Manya would work as a governess to support her sister's studies. After Bronya finishes her studies and finds a job, Manya would take her turn. For four years Manya worked as governess teaching children of rich families in the countryside.

Manya returned to Warsaw in 1889. During this period in Poland, there existed an "underground" college, known as the Floating University run by Polish patriots, who viewed this as a pathway to the eventual freedom for their nation. Manya was an active participant in this voluntary effort and was introduced to philosophy, progressive politics, and to the latest developments in chemistry, physics, and physiology. They also found time to teach polish peasants and youths alphabet, language, literature etc. The Polish economist and later a prominent Marxist leader, Rosa Luxembourg was a contemporary of hers in the Floating University.

Meanwhile Bronya completed her medical studies in Paris and married a classmate Cassimir Dluska, a Polish exile, and started their medical practice in Paris. Manya joined them and began her higher studies in the Sorbonne University in 1891. "So it was in November, 1891," she recalled, "at the age of 24 that I was able to realize the dream that had been constantly in my mind for several years." Manya became Marie when she enrolled herself in Sorbonne. She completed her Masters degree in Physics in 1893 and with a Polish scholarship her Masters in Mathematics in 1894. She had to face extreme hardships and poverty during the entire period of her studies.

Marie had planned to return to Poland after she received her formal education, but "The Society for the Encouragement of National Industry" offered her a research work to conduct a study of the magnetic properties of steel. In the search for a proper laboratory to do these studies, she met Pierre Curie, a French physicist, a charming personality who worked at the Municipal School for Industrial Physics and Chemistry. This was the beginning of a journey that changed not only Marie's course of life, but also the course of modern science. Marie started her research work in the rudimentary lab space at the School. Even though the facilities in the lab were poor, the presence of a man of Pierre's caliber provided an intellectual ambience for research.

Pierre Curie (18591906) was born on May 15, 1859, the second son of Dr. Eugene Curie, who was himself the son of a doctor. His best friend was his elder brother, Jacques. By the time Pierre was 21 and Jacques 24, the brothers had discovered the piezoelectric effect (from the Greek word meaning "to press"). The Curie brothers had found that when pressure is applied to certain crystals, they generate electrical voltage. Reciprocally, when placed in an electric field these same crystals become compressed. Recognizing the connection between the two phenomena helped Pierre to develop pioneering ideas about the fundamental role of symmetry in the laws of physics. The brothers meanwhile put their discovery to immediate practical use by devising the piezoelectric quartz electrometer, which can measure faint electric currents. Nearly two decades later, the device helped Marie Curie in her early research. In the century following its discovery by the Curie brothers, the piezoelectric effect was put to use in familiar everyday devices like microphones, quartz watches, and electronic components.

Pierre was also a pioneer in the study of magnetism. He discovered a basic relationship between magnetic properties and temperature. The temperature at which cer-

Meanwhile Marie's relationship with Pierre was growing from mutual respect to love. "Our work drew us closer and closer, until we were both convinced that neither of us could find a better life companion." — Marie

In a simple civil ceremony in July 1895, they became husband and wife. Neither wanted a religious service. Marie had lost her faith when her devout Roman Catholic mother died young, and Pierre was the son of non-practicing Protestants. Nor did they exchange rings. Instead of a bridal gown Marie wore a dark blue outfit, which for years afterward served as a lab apparel.

The Curies' honeymoon trip was a tour of France on bicycles bought with a wedding gift.

tain magnetic materials undergo a marked change in their magnetic properties is today called the Curie point after Pierre. He also invented a highly sensitive scientific balance, similarly named in his honour, and which, too, was extremely useful in Marie's later work.

Although Pierre had done important scientific research in more than one field over 15 years, he had not completed his doctorate. Marie persuaded him to write up his research thesis on magnetism. In March 1895 he was awarded the degree and at the Municipal School Pierre was promoted to a professorship.

Marie's choice of a topic for her doctoral thesis was influenced by two discoveries by other scientists. In December 1895, about six months after the Curies married, the German physicist Wilhelm Roentgen discovered a kind of ray that could travel through flesh and yield photographs of living people's bones. Roentgen called these mysterious rays X-rays, with X standing for unknown. In recognition of his discovery, Roentgen in 1901 became the first Nobel laureate in physics.

In early 1896, only a few months after Roentgen's discovery, French physicist Henri Becquerel reported to the French Academy of Sciences that uranium compounds, even if they were kept in the dark, emitted rays that would fog a photographic plate. He had come upon this discovery accidentally. Despite Becquerel's intriguing finding, the scientific community continued to focus its attention on Roentgen's X-rays, neglecting the much weaker Becquerel rays or uranium rays.

