Marie Curie
Her Story in Brief

From Poland to Paris

Looking for a Laboratory, Finding Love

The Discovery of Radium

Honors, Disasters, & Renewal

Radium Campaigns

Marie Sklodowska Curie discovered the mysterious element radium. It opened the door to deep changes in the way scientists think about matter and energy. She also led the way to a new era for medical knowledge and the treatment of diseases

This file contains most of the text of the Web exhibit "Marie Curie and the Science of Radioactivity" at http://www.aip.org/history/curie/brief/. You must visit the Web exhibit to explore hyperlinks within the exhibit and to other exhibits.

This exhibit brought to you by The Center for History of Physics
A Division of The American Institute of Physics

Site created 2000, revised May 2005

Table of Contents

A Patriot without a Nation

The woman who became "Madame Marie Curie" was named Maria Sklodowska at birth. Her family and friends called her by a nickname, Manya. She was born on November 7, 1867, in Warsaw, the city that had once been the capital of Poland.

The Sklodowski children
Zosia died of typhus, Hela became an educator, Jozef and Bronya became doctors

Europe in the late 19th century
"Poland" including Warsaw, where the Sklodowskis lived, was a province of Russia. Other parts of the province had been taken over by Prussia and Austria.

Manya's parents raised their children to be patriots of a nation that no longer existed. By 1815, through wars and treaties, the countries around Poland had divided up the country and swallowed the pieces. Warsaw was in the piece controlled by the czar of Russia, a provincial city of the Russian Empire. The Sklodowskis and other patriots were determined to preserve Polish culture at all costs.

The family suffered because of their patriotism. Manya's father was forced out of a good teaching position because of his pro-Polish beliefs, and during her childhood the family struggled financially. Manya's parents were teachers, and they taught their five children the value of learning. Only modern education could lift them, and Poland, from their lowly condition.

Polish Schools under Russian Rule

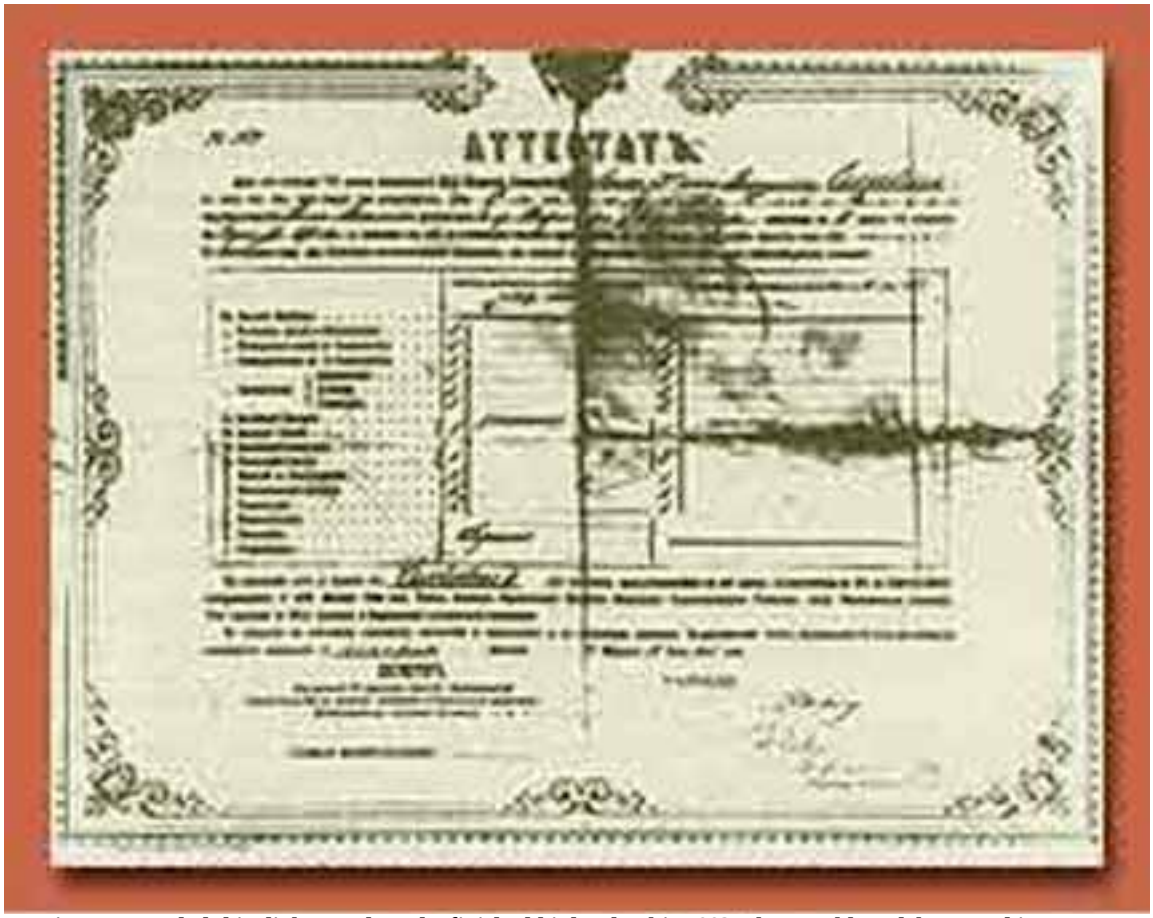
"**Warsaw was then under** Russian domination, and one of the worst aspects of this control was the oppression exerted on the school and the child. The private schools directed by Poles were closely watched by the police and overburdened with the necessity of teaching the Russian language even to children so young that they could scarcely speak their native Polish. Nevertheless, since the teachers were nearly all of Polish nationality, they endeavored in every possible way to mitigate the difficulties resulting from the national persecution. These schools, however, could not legally give diplomas, which were obtainable only in the schools of the government.

These schools, entirely Russian, were directly opposed to the Polish national spirit. All instruction was given in Russian, by Russian professors, who, being hostile to the Polish nation, treated their pupils as enemies. Men of moral and intellectual distinction could scarcely agree to teach in schools where an alien attitude was forced upon them. So what the pupils were taught was of questionable value, and the moral atmosphere was altogether unbearable. Constantly held in suspicion and spied upon, the children knew that a single conversation in Polish, or an imprudent word, might seriously harm, not only themselves, but also their families. Amidst these hostilities, they lost all the joy of life, and precocious feelings of distrust and indignation weighed upon their childhood. On the other side, this abnormal situation resulted in exciting the patriotic feeling of Polish youths to the highest degree."

—from Autobiographical Notes pp. 158-159.

Before Manya turned 11, her eldest sister had died of typhus and her mother had died of tuberculosis. Despite these losses, Manya graduated from high school at 15 with the highest honors. After graduating, however, she suffered from a nervous illness, which left her feeling too tired to do anything. It may have been what modern doctors call depression. Her father sent her to visit cousins in the countryside, where she could spend a carefree year.

Maria's first great sorrow came when she was only 10. Her devout Roman Catholic mother died young, after a long illness.



Maria was awarded this diploma when she finished high school in 1883, plus a gold medal. Her achievement, though, meant she had to force herself to shake hands with the grandmaster, who represented the hated Russian rule of Poland.

