

MARYA SKŁODOVSKA —
MARIE CURIE

1867 — 1934



Pierre and Marie Curie shortly after their marriage. (Photograph courtesy of Laboratoire Curie.)

“His Majesty Alexander II, Tsar of All the Russians.”

The Inspector nodded and moved on to the next classroom. The Polish schoolmistress who only minutes before had been giving an illegal lesson on Polish history in the Polish language, said to Marya, “Come here, my little soul.” Marya went up to the schoolmistress who kissed her on the forehead, and the child burst into tears.

This girl, from a poor family in an oppressed nation, grew up not only to be the first person to receive two Nobel Prizes, but also to raise a daughter who herself became a Nobel Prize winner. Her father had been a high-school teacher of mathematics and physics, but a series of misfortunes had reduced him to supporting his family of six by boarding boys from the school. Because there were as many as ten boarders at a time, Marya had to give up her room and sleep in the living room. One of her older sisters contracted a fatal case of typhus from a boarder, and two years later, when Marya was eleven, her mother died of tuberculosis. The father had hoped to send his daughters to foreign universities, but despite their gold medals for

When the Inspector of private schools in Warsaw entered the classroom, the little girls knew he had come to make sure that Russian language and history were being taught, as required. Much of Poland had been under Russian domination for a century, and Polish language and culture were suppressed in the schools.

“Please call on one of these young people,” the Inspector asked of the schoolmistress. As in nearly all inspections, Marya Skłodowska was the student selected. Her Russian was flawless, her memory remarkable, and her emotions under sufficient control to withstand antagonistic questioning.

The Inspector demanded, “Name the tsars who have reigned over our Holy Russia since Catherine II.” The child replied, “Catherine II, Paul I, Alexander I, Nicholas I, Alexander II.”

Then came a series of further questions that emphasized Polish subjugation. Finally the Inspector asked, “Who rules over us?” Marya hesitated and he demanded, “Who rules over us?”

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Marya supported herself for five years as a governess with well-to-do families in the provinces and in Warsaw. She sent half of her meager monthly salary to her older sister, who had gone to Paris to study medicine. They agreed that once the sister was established as a doctor, she would send for Marya, who would then start university. In Poland higher education was closed to women.

Marya was 24 by the time her sister sent for her. She traveled by third-class train, except in Germany where there was a fourth class. Marya Gallicized her name to Marie and registered as a student in the Faculty of Science in the University of Paris. Because her brother-in-law's ceaseless chatter interrupted her study, she moved to an unheated garret. For weeks on end she was so absorbed in work that she ate only buttered bread and tea. At the end of the year she passed the exams in physics ranking first, and then the next year in mathematics, ranking second. Starting research, she met Pierre Curie, a physicist, eight years her senior, who had established a scientific reputation for studies of the magnetic properties of crystals, and who shared her serious approach to science. His first gift to her was a copy of his paper on the symmetry of electromagnetic fields.

They were married in 1895. An in-law of Marie's offered her a wedding dress as a present. Marie responded, "I have no dress except the one I wear every day. If you are going to be kind enough to give me one, please let it be practical and dark, so that I can put it on afterwards to go to the laboratory." With their only money, a gift from a cousin, they bought two bicycles.

The year 1897 was an important one. It brought both their first daughter (the future Nobel Prize winning physicist) and Marie's first scientific paper. Marie had

placed first in her exams for certification as a physics teacher and was now looking for a thesis topic for her Ph.D. degree. Among physicists there was much excitement about Roentgen's discovery of x-rays, and in 1896 Henri Becquerel in Paris had found that uranium salts emit rays related in their effects to x-rays.

She chose this topic for research, and was given as a laboratory a rough glassed-in studio, previously used as a storeroom on the ground floor of the School of Physics in which Pierre was on the faculty. It was not really suitable for laboratory work: her research notebook shows that on February 6, 1898 the room temperature was 6.25°C. Using a sensitive electroscope built by Pierre Curie and his brother, Marie detected the radiation emitted by uranium. She called this property *radioactivity*.

Marie found that that radioactivity was proportional to the mass of uranium in a sample, and that it was independent of temperature and exposure to light. This led to an insight of great importance: radioactivity is an *atomic property*. With this hypothesis she tested every other element to find if other atoms displayed this property. One did—thorium. Continuing her systematic tests, she found that several minerals in the collection of the School of Physics, particularly pitchblende ore, registered greater radioactivity than could be accounted for by their uranium or thorium contents. Since she had already tested every known element, logic forced her to conclude that this ore contained a new, highly radioactive element.

Pierre dropped his research to share the excitement of Marie's work. She remained an unpaid researcher and supplemented his small salary by lecturing in physics at a girls' school. In setting out to isolate the new element, radium, from ore, the Curies had to pay for pitchblende from Pierre's salary. Fortunately, through the intervention of the



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Austrian Academy of Sciences, the Austrian government donated a ton of pitchblende from the state-owned mine in Bohemia, and the Curies had to pay only for its transportation.

Marie underestimated the work of isolation. Originally she guessed that pitchblende might contain 1% radium, whereas in fact it contained less than one part per million. She later recalled, "And yet it was in that miserable old shed that the best and happiest years of our life were spent. I sometimes passed the whole day stirring a mass in ebullition, with an iron rod nearly as big as myself. In the evening I was broken with fatigue." Along the way, the radioactivity separated into two fractions, and it was evident that there was another new element in the ore. "You will have to name it," said Pierre to his young wife. "Could we call it polonium?" she asked, thinking her work could honor her oppressed homeland.