The ignored uranium rays fascinated Marie Curie. Marie now used the Curie electrometer invented by Pierre and his elder brother, Jacques, 15 years back, to measure the faint currents that can pass through air that has been bombarded with uranium rays. With numerous experiments Marie confirmed Becquerel's observations that the electrical effects of uranium rays are constant, regardless of whether the uranium was solid or pulverized, pure or in a compound, wet or dry, or whether exposed to light or heat. Likewise, her study

of the rays emitted by different uranium compounds validated Becquerel's conclusion that the minerals with a higher proportion of uranium emitted the most intense rays. She went beyond Becquerel's work, however, in forming a crucial hypothesis: the emission of rays by uranium compounds could be an atomic property of the element uranium—something built into the very structure of its atoms.

Marie's hypothesis was something revolutionary that would ultimately contribute to a fundamental shift in scientific understanding. At the time scientists regarded the atom—a word meaning undivided or indivisible—as the most elementary particle. A hint that this idea was false came from the discovery of the electron by other scientists around this same time. But nobody grasped the complex inner structure or the immense energy stored in atoms. Marie tested all the known elements in order to determine whether other elements or minerals would make air conduct electricity better, or if uranium alone could do this. In this task she was assisted by a number of chemists who donated a variety of mineral samples, including some containing very rare elements. In April 1898 her research revealed that thorium compounds, like those of uranium, emit Becquerel rays. Again the emission appeared to be an atomic property. To describe the behaviour of uranium and thorium she invented the word "radioactivity" – based on the Latin word for ray.

Pierre was so intrigued by Marie's work that he joined forces with her. Her research had revealed that two uranium ores, pitchblende and chalcolite, were much more radioactive than pure uranium itself. She concluded that the highly radioactive nature of these ores might be due to one or more additional, as yet undiscovered, radioactive elements. The duo set out on an adventurous journey in trail of the suspected elements.

Since the Municipal School storeroom was inadequate for the task, the Curies moved their laboratory to an abandoned shed across the school courtyard. The shed, formerly a medical school dissection room, was too cold in winter, too hot in summer and was poorly ventilated.

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"Neither of us could foresee that in beginning this work we were to enter the path of a new Science which we should follow for all our future." — Marie

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Making repeated separations of the various substances in the pitchblende, Marie and Pierre used the Curie electrometer to identify the most radioactive fractions. They thus discovered that two fractions, one containing mostly bismuth and the other containing mostly barium, were strongly radioactive. In July 1898 the Curies published their conclusion: the bismuth fraction contained a new element. Chemically it acted almost exactly like bismuth, but since it was radioactive, it had to be something new. They named it "Polonium" in honour of the country of Marie's birth. A second publication, in December 1898, explained their discovery in the barium fraction of another new element, which they named "Radium" from the Latin word for ray. By 1898, the Curies had obtained only traces of radium, but appreciable quantities uncontaminated with barium still were beyond reach. They could not separate out polonium, the reason being that its half-life was only 138 days. After four long years of herculean struggle, from one ton of pitchblende, one-tenth of a gram of radium chloride was separated in 1902. Years later Marie wrote "Yet it was in this miserable old shed that we passed the best

and happiest years of our life, devoting our entire days to our work. Often I had to prepare our lunch in the shed, so as not to interrupt some particularly important operation. Sometimes I had to spend a whole day mixing a boiling mass with a heavy iron rod nearly as large as myself. I would be broken with fatigue at the day's end ···"

The Curies had discovered the radiochemical method of separation of elements. On the results of this research Marie Curie received her doctorate of science in June 1903 and, with Pierre, was awarded the Davy Medal of the Royal Society. Initially in 1903 the French Academy of Sciences, suffering from male chauvinism, nominated Henri Becquerel and Pierre but not Marie as candidates for the physics Nobel Prize. In a letter to Swedish mathematician Magnus Goesta Mittag-Leffler, Pierre wrote, "If it is true that one is seriously thinking about me [for the Nobel Prize], I very much wish to be considered together with Madame Curie with respect to our research on radioactive bodies." The Curies stood their ground. The 1903 Nobel Prize in physics was finally awarded to Pierre Curie, Marie Curie and Henri Becquerel "in recognition of the extraordinary services they have rendered by their joint researches on the radiation phenomena discovered by Professor Henri Becquerel."

The Nobel Prize brought worldwide fame to the Curies. But fame and glory did not blind the Curies. They continued their work with the same fervour as before. They had set many more tasks before them. The 70,000 gold francs awarded to them were used by the Curies for further experimentations and research, as well as to repay the generous support of family and friends, and to provide financial support for poor Polish students to continue their studies.

The Curies published in detail the procedures they used to isolate radium, refusing to patent any of them. They considered that the discovery of radium belonged to entire humanity; it was not to be reckoned their private property. Later in 1921 when Madame Curie required 1 gram of radium for the Radium Institute Paris, she was provided that 1 gram costing $100,000 by the women of America through a public fund raising programme led by the American reporter Mrs. W. B. Meloney. In 1925, when the Polish Government opened the Radium Institute in Warsaw in Curie's honor, the women of America saluted her a second time by raising funds to purchase another gram of radium for the Institute's use.

