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PORTRAITS OF SCIENCE

Scientist, Technologist, Proto-Feminist, Superstar

Roger M. Macklis

Although known primarily for her discovery of radium, Marie Curie's true gift to science was her realization that radioactivity is an intrinsic atomic property of matter.

With the possible exception of Albert Einstein, Marie Curie was the most famous scientist of her era and is almost certainly the most celebrated female scientist in history (*1*). Although known primarily for her discovery of radium, her true gift to science was her realization that radioactivity is an intrinsic atomic property of matter rather than the result of more superficial chemical processes. She was one of the exceedingly rare Nobel laureates to win the prize twice (physics and chemistry). Her life will forever reflect dogged determination, unswerving devotion to work, political tenacity, and an optimistic belief in scientific positivism. On a more personal note, she unfortunately has also come to symbolize a cautionary tale concerning the difficulties encountered when a woman enters and succeeds dramatically and publicly in a sphere traditionally dominated by men. Initially viewed as a mere research assistant "riding" on the coattails of her more talented husband Pierre, his death in 1906 confronted her with the need and the opportunity to both establish her own scientific identity and to insist, despite her critics, on her place in the annals of the dawning technologic age. She succeeded brilliantly, although she paid a personal price for her temerity (*2–4*).

Marya Salomée Sklodowska was born in Warsaw on 7 November 1867, the fifth child of two teachers whose careers were stymied by the prevailing bias toward Tsarist "Russification" of the Polish educational system. Her honors obtained in secondary school, together with her subsequent involvement with a group of young Polish autodidacts and intellectuals, kindled her political and scientific interests. After a brief stint working as a country governess, she returned to Warsaw to study for the entrance exam for the University of Paris, which she passed.

Paris was succumbing to a liberal techno-enthusiasm symbolized by new-age wonders such as electric lighting and the Eiffel Tower built for the 1889 Universal Exposition. Marya (later Marie) was impressed by the technology embodied in these marvels and graduated from the University of Paris with high honors in physics and mathematics. As a 26-year-old novice researcher, she sought help in measurement methods from Pierre Curie, a young faculty member at the Paris Municipal School of Industrial Physics and Chemistry. He was 8 years her senior and already an expert in electromagnetism and piezoelectricity (electrical charges induced by crystal distortion). Recognizing that they were kindred spirits, Pierre and Marie married in 1895.

Marie Curie
(1867—1934)

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Pierre had a reputation as a competent but unremarkable investigator who as a "pure scientist" professed to have little interest in the social implications of his research. In contrast, Marie was more pragmatic; she understood that society saw science as a means to an end, and this kindled in her a deep interest in the applications of her scientific work. In her subsequent career as a scientific manager, she came to realize the need for increased societal support for the scientific enterprise (*5*). Although it is unclear whether she was a paid industrial consultant, her own research work was conducted with the financial support and collaboration of industrial concerns such as the Standard Chemical Company of Pittsburgh. As young cosmopolites, she and Pierre had argued against the idea that scientists should be motivated by personal gain and patent protection. However, she found herself rethinking this antipatent bias as the financial requirements of first-class research became clear. She did not seem to have been particularly interested in money but did become increasingly aware of the scientific freedom that money can bring.

When Marie Curie began her doctoral studies in 1897 (she was one of the first women to enter Ph.D. training in France) she was already pregnant with her daughter, Irene. The subject of her doctoral work in Antoine Becquerel's laboratory was an extension of the work of Wilhelm Roentgen and Becquerel on the mysterious "rays" that could fog photographic plates without external sources of light. Roentgen's discovery of electrically generated x-rays in 1895 was followed in 1897 by Becquerel's description of a similar natural phenomenon produced by potassium uranyl sulfate. For her doctoral dissertation, Marie decided to investigate whether other heavy elements might possess similar capabilities. This work required the development of a rapid, quantitative assay to detect the ionizing rays. Pierre's background lent itself to development of exactly the sort of measurement system required. They made rapid progress, with Marie concentrating on the chemistry and Pierre concentrating on physics and measurements. By late 1898, Pierre had abandoned his own research to work full time on Marie's project.

Setting up shop in a small shed on rue l'Homond, Marie found that, to a first approximation, the intensity of the Becquerel rays appeared to be proportional to the uranium content of the tested samples and was apparently unaffected by temperature, solvents, or chemical manipulations. The rays thus appeared to be an intrinsic atomic property of the test samples. She called this property "radio-activity." Further investigating this property, the Curies noticed something quite strange and wonderful: As they separated the uranium impurities found in the raw ore they had expected that the radioactivity would copurify with the elemental uranium itself. However, they observed the reverse—although the uranium retained some level of intrinsic radioactivity, purification revealed minute amounts of a new set of substances, which seemed to be much more radioactive than uranium. Attacking this problem using brute force and classical analytical chemistry, the Curies determined that the highly active component was not a known element but instead represented something new. Beginning with a

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large shipment of pitchblende ore obtained from the Austrian government, the Curies identified and described first polonium, and then, using the same principles, their magnum opus, radium (*6*, *7*). Radium, much more radioactive than uranium, seemed a perfect metaphor for the triumphant futurism of the new century. Although the medical potential of radium did not, in the end, live up to the hopes of the Curies, its discovery marked a key starting point for the fields of radiation oncology and radiation biology (*8*).