In 1902, four years after the start of the work, Marie succeeded in isolating radium and in determining its atomic weight. Recognition followed almost immediately. The following year the Curies shared the Nobel Prize with Becquerel. Pierre and Marie skipped the official ceremony, saying that it would take them away from their teaching for too long. About this time it became evident that radium would be useful in medicine, and that to patent the process for its isolation would make the Curies rich. Pierre raised this possibility to Marie, who needed to consider it only a few seconds. "It is impossible," she said, "It would be contrary to the scientific spirit."

Just as Marie's life appeared to have reached a point of ease, tragedy stepped in. First Pierre died in a horrible accident. His head was crushed beneath the wheels of a horsedrawn wagon in a street of Paris. Marie firmly rejected collections on her behalf but did accept the

professorial chair that Pierre had occupied for eighteen months at the Faculty of Science. She was the first female professor at the Sorbonne and in the whole of France.

Having triumphed in her first move alone in the male-dominated scientific world, she suffered in the next a highly publicized defeat. She announced in the fall of 1910 that she would stand for election to the vacancy in the general physics section of the French Academy of Sciences. Since its reestablishment in 1795, this prestigious body had admitted no woman. Sensing drama in this situation, the popular press began to build up the election. The respectable paper *Le Temps* opened its columns to the permanent secretary of the Academy who documented the case for Madame Curie's election. But the right-wing press hotly opposed her election, with arguments to the effect that she had ridden Pierre's coattails to the Nobel Prize and a professorship. Just then Edouard Branly announced he would oppose Marie. Branly had done creditable research on aerials for electromagnetic waves, but his work was in no way the equal of Marie's fundamental discoveries. His main qualifications were that he was male, gentlemanly, devoutly Catholic, and might not live until another vacancy occurred. The right-wing press lined up behind him, and the election was called "the War of the Sexes." In front of a crowd of journalists and photographers, the members cast 30 votes for Branly and 28 for Curie.

As distressing as was this public defeat, there was worse to come. The uproar over the election had made every move of Madame Curie's a subject for public interest, and late in the same year came another round of intense publicity. It was started by the headline of *Le Journal*, "A Story of Love. Mme Curie and Professor Langevin." Paul Langevin had been Pierre Curie's pupil and protégé and was his successor at the School of Physics.

Langevin had a working-class background, advanced in education, and four children. His reluctance to accept the post for better pay had sought the sympathy of his friends, and his election touched Marie's sense of justice. Langevin's appointment near the Sorbonne Marie visited him, and matters worse for her also put her feelings. Her brother-in-law broke the lock on the door, took the letters, and used them to get a separation.

These letters were the most unpleasant. The popular press turned the situation into an article for example "the vestal virgin" and vile suggestions to his wife and child.

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6-9 Section: Integrating

Rate equations for as we have done the concentration of the various books, including derive and discussion of the form

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which is described

$$-\frac{1}{2} \frac{d[A]}{dt}$$

Langevin had married a girl of his own working-class background, and as he advanced in education, she raised their four children. She could not understand his reluctance to leave his university post for better pay in industry. He sought the sympathy of university friends, and his distress particularly touched Marie, with her ethic of pure science. Langevin took a small apartment near the School of Physics, where Marie visited him frequently. What made matters worse for Marie was that she also put her feelings in letters. Aided by her brother-in-law, Madame Langevin broke the lock of Langevin's study and took the letters, which she planned to use to get a separation.

These letters were the basis of attacks of the most unpleasant sort on Marie from the popular press, which gradually built the situation into a great scandal. One article for example said that Marie Curie, "the vestal virgin of radium," had used vile suggestions to detach Langevin from his wife and children. Others hinted that

she had driven Pierre to suicide. Crowds gathered outside the Curie house shouting, "Get the foreign women out! Husband stealer!" and a rock was thrown at the house. The Curies were taken to a friend's apartment where the fourteen-year-old daughter, having seen a copy of the main press attack, lay numbed. Langevin challenged the author of the attack to a pistol duel, but it was concluded without wounds.

In the midst of all this came a telegram revealing that Marie had received a second Nobel Prize, this time for the chemistry of radium. She took her older daughter to Stockholm for the award ceremony, as interest in Paris in her private life gradually died away. When she returned she collapsed and was carried to a nursing home. It took a year for her to return fully to work.

Before her death from leukemia, Marie Curie suffered from cataracts. Her extensive exposure to atomic radiation probably contributed to both afflictions.

rems (exposure to hands) per year. For comparison, the whole-body radiation absorbed from background natural sources is roughly 0.1 rem per year, and the average exposure due to medical diagnosis is about 0.07 rem per year.

6-9 Second-Order Rate Laws can be Integrated

Rate equations for reactions of second and higher orders can be integrated—as we have done for first-order rate laws—to give explicit expressions for the concentrations of reactants and products as a function of time. Numerous books, including those by Frost and Pearson (1952) and Moore (1972), derive and discuss these expressions. Let us consider one example, a reaction of the form



which is described by a rate equation

$$-\frac{1}{2} \frac{d[A]}{dt} = k[A]^2 \quad (6-26)$$