A Pact between Sisters

Education drew Maria back to Warsaw from her year of recuperation in the country. Women were not permitted to study at the University of Warsaw. So Maria and her older sister Bronya joined other students at a "floating university." The classes met at night, at changing locations to avoid detection by the czar's police.

Maria and Bronya knew that to get a true professional education, they would have to go to a major university in Western Europe. The sisters made a pact. Maria would work as a governess to help pay for Bronya's medical studies in Paris. As soon as Bronya was trained and began to earn money, she would help cover the costs of Maria's university training.

Leaving Home at 15

"**I was only fifteen when I finished** my high-school studies, always having held first rank in my class. The fatigue of growth and study compelled me to take almost a year's rest in the country. I then returned to my father in Warsaw, hoping to teach in the free schools. But family circumstances obliged me to change my decision. My father, now aged and tired, needed rest; his fortune was very

modest. So I resolved to accept a position as governess for several children. Thus, when scarcely seventeen, I left my father's house to begin an independent life.

That going away remains one of the most vivid memories of my youth. My heart was heavy as I climbed into the railway car. It was to carry me for several hours, away from those I loved. And after the railway journey I must drive for five hours longer. What experience was awaiting me? So I questioned as I sat close to the car window looking out across the wide plains."

—*from Autobiographical Notes p. 163.*

So Maria spent three years in a village 150 kilometers from Warsaw. She was hired by the owner of a beet-sugar factory to teach his children. He did not object when she used some of her spare time to teach the children of the Polish peasant workers how to read, although she risked punishment if the Russian authorities found out. Maria used her free hours to read widely in many subjects. She found that she was best at math, physics, and chemistry. The Russian authorities had forbidden Poles to teach laboratory science, but a chemist in the beet-sugar factory gave Maria some lessons.

Maria and her sister Bronya (at right) were close friends until the end of their lives.

Secret Studies In Warsaw

"**I continued my efforts** to educate myself. This was no easy task under the Russian government of Warsaw; yet I found more opportunities than in the country. To my great joy, I was able, for the first time in my life, to find access to a laboratory: a small municipal physical laboratory directed by one of my cousins. I found little time to work there, except in the evenings and on Sundays, and was generally left to myself. I tried out various experiments described in treatises on physics and chemistry, and the results were sometimes unexpected. At times I would be encouraged by a little unhoped-for success, at others I would be in the deepest despair because of accidents and failures resulting from my inexperience. But on the whole, though I was taught that the way of progress is neither swift nor easy, this first trial confirmed in me the taste for experimental research in the fields of physics and chemistry.

Other means of instruction came to me through my being one of an enthusiastic group of young men and women of Warsaw, who united in a common desire to study, and whose activities were at the same time social and patriotic. It was one of those groups of Polish youths who believed that the hope of their country lay in a great effort to develop the intellectual and moral strength of the

nation, and that such an effort would lead to a better national situation. The nearest purpose was to work at one's own instruction and to provide means of instruction for workmen and peasants. In accordance with this program we agreed among ourselves to give evening courses, each one teaching what he knew best. There is no need to say that this was a secret organization, which made everything extremely difficult. There were in our group very devoted young people who, as I still believe today, could do truly useful work.

I have a bright remembrance of the sympathetic intellectual and social companionship which I enjoyed at that time. Truly the means of action were poor and the results obtained could not be considerable; yet I still believe that the ideas which inspired us then are the only way to real social progress. You cannot hope to build a better world without improving the individuals. To that end each of us must work for his own improvement, and at the same time share a general responsibility for all humanity, our particular duty being to aid those to whom we think we can be most useful."

—from Autobiographical Notes pp. 167-168.

Maria and Kazmierz Zorawski, the son of her employer, fell in love. His family refused to let their son marry the mere governess. Staying on as employee of his family was hard. Yet her promise to help Bronya was so important to Maria that she put her feelings aside.

Maria returned to Warsaw in 1889. Her father was now earning a better salary as head of a reform school, and was able to send money to Bronya in Paris each month. For another two years Maria went on working as a governess and tutor. On Sundays and evenings she secretly studied chemistry course at a "Museum," which was actually an illegal lab for training Polish scientists.

These buildings in the Old Town of Warsaw (destroyed in World War II and rebuilt) show the high level of beauty and civilization that helped inspire Polish patriots.

Shortly before she turned 24, Maria calculated she had saved up just enough money for university studies in Paris. She had looked forward to this moment for a long time. All the same, she took leave of her beloved father and their beloved Poland with sadness. She promised to return after finishing her studies.

Looking for a Laboratory, Finding Love (1891-1897)

A young Polish woman traveled economy-class from Warsaw to Paris in autumn 1891. She had enough money to cover university tuition, a small room and the cheapest food, but little else. Maria Sklodowska left behind not only her beloved father and country but her very name. She registered at the famous Sorbonne university as Marie, the French form of Maria.

Marie was not as well prepared as her fellow students. Nevertheless, through hard work she completed master's degrees in physics and math in only three years. Living on her own for the first time, she focused so hard on her studies that she sometimes forgot to eat.

The Eiffel tower displayed the new electric lighting in 1900. Physics was hailed as a revolutionary science, with electricity coming into use and strange new forms of radiation promising still greater discoveries to come.

A Poor Student In Paris

"**It would be impossible** to tell of all the good these years brought to me. Undistracted by any outside occupation, I was entirely absorbed in the joy of learning and understanding. Yet, all the while, my living conditions were far from easy, my own funds being small and my family not having the means to aid me as they would have liked to do. However, my situation was not exceptional; it was the familiar experience of many of the Polish students whom I knew. The room I lived in was in a garret, very cold in winter, for it was insufficiently heated by a small stove which often lacked coal. During a particularly rigorous winter, it was not unusual for the water to freeze in the basin in the night; to be able to sleep I was obliged to pile all my clothes on the bedcovers. In the same room I prepared my meals with the aid of an alcohol lamp and a few kitchen utensils. These meals were often reduced to bread with a cup of chocolate, eggs or fruit. I had no help in housekeeping and I myself carried the little coal I used up the six flights.

This life, painful from certain points of view, had, for all that, a real charm for me. It gave me a very precious sense of liberty and independence. Unknown in Paris, I was lost in the great city, but the feeling of living there alone, taking care of myself without any aid, did not at all depress me. If sometimes I felt lonesome, my usual state of mind was one of calm and great moral satisfaction.

All my mind was centered on my studies, which, especially at the beginning, were difficult. In fact, I was insufficiently prepared to follow the physical science course at the Sorbonne, for, despite all my efforts, I had not succeeded in acquiring in Poland a preparation as complete as that of the French students following the same course. So I was obliged to supply this deficiency, especially in

mathematics. 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 that was new delighted me. It was like a new world opened to me, the world of science, which I was at last permitted to know in all liberty."

—*from Autobiographical Notes pp. 170-171.*

Marie's superior work in physics won her a scholarship. And a group of industrialists, the Society for the Encouragement of National Industry, paid her to investigate the magnetic properties of different steels. To carry out the work she needed a lab.

Marie found a cheap rental in a Paris attic. To save money she kept herself warm by wearing every piece of clothing she owned. Painting by Gustave Caillebotte.