The Curies decided that they needed to purify a substantial sample of their new element to stake their claim for posterity. After 4 years, Marie was rewarded with approximately 100 mg of pure radium. Marie was to recall this period of hard work under difficult conditions as the "best and happiest years of our lives." She successfully defended her doctoral thesis in June 1903. Within 6 months of her degree, the Curies had been awarded the Davy medal from the Royal Society of London and the Nobel Prize in Physics (along with Becquerel) for their "work on the radiation phenomenon."

Prize money awarded for their work on radioactivity together with the stipend accompanying Pierre's new Chair of Physics at the University of Paris (Marie was given a lesser job as "Chief of Laboratories") allowed the Curies to begin to live the comfortable life of academics. When Marie had a second daughter, Eve, in December of 1904, their family happiness seemed assured. Sadly, on April 19, 1906, the absentminded Pierre ambled onto a busy Paris street, and was knocked to the ground and killed instantly by a heavy horse-drawn wagon. A widow at 38, the distraught Marie resolved to carry on the work that had been so important to her and Pierre. She was promoted, amid some grumbling, to Pierre's old chair. She continued her work on the chemical purification and characterization of radium and its byproducts, but her colleagues noted that she had lost the fire that had imbued her earlier professional endeavors.

A clandestine affair with Paul Langevin, a married student of Pierre's, 5 years her junior, perhaps renewed her zeal for life. Unfortunately, legal action by Langevin's wife brought the affair to the attention of the nationalist scandal sheets. They gloried in this tale of the brazen, foreign-born widow who seemed attached to some of the Republic's brightest men. Marie's indiscretions might have been dismissed or even lionized had they revolved around the amorous affairs of a male scientist. However, in turn-of-the-century Europe the adulterous affair was too much even for French society to ignore. In the midst of the fallout, the Swedish Academy, perhaps making a political statement, announced that Marie Curie had been awarded an unprecedented second Nobel Prize in chemistry for the discovery of radium. Marie traveled to Stockholm to accept the prize, but the public scandal followed her.

Marie collapsed both physically and psychologically in 1911. Perhaps to rebuild her battered self-confidence, she began to pursue her dream of organizing a national institute that would emulate the medical-science synergy created by the Pasteur Institute several decades earlier. The costs were to be borne jointly by the University of Paris and the Pasteur Institute. The Institut du Radium was to consist of two buildings: the Curie Pavilion for physics and mathematics research, to be directed by Marie, and the Pasteur Pavilion for related biomedical research (*9*). A well-known French radiologic physician, Claudius Regaud, was selected to direct biological and medical research including radiobiology in the Pasteur Pavilion. Building plans were drawn up and work was begun, but WWI erupted in August 1914 putting plans for the Radium Institute on hold.

Sensitive to those who had questioned her French patriotism, Marie decided to apply her scientific talents to training radiologists and radiographers to aid in the defense of the French homeland. She agreed to organize a corps of mobile radiology trucks (later called "little Curies") equipped for front-line radiographic evaluation of the wounded. Although Marie was not a physician, her organizational skills and unstoppable drive brought her great acclaim and a grudging patriotic salute from even her most ardent detractors. With the end of the war, a cadre of radiologically trained physicians, scientists, and physicists was released from active military duty and found work at the new Radium Institute.

The post-war years signaled a renaissance for Marie. As the principal organizer of the Radium Institute, she realized that the caliber of scientific work that she and Regaud envisioned would require a dramatic increase in funding. Andrew Carnegie had supported her laboratory from 1907 onward, and several other commercial concerns interested in radium purification technologies continued to provide targeted funding. Although radium became an icon for miraculous new biomedical advances (*10*), money for Marie's research remained scarce. However, in 1920, a bridge to worldwide philanthropy and commercial largesse appeared in the form of an American society journalist, Mrs. Marie Mattingly Meloney. "Missy" Meloney was a natural publicity hound, and she was instrumental in organizing multiple fund-raising trips with Madame Curie as the headliner. Marie was by nature shy, reserved, and understated, but with Meloney helping to manage her image, her fame, as both a scientist and as an exemplar of a liberated professional woman of the roaring twenties, grew to superstar proportions. She visited the USA twice, in 1921 and 1929. On her first trip, President Warren G. Harding presented her with one gram of radium purchased, it was said, through the philanthropy of the women of America. She was photographed visiting leading women's colleges and conversing as a scientific equal with many of the outstanding male researchers of her day. Although not a riveting speaker, Marie was now much in demand as a participant in international scientific collaborations. She served on the Council of the League of Nations and received awards and degrees from dozens of foundations and universities.

Never strong, her health began to fail in the late 1920s. Although she had always minimized the personal risks of radiation, her hearing and eyesight were in decline, and her scarred hands bore testimony to chronic radiation exposure. In the summer of 1934, she was admitted to a sanatorium. She died a few months later of preleukemia, at the age of 67. Decades later, she became the first woman to be granted the great honor of perpetual interment at the Pantheon in Paris. A year after her death, her daughter Irene won the family's third Nobel Prize.

Historians and colleagues familiar with Marie Curie's professional achievements are divided between those who saw her as a truly visionary intellect and those who saw her as a focused, hardworking, but not particularly creative, scientific manager with a single "eureka" moment. Regardless of the truth, in this current era of "big science" it is clear that major scientific and medical advances require both creative inspiration and excellent organizational skills, both of which Marie had in abundance. The fact that she accomplished so much in an era when women were given so little credit for achievements, particularly in the physical sciences, makes her all the more remarkable.

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