The happiness of the Curies was short lived. In 1906, a tragedy took away the precious life of Pierre. Pierre Curie's engagement for Thursday, April 19, 1906, was that of a man actively involved fully in both professional and social life. After a meeting of the Association of Professors of the Science Faculties, he was scheduled to go over proofs with his publisher and to visit a nearby library. After the meeting while hurrying to cross the street, he was run over by a horse-drawn wagon with a load of military uniforms, weighing some six tons. Death engulfed him instantaneously.

The French Government offered Marie a significant annual pension as Pierre's widow, which she refused. She stated that she was 38 years old, healthy, and could work. What Marie really desired was to have a laboratory to continue her work.

Marie was offered Pierre's Chair at the Sorbonne. This was an epoch-making event, as she became the first woman in its more than 600-year history to teach there. The amphitheater where she gave her first lesson was packed with reporters, students, professors, and celebrities from the world over. Many expected her to preface her lecture with a tearful tribute to her dead husband. Instead she entered amidst sus-

Marie with Albert Einstein in Geneva, 1925.

One of Marie Curie's greatest admirers among her scientific colleagues was Albert Einstein. In the early days, before Einstein's immense popularity, it was Madame Curie and Raymond Poincaré who were true friends and advocates of the young physicist. In the early 1950s, long after Madame Curie's death, Einstein was asked, in an interview, which physicist he respected the most. Einstein named two: Hendrik Lorentz and Marie Sklodowska Curie. Of Curie he said: I have always admired Marie Curie. Not only did she do outstanding work in her lifetime and not only did she help humanity greatly by her work, but she invested all of her work with the highest moral quality. All of this she accomplished with great strength, objectivity, and judgment. It is very rare to find all of these qualities in one individual. In fact, if more European intellectuals had had Madame Curie's modesty, conditions might have been brighter [Polish Review, p. 131]

tained applause, and simply began her lecture at exactly the point that Pierre had stopped his last lecture.

The sudden death of Pierre Curie was a bitter blow to Marie Curie, but that did not deter her noble pursuits. She, with the help of a brilliant chemist Debierne, isolated Radium in the metallic state in 1910. Her fundamental treatise on radioactivity was also published in 1910. In 1911 she was awarded her second Nobel Prize, this time in Chemistry, 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. She is the only woman ever to receive the Nobel Prize twice. In 1914 she saw the completion of the building of the laboratories of the Radium Institute at the University of Paris. Throughout the World War I, Marie Curie, with the help of her daughter Irene, devoted herself to the development of the use of X-radiography. In 1918 the Radium Institute began to operate in full earnest, and it was to become a universal centre for nuclear physics and chemistry. Marie Curie, now at the pinnacle of fame, and from 1922, a member of the Academy of Medicine, devoted her researches to the study of the chemistry of radioactive substances and the medical applications of these substances.

In 1921, accompanied by her two daughters Irene and Eve, Marie Curie made a triumphant journey to the United States, where President Warren G. Harding presented her with a gram of radium bought as the result of a collection organized by American women. In 1932, Madame Marie Sklodowska Curie returned to Poland to dedicate, along with her sister Bronya, the Warsaw Radium Institute. It was to be her last journey to Poland. Marie Curie's last years were brightened by the flourishing collaboration between her two lab assis-

We must not forget that when radium was discovered no one knew that it would prove useful in hospitals. The work was one of pure science. And this is a proof that scientific work must not be considered from the point of view of the direct usefulness of it. It must be done for itself, for the beauty of science, and then there is always the chance that a scientific discovery may become like the radium a benefit for humanity.

— Madame Curie

That one must do some work seriously and must be independent and not merely amuse oneself in life – this our mother has told us always, but never that science was the only career worth following.

— Irene Joliot-Curie

tants at the Radium Institute, her daughter Irene and young Frederic Joliot. Just as Marie and Pierre had combined personal love with impersonal passion for science, so did the Joliot-Curies. In 1934, by bombarding stable elements with nuclear projectiles, they were the first to discover artificial radioactivity—a normal element or isotope changing to a radioactive one through human intervention. This opened a new era; the very many radio-isotopes that we use today for medical uses have resulted from this discovery. This discovery brought the pair the 1935 Nobel Prize in Chemistry.

A few months after this discovery, on July 4, 1934, Marie Curie's noble heart stopped beating forever. She died of leukemia caused by the prolonged action of radiation exposure she had received in her earlier days while working with radium. Humanity salutes her, all society will remember her ever—and that not alone for her genius as a scientist, not just because of her service to mankind and her sacrifice in silence, aflame will remain her memory to evoke the spirit of scientific outlook on life in man and woman in the years to come. □

**References**

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