Pierre Curie had a lab, so Marie was introduced to him in spring 1894. He had the impressive title of Laboratory Chief at the Paris Municipal School of Industrial Physics and Chemistry. In fact his lab facilities were poor, but he let Marie work there. Curie, about 10 years older than Marie, had made important scientific discoveries on magnetism and crystals. But he had never bothered to complete a doctoral thesis.

Another Polish student in Paris drew this portrait of Marie in 1893, a few months after she arrived there. At first she spent a lot of time with other Poles, but soon she devoted herself completely to her studies.

Meeting Pierre Curie

I met Pierre Curie for the first time in the spring of the year 1894.... A Polish physicist whom I knew, and who was a great admirer of Pierre Curie, one day invited us together to spend the evening with himself and his wife.

As I entered the room, Pierre Curie was standing in the recess of a French window opening on a balcony. He seemed to me very young, though he was at that time thirty-five years old. I was struck by the open expression of his face and by the slight suggestion of detachment in his whole attitude. His speech, rather slow and deliberate, his simplicity, and his smile, at once grave and youthful, inspired confidence. We began a conversation which soon became friendly. It first concerned certain scientific matters about which I was very glad to be able to ask his opinion. Then we discussed certain social and humanitarian subjects which interested us both. There was, between his conceptions and mine, despite the difference between our native countries, a surprising kinship, no doubt attributable to a certain likeness in the moral atmosphere in which we were both raised by our families.

We met again at the Physics Society and in the laboratory. Then he asked if he might call upon me.... Pierre Curie came to see me, and showed a simple and sincere sympathy with my student life. Soon he caught the habit of speaking to me of his dream of an existence consecrated entirely to scientific research, and he asked me to share that life. It was not, however, easy for me to make such a decision, for it meant separation from my country and my family, and the renouncement of certain social projects that were dear to me. Having grown up in an atmosphere of patriotism kept alive by the oppression of Poland, I wished, like many other young people of my country, to contribute my effort toward the conservation of our national spirit....

During the year 1894 Pierre Curie wrote me letters that seem to me admirable in their form. No one of them was very long, for he had the habit of concise expression, but all were written in a spirit of sincerity and with an evident anxiety to make the one he desired as a companion know him as he was.... It is appropriate to quote here a few lines which express how he looked on the possibility of our marriage:

“We have promised each other (is it not true?) to have, the one for the other, at least a great affection. Provided that you do not change your mind! For there are no promises which hold; these are things that do not admit of compulsion.

“It would, nevertheless, be a beautiful thing in which I hardly dare believe, to pass through life together hypnotized in our dreams: your dream for your country; our dream for humanity; our dream for science. Of all these dreams, I believe the last, alone, is legitimate. I mean to say by this that we are powerless to change the social order. Even if this were not true we should not know what to do.... From the point of view of science, on the contrary, we can pretend to accomplish something. The territory here is more solid and obvious, and however small it is, it is truly in our possession.”

One can understand, from this letter, that for Pierre Curie there was only one way of looking at the future. He had dedicated his life to his dream of science: he felt the need of a companion who could live his dream with him

—from Pierre Curie pp. 72-77.

Like Marie, Pierre Curie had been in love once before. Marie had always meant to return to her native land. Then she found that she could not hope for "a better life companion" than Pierre.

As the relationship between Pierre and Marie deepened, he convinced her that she should pursue science in Paris, not return to Poland for good. She in turn convinced him to write up his magnetism research and get a doctoral degree. He was then promoted to a professorship, but his teaching duties grew, and his lab got no better.

The Curies in their lab at the Paris Municipal School in 1896. While she worked on the properties of steel, he studied crystals.

Pierre and Marie married in July 1895. Over the next two years, Marie completed her research on the magnetic properties of steels. She submitted her final results shortly before giving birth to their first daughter, Irène, in September 1897. Pierre's father, a retired doctor, moved in with them and helped raise Irène. Marie began looking for a research topic that would earn her a doctorate in science. No woman in the world had yet completed that degree.

Family and Professional Life

"**It became a serious problem** how to take care of our little Irène and of our home without giving up my scientific work. Such a renunciation would have been very painful to me, and my husband would not even think of it; he used to say that he had got a wife made expressly for him to share all his preoccupations. Neither of us would contemplate abandoning what was so precious to both.

Of course we had to have a servant, but I personally saw to all the details of the child's care. While I was in the laboratory, she was in the care of her grandfather, who loved her tenderly and whose own life was made brighter by her. So the close union of our family enabled me to meet my obligations. Things were particularly difficult only in case of more exceptional events, such as a child's illness, when sleepless nights interrupted the normal course of life.

It can be easily understood that there was no place in our life for worldly relations. We saw but a few friends, scientific workers, like ourselves, with whom we talked in our home or in our garden, while I did some sewing for my little girl. We also maintained affectionate relations with my husband's brother and his family. But I was separated from all my relatives, as my sister had left Paris with her husband to live in Poland.

It was under this mode of quiet living, organized according to our desires, that we achieved the great work of our lives, work begun about the end of 1897 and lasting for many years."

—*from Autobiographical Notes pp. 179-180.*

Marie (expecting her second baby) with Pierre and their daughter Irène in the garden of their home, 1904.

The Mystery of the Rays

Two mysterious discoveries led Marie Curie to her life's work. In December 1895, a German physicist, Wilhelm Roentgen, had discovered rays that could travel through solid wood or flesh. A few months later a French physicist, Henri Becquerel, discovered that minerals containing uranium also gave off rays. Roentgen's X-rays amazed scientists, who took to studying them with great energy. They mostly ignored Becquerel's rays, which seemed much the same, only weaker. Marie decided to investigate the uranium rays. There was so little work on them for her to read about that she could begin experiments at once.

First Marie needed a lab. She had to settle for a storeroom in the Paris Municipal School, where her husband, Pierre Curie, was now a professor. The storeroom was crowded and damp, but somehow she had to overcome its problems. She started off by studying a variety of chemical compounds that contained uranium. She discovered that the strength of the rays that came out depended only on the amount of uranium in the compound. It had nothing to do with whether the material was solid or powdered, dry or wet, pure or combined with other chemical elements. If you had a certain amount of uranium—a certain number of uranium atoms—then you got a certain intensity of radiation. Nothing else made a difference.

One of Roentgen's first X-ray photographs – a colleague's hand (note the wedding ring). The revelation of X-rays fascinated the public and deeply puzzled the scientists.

This was very strange. Normal properties, color or smell or hardness, changed according to how you treated a substance. Scientists of the time knew that such properties came from the way atoms combined with one another. The atoms themselves, most scientists believed, had all been created at the beginning of time, and could not possibly change. Marie puzzled over this, trying out every possible idea. Perhaps, she suspected, something was happening inside uranium atoms that gave rise to rays.

And not only inside uranium. Trying out various chemicals, Marie found that compounds that contained an uncommon element, thorium, also gave off rays. To describe the behavior of these two elements, Marie made up the term "radioactivity."

A lump of pitchblende. Marie found this mineral was far more radioactive than could be accounted for by the amount of uranium it contained.

Marie got another surprise as she pushed through more compounds. The mineral pitchblende, rich in uranium, gave off more radioactivity than could be accounted for by the uranium in it (and there was no thorium). She figured the pitchblende must contain another element, fiercely radioactive, and never seen before. The promise of a strange new element was so exciting that Pierre put aside his work on crystals to help speed up the discovery. They worked as a team, each responsible for a specific task.

Discovering Radium

"**My experiments proved** that the radiation of uranium compounds can be measured with precision under determined conditions, and that this radiation is an atomic property of the element of uranium. Its intensity is proportional to the quantity of uranium contained in the compound, and depends neither on conditions of chemical combination, nor on external circumstances, such as light or temperature.

I undertook next to discover if there were other elements possessing the same property, and with this aim I examined all the elements then known, either in their pure state or in compounds. I found that among these bodies, thorium compounds are the only ones which emit rays similar to those of uranium. The radiation of thorium has an intensity of the same order as that of uranium, and is, as in the case of uranium, an atomic property of the element....

During the course of my research, I had had occasion to examine not only simple compounds, salts and oxides, but also a great number of minerals. Certain ones proved radioactive; these were those containing uranium and thorium; but their radioactivity seemed abnormal, for it was much greater than the amount I had found in uranium and thorium had led me to expect.

This abnormality greatly surprised us. When I had assured myself that it was not due to an error in the experiment, it became necessary to find an explanation. I then made the hypothesis that the ores uranium and thorium contain in small quantity a substance much more strongly radioactive than either uranium or thorium. This substance could not be one of the known elements, because these had already been examined; it must, therefore, be a new chemical element.

I had a passionate desire to verify this hypothesis as rapidly as possible. And Pierre Curie, keenly interested in the question, abandoned his work on crystals (provisionally, he thought) to join me in the search for this unknown substance.

We chose, for our work, the ore pitchblende, a uranium ore, which in its pure state is about four times more active than oxide of uranium. Since the composition of this ore was known through very careful chemical analysis, we could expect to find, at a maximum, 1 per cent of new substance. The result of our experiment proved that there were in reality new radioactive elements in pitchblende, but that their proportion did not reach even a millionth per cent!"

—from Pierre Curie pp. 96-98.

A page from Curies' lab notebook, showing Pierre's handwriting mixed in with Marie's as they worked together.

Penetrating the Mystery

A chunk of pitchblende may contain up to 30 different chemical elements. The Curies were like detectives searching for a suspected criminal in a crowded street. They had no idea what the new element would be like, except that it was radioactive. After long labor they succeeded in finding not one but two new elements! In July 1898 they published a paper revealing their first discovery. They honored Marie's native land by naming the element "polonium." That December they announced the second new element, which they named "radium" from the Latin word for ray.

Other scientists did not trust the announcement, for the Curies did not have enough polonium and radium to see and weigh. The elements' existence was known from nothing but their radioactivity. The Curies would have to separate their elements from the other substances they were mixed with. The storeroom at Pierre's school was too small for such work, and the Curies continued their work in an abandoned shed nearby.

A French newspaper drawing of the Curies in their lab. The discovery of a new element was a rare event, bringing fame to the scientists and pride to the nation.

The Struggle to Isolate Radium

"The School of Physics could give us no suitable premises, but for lack of anything better, the Director permitted us to use an abandoned shed which had been in service as a dissecting room of the School of Medicine. Its glass roof did not afford complete shelter against rain; the heat was suffocating in summer, and the bitter cold of winter was only a little lessened by the iron stove, except in its immediate vicinity. There was no question of obtaining the needed proper apparatus in common use by chemists. We simply had some old pine-wood tables with furnaces and gas burners. We had to use the adjoining yard for those of our chemical operations that involved producing irritating gases; even then the gas often filled our shed. With this equipment we entered on our exhausting work.

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. Other days, on the contrary, the work would be a most minute and delicate fractional crystallization, in the effort to concentrate the radium. I was then annoyed by the floating dust of iron and coal

from which I could not protect my precious products. But I shall never be able to express the joy of the untroubled quietness of this atmosphere of research and the excitement of actual progress with the confident hope of still better results. The feeling of discouragement that sometimes came after some unsuccessful toil did not last long and gave way to renewed activity. We had happy moments devoted to a quiet discussion of our work, walking around our shed.

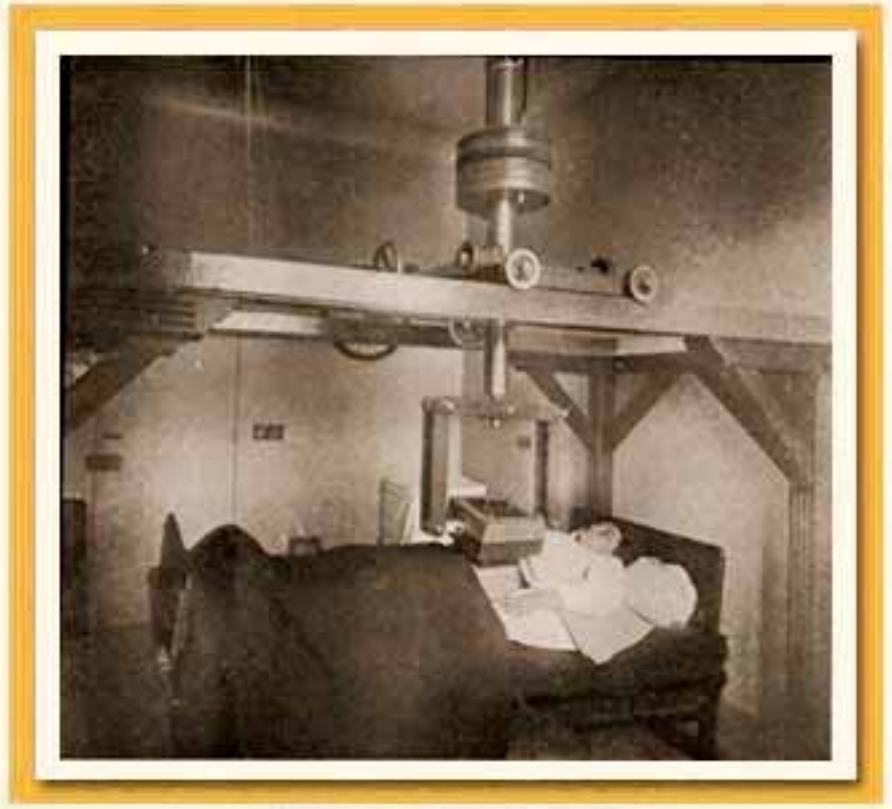
One of our joys was to go into our workroom at night; we then perceived on all sides the feebly luminous silhouettes of the bottles or capsules containing our products. It was really a lovely sight and one always new to us. The glowing tubes looked like faint, fairy lights."

—from Autobiographical Notes pp. 186-187.

The shed where radium was isolated. The Curies' new work space was not weatherproof and lacked standard lab equipment.

Inside the shed. After the Curies' first discoveries, the French government and industry provided some money to hire help in extracting radium.

The public and industrialists were fascinated by the Curies' discoveries. Radium, inexhaustibly giving out energy (you could see the light, and it gave out heat too), hinted at great mysteries and perhaps amazing inventions. Moreover, Pierre proved that radium could damage living flesh. That opened a new way to treat cancer and other ailments. But Marie lost nearly 20 pounds while doing her doctoral research, and Pierre was often exhausted and in pain. Was it overwork and stress, or was radiation the cause of their frequent illnesses? Marie refused to believe that radiation was very harmful, but doctors today think otherwise.



A large dose of radiation will kill people. But in controlled doses, as in the treatment of this patient, radiation can destroy cancer cells and attack other diseases. Radiation therapy has saved many millions of lives.

Industrial firms saw an opportunity in the Curies' research. They helped the Curies by providing additional lab space, raw materials, and support staff. A thriving industry grew up, extracting radioactive substances for medical uses (and other uses too, like watches that glowed in the dark). Radium was also used by scientists for experiments on atoms. They confirmed what Marie had suspected—the powerful energy that showed up in radioactivity was a fundamental property of every atom of matter.

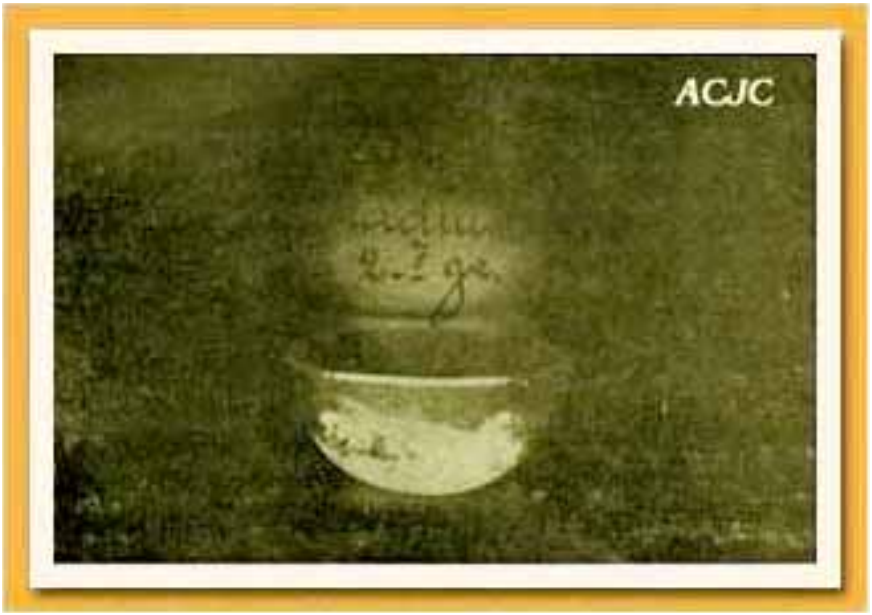
Radium Therapy

"**The first experiments** on the biological properties of radium were successfully made in France with samples from our laboratory, while my husband was living. The results were, at once, encouraging, so that the new branch of medical science, called radiumtherapy (in France, Curietherapy), developed rapidly, first in France and later in other countries. To supply the radium wanted for this purpose, a radium-producing industry was established. The first plant was created in France and worked very successfully, but afterwards manufactures were founded in other countries, the most important of which are now in America, where great quantities of radium ore, named "carnotite," are available. The radiumtherapy and the radium production developed conjointly, and

the results were more and more important for the treatment of several diseases, and particularly of cancer. As a consequence of this, several institutes have been founded, in the large cities, for the application of the new therapy. Some of these institutes own several grams of radium, the commercial price of the gram being now about $70,000, the cost of production depending on the very small proportion of radium in the ore.

It may be easily understood how deeply I appreciated the privilege of realizing that our discovery had become a benefit to mankind, not only through its great scientific importance, but also by its power of efficient action against human suffering and terrible disease. This was indeed a splendid reward for our years of hard toil."

—from Autobiographical Notes pp. 199-200.



A dish with a bit of radium compound, glowing in the dark, lighting up it surroundings and the card above it. People speculated that radioactivity might become more important than electricity.

The Curies themselves did not grow rich from this industry. In fact, they had trouble covering their household expenses. They increased their income in 1900 by taking on more teaching work. Marie became the first woman faculty member at France's top training school for women teachers. In 1903 she completed her doctoral thesis, becoming the first woman to receive a doctorate in France. The committee of examiners declared that her work had done more for science than any previous thesis project. Famous now, the Curies seemed destined for an easy life at the top of their profession.

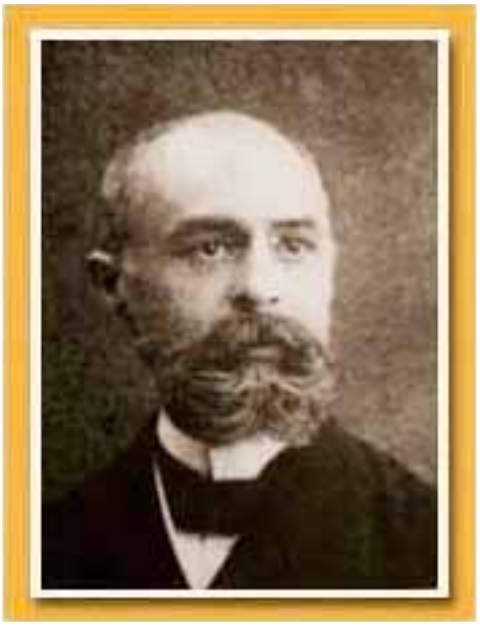
The Curies had a suburban home with a pleasant garden. Each August they vacationed at a cottage near the sea in Brittany, alongside some of their professional friends.

Radium Supplementals

I. The Mystery of the Rays

Scientists were fascinated by the discovery of X-rays. It was not just that the rays would be a huge help in medicine and must have many other practical uses. Here was a new tool for penetrating and studying matter. At this time, the end of the 19th century, many of the great problems of physics had been solved. There were laws for electricity and magnetism and gravity and more. But scientists knew they faced even greater mysteries, for the true nature of energy and matter were entirely unknown.

In Paris, Henri Becquerel was as intrigued as any scientist by X-rays. For many years he had studied unusual fluorescent minerals. If he let the sun shine on such a mineral, he wondered, might the energy of the sunlight make it give off X-rays? He found that a rock containing uranium did give off rays that could go through a sheet of black paper. By accident, he discovered that the rock gave off rays even when the sun was not shining on it! Where did the energy of the rays come from? What was it about this mineral that gave it such mysterious power?



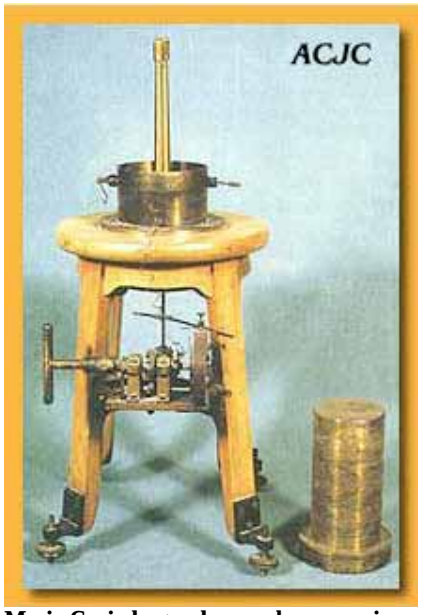
Henri Becquerel was 44 years old when he discovered uranium radiation, giving Marie Curie an opportunity to break new scientific ground.

A rock containing radium. The radium compounds could be used to color things yellow. And they were fluorescent, glowing under ultraviolet light ("black light"). Otherwise, scientists in the 1890s didn't think there was anything special about uranium.

Scientists soon found that uranium rays were too weak to produce good pictures of bones. It was easier to work with X-rays (all you needed was a special glass tube and electricity), and the unusual minerals containing uranium were not easy to get. Marie Curie decided to take the road less traveled. Others might ignore uranium rays, but she would try to understand the mystery behind them.

II. Attacking the Mystery

To study the rays, Marie Curie used a property that Becquerel had discovered. When uranium rays passed through the air near an electrical measuring instrument, he found, the instrument detected a difference. Marie Curie was lucky to have at hand just the right kind of instrument—a very sensitive and precise device—invented about 15 years earlier by Pierre Curie and his brother, Jacques. Marie used this "Curie electrometer" to make exact measurements of the tiny electrical changes that uranium rays caused as they passed through air. Great care was needed to get reliable numbers. As she measured the rays from different uranium compounds, she discovered that the more uranium atoms in a substance, the more intense the rays the substance gave off. Trying to see what was so special about uranium, she tested minerals containing other elements. She found that thorium compounds also gave off "Becquerel rays."

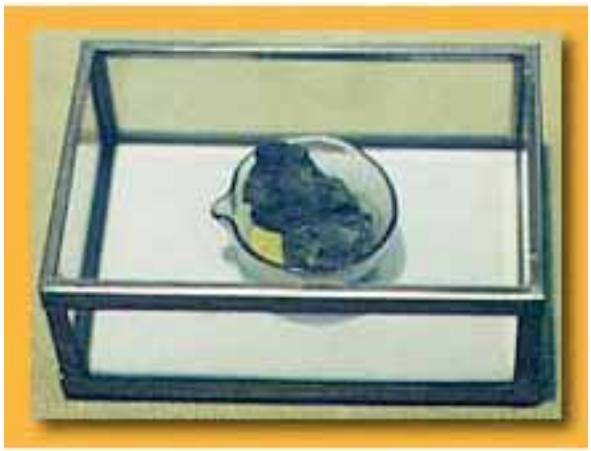


Marie Curie began her work on uranium rays using this device for precise electrical measurement. It was the "Curie electrometer," invented years earlier by Pierre Curie and his brother, Jacques.

Thorite. A mineral containing thorium and uranium and other elements. Using chemistry to separate out the different substances in such minerals, Marie found how much radioactivity was accounted for by each element.

Marie discovered that the mineral pitchblende was more radioactive than could be accounted for by the uranium or thorium it contained. She was convinced that a careful analysis of pitchblende would uncover a new radioactive element. Pierre, excited by his wife's idea, joined her search.

The Curies used standard chemical procedures to separate the different substances in pitchblende. For example, a particular element might dissolve in an acid, which they could pour off, leaving other elements behind in a sludge at the bottom of the pot. After the materials were separated into different types of compounds, the Curies used a new method of chemical analysis. The trick they invented was to find which of the separated parts was most radioactive, using the Curie electrometer to make precise measurements. Then they would make more separations, again and again, tracking down the unknown element by its radioactivity.



This is the sample of pitchblende that led the Curies to their discovery of radium & plutonium.

The school courtyard where Marie (sometimes with hired helpers) had vats of chemicals that gave off poisonous gases. The work could be physically demanding, for it meant pulverizing large quantities of materials and boiling them, stirring the solutions with a heavy iron bar.

In the end they found not one but two new radioactive elements. The substance they named "polonium" behaved chemically about the same as an element that was already known, bismuth, and the substance they named "radium" had about the same chemistry as the element barium. But polonium and radium were different from the known elements in one big way—each was strongly radioactive.

III. The Mystery Answered

Scientists had a hard time telling whether a new substance was a new element or only a compound of elements that were already known. About the time Marie Curie was born, the Russian chemist Dmitri Mendeleev created a chart for organizing the elements. Over 60 elements were known by that time. Mendeleev classified the known elements according to the weight of their atoms. The atomic weight was found by comparing a known number of the element's atoms to the same number of atoms of hydrogen, the lightest element.

To prove that radium and polonium were elements, the Curies would have to show that their atomic weights were different from the weights of any of the known elements. It was a tough challenge. For these elements are found in minerals only in quantities so tiny that they are invisible. If they weren't radioactive, nobody could have known they existed.

Radium metal (freshly prepared–it turns black when exposed to air).

Polonium, just enough to make a thin film on a steel disc. Marie Curie was never able to isolate enough of either element to see them like this.

It took Marie Curie more than three years to isolate one-tenth of a gram of pure radium chloride, a speck almost too tiny to see. Only then could she find the new element's atomic weight. It took her another eight years to isolate pure radium. She never succeeded in isolating polonium. It took a while for scientists to understand why radioactive elements were so hard to work with.

Building on Marie Curie's research, scientists came to a clearer understanding of atoms. Atoms were not the smallest possible bits of matter, for there were particles within atoms. Atoms of different elements were different because they had different numbers of these subatomic particles inside them. Each atom also contained an amazingly large stock of energy. This was the source of the mysterious energy of radioactivity—it was a fundamental property of matter itself. (In 1905, Albert Einstein explained how matter and energy were really one and the same thing.

It turned out that some of the mysterious "rays" that radioactive substances give off are actually tiny particles. When a radioactive atom shoots out a particle, the atom may change into an atom of a different element. For a uranium atom the result, after a series of steps, is a radium atom. This atom too is not stable, and eventually it becomes a polonium atom. The changes continue, ending up with an atom of lead, which is a stable element, not radioactive. It all takes millions of years. Scientists soon used radioactivity to measure the age of the Earth.

Marie Curie could not get pure polonium because it decays very rapidly. It takes only 138 days for half the atoms in the most stable form of polonium to change. While Curie was carrying out her careful chemical analysis of polonium, the polonium in her raw material was disappearing!

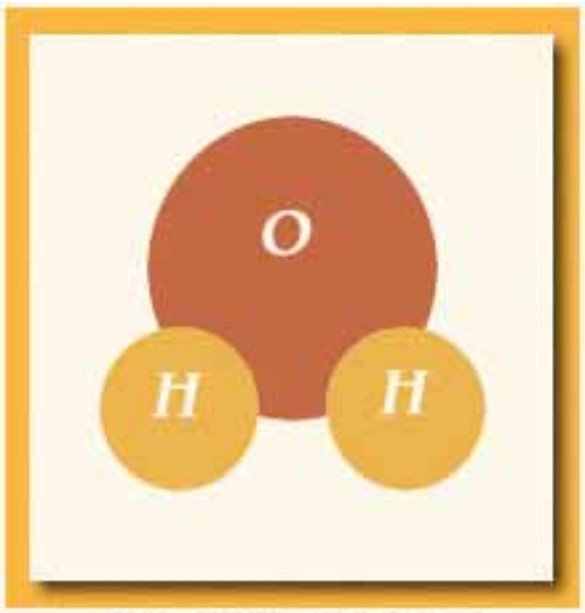
Ernest Rutherford, working in England, explained how radioactive elements transform themselves into other elements, giving out energy along the way. The process seemed as wonderful as the transmutation fruitlessly sought by ancient alchemists. Rutherford and other scientists often used Marie Curie's radium to drive their experiments.

A flask with radium compound emits light and heat. Building on Curie's work, Rutherford and other scientists found that a radioactive atom gives out energy when it changes into another kind of atom. The amount of energy was amazingly large.

Atoms, Elements, Compounds

At the time the Curies discovered polonium and radium, identifying new chemical elements was one of the highest goals a scientist could hope to reach. A chemical element is a substance that contains only one kind of atom. If you keep dividing up such a substance, you finally get to the tiny atoms. Nobody had been able to divide an atom further, into smaller pieces.

Everything in the world around us is made up of the atoms of the chemical elements, combined with one another in countless ways in compounds. For example, water is not an element but a compound of two true elements, hydrogen and oxygen. When chemists describe water as H_2O they mean that the smallest particle of water is made of two atoms of hydrogen and one atom of oxygen. For scientists of Marie Curie's time, it was a great mystery why atoms of different elements had different chemical properties—for example, why it was in the nature of oxygen atoms to combine in this way with hydrogen to make a wet liquid. Experiments using radioactivity helped bring the answer after many years.



Since the early nineteenth century scientists have known that a substance like water is a collection of many particles like this one. Each is made of one atom of oxygen stuck together with two atoms of hydrogen. Hydrogen & oxygen themselves are elements, not compounds of other atoms.

High Honors, then Tragedy

When the Nobel Prize for Physics was awarded to Pierre and Marie Curie in 1903, the great honor quickly changed their lives. Pierre was finally appointed to a professorship at the Sorbonne, and the university belatedly found funds for a laboratory for him. It also hired Marie—the first woman to win a Nobel Prize—as "laboratory chief."

Fame and Illness

"**In 1903 I finished my doctor's thesis** and obtained the degree. At the end of the same year the Nobel prize was awarded jointly to Becquerel, my husband and me for the discovery of radioactivity and new radioactive elements.

This event greatly increased the publicity of our work. For some time there was no more peace. Visitors and demands for lectures and articles interrupted every day....

The fatigue resulting from the effort exceeding our forces, imposed by the unsatisfactory conditions of our labor, was augmented by the invasion of publicity. The overturn of our voluntary isolation was a cause of real suffering for us and had all the effect of disaster. It was serious trouble brought into the organization of our life, and I have already explained how indispensable was our freedom from external distraction, in order to maintain our family life and our scientific activity. Of course, people who contribute to that kind of trouble generally mean it kindly. It is only that they do not realize the conditions of the problem."

—from Autobiographical Notes pp. 190-191.

Letters from Pierre Curie to his friend E. Gouy

20 March 1902

As you have seen, fortune favors us at this moment; but these favors of fortune do not come without many worries. We have never been less tranquil than at this moment. There are days when we scarcely have time to breathe. And to think that we dreamed of living in the wild, quite removed from human beings!

---

22 January 1904

I have wanted to write to you for a long time; excuse me if I have not done so. The cause is the stupid life which I lead at present. You have seen this sudden infatuation for radium, which has resulted for us in all the advantages of a moment of popularity.

We have been pursued by journalists and photographers from all countries of the world; they have gone even so far as to report the conversation between my daughter and her nurse, and to describe the black- and-white cat that lives with us.... Further, we have had a great many appeals for money.... Finally, the collectors of autographs, snobs, society people, and even at times, scientists, have come to see us—in our magnificent and tranquil quarters in the laboratory—and every evening there has been a voluminous correspondence to send off. With such a state of things I feel myself invaded by a kind of stupor. And yet all this turmoil will not perhaps have been in vain, if it results in my getting a chair and a laboratory.

---

25 July 1905

We have regretted so much being deprived of your visit this year, but hope to see you in October. If we do not make an effort from time to time, we end by losing touch with our best and most congenial friends, and in keeping company with others for the simple reason that it is easy to meet them.

We continue to lead the same life of people who are extremely occupied, without being able to accomplish anything interesting. It is now more than a year since I have been able to engage in any research, and I have no moment to myself. Clearly I have not yet discovered a means to defend ourselves against this frittering away of our time which is nevertheless extremely necessary. Intellectually, it is a question of life or death.

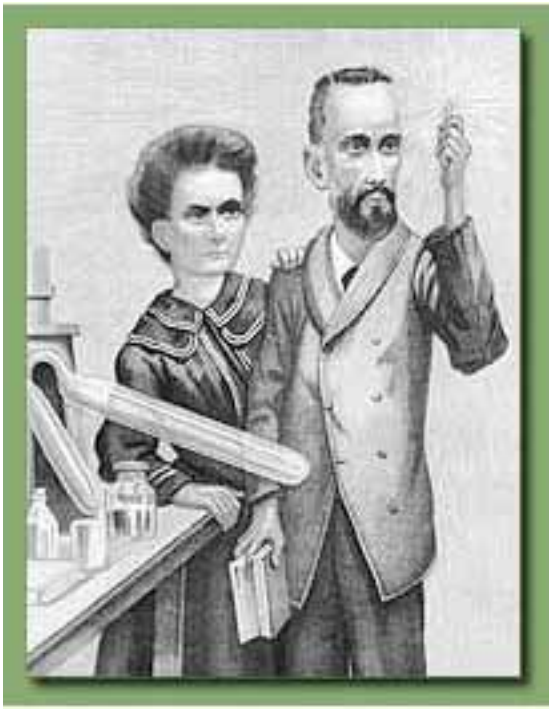
---

7 November 1905

I am neither very well, nor very ill; but I am easily fatigued, and I have left but very little capacity for work. My wife, on the contrary, leads a very active life, between her children, the School at Sèvres, and the laboratory. She does not lose a minute, and occupies herself more regularly than I can with the direction of the laboratory in which she passes the greater part of the day.

—from Pierre Curie pp. 127-129.

Pierre and Marie felt too ill, and too busy, to get to Sweden to deliver the traditional lecture accepting the Nobel Prize until 1905. The following spring Pierre was finally feeling more positive about his research. Although rainy, April 19, 1906, promised to be a productive day for him. After working in the laboratory in the morning, he was on his way to a library when he slipped on the wet street and fell in front of a heavy horse-drawn wagon. It ran over his head, killing him instantly.



The Curies were now world-famous. In December 1904 the popular British magazine Vanity Fair published this caricature of the Curies under the title "Radium." That same month, the Curies' second daughter, Eve, was born. Both Curies complained of the way the press intruded on their private lives.

Eleven days after Pierre's death Marie began a diary. Pouring out her grief to the dead Pierre, she reported putting in his coffin a copy of this photograph. It was taken during her student days at the Sorbonne, around the time they met.

Tragedy

"**In 1906 just as we were** definitely giving up the old shed laboratory where we had been so happy, there came the dreadful catastrophe which took my husband away from me and left me alone to bring up our children and, at the same time, to continue our work of research.

It is impossible for me to express the profoundness and importance of the crisis brought into my life by the loss of the one who had been my closest companion and best friend. Crushed by the blow, I did not feel able to face the future. I could not forget, however, what my husband used sometimes to say, that, even deprived of him, I ought to continue my work.

The death of my husband, coming immediately after the general knowledge of the discoveries with which his name is associated, was felt by the public, and especially by the scientific circles, to be a national misfortune. It was largely under the influence of this emotion that the Faculty of Sciences of Paris decided to offer me the chair, as professor, which my husband had occupied only one year and a half in the Sorbonne. It was an exceptional decision, as up to then no woman had held such a position.... The honor that now came to me was deeply painful under the cruel circumstances of its coming."

—*from Autobiographical Notes pp. 191-192.*

Selections from Marie Curie's diary

"**We put you into the coffin** Saturday morning, and I held your head up for this move. We kissed your cold face for the last time. Then a few periwinkles from the garden on the coffin and the little picture of me that you called "the good little student" and that you loved. It is the picture that must go with you into the grave, the picture of her who had the happiness of pleasing you enough so that you did not hesitate to offer to share your life with her, even when you had seen her only a few times. You often told me that this was the only occasion in your life when you acted without hesitation, with the absolute conviction that you were doing well. My Pierre, I think you were not wrong. We were made to live together, and our union had to be.

Your coffin was closed and I could see you no more. I didn't allow them to cover it with the horrible black cloth. I covered it with flowers and I sat beside it....

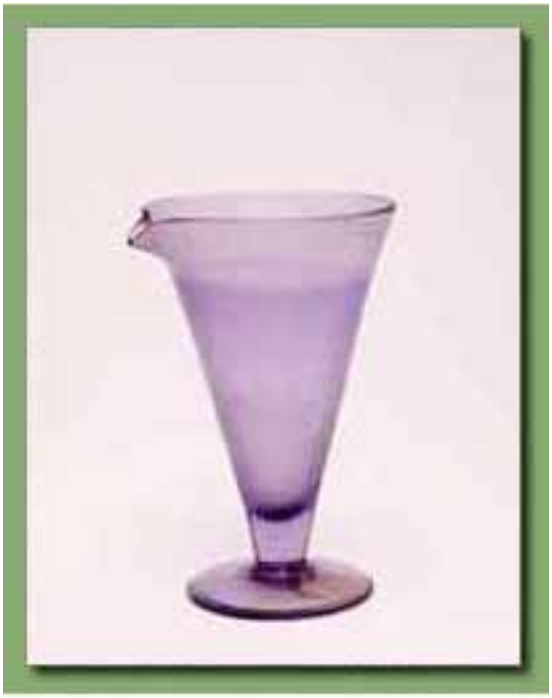
They filled the grave and put sheaves of flowers on it. Everything is over, Pierre is sleeping his last sleep beneath the earth; it is the end of everything, everything, everything.

I am working in the laboratory all day long, it is all I can do; I am better off there than anywhere else. I conceive of nothing any more that could give me personal joy, except perhaps scientific work–and even there, no, because if I succeeded with it, I would not endure you not to know it."

—*from Madame Curie p. 249.*

Despite her shock and grief, Marie went back to work a day after the funeral. Less than a month later, the Sorbonne agreed to make her its first woman professor, taking up Pierre's position. Meanwhile she began important lab work. Another scientist had come up with a theory that radium was not an element at all, but a compound of the known elements lead and helium. It took her several years to prove beyond doubt that radium was indeed an element.

Still more important, she decided to establish a scientific institution worthy of Pierre's memory. Helped by her scientist friends, she persuaded the French government and the private Pasteur Foundation to fund a Radium Institute. Marie would head a radioactivity laboratory, and an eminent physician would lead its medical research laboratory.



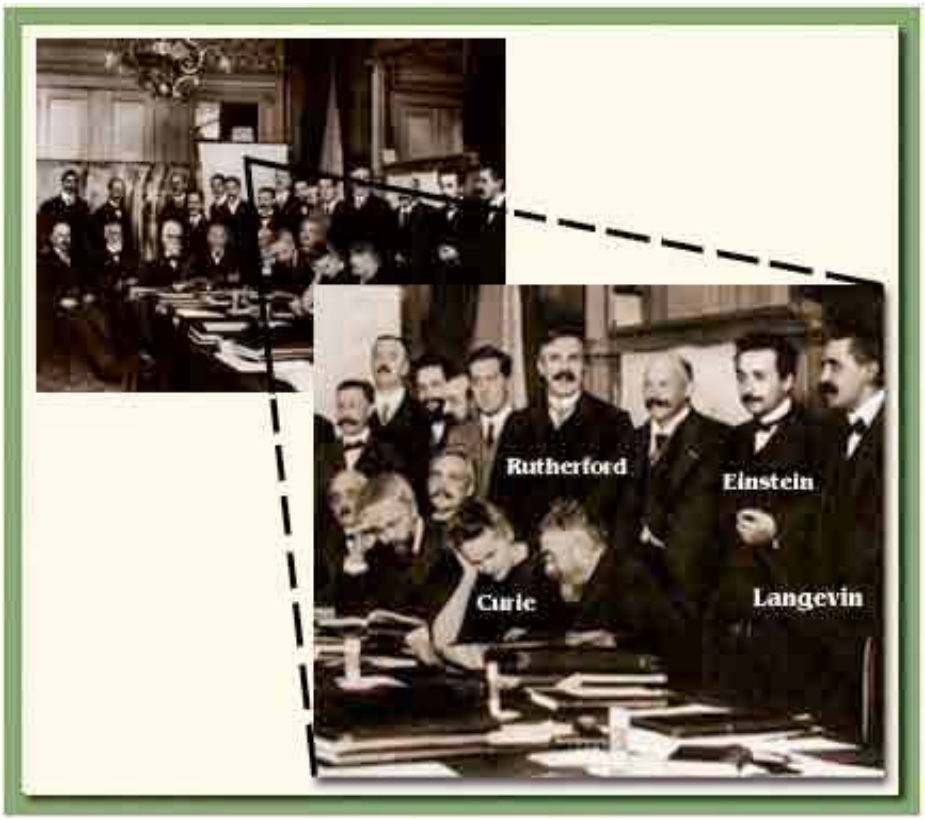
A glass flask used by Marie Curie during her research on radium. Radiation from the radium has changed the color of the glass.

Work, a Scandal and Back to Work

Marie Curie was busy not only with her teaching, research, and efforts to set up the Radium Institute, but also as a mother. Between 1906 and 1908 she taught physical science once a week at a cooperative school, where her daughter Irène and a few other children got lessons from their parents. Her father-in-law helped raise Irène and Eve, but he died in 1910. A series of Polish governesses was hired, some more successful than others. The next few years were difficult. In 1911 the French Academy of Sciences rejected Curie's bid to become a member. Later that year, a scandal erupted.

Paul Langevin had been one of Pierre's brightest students. Now he was in love with Pierre's widow. Langevin was unhappily married to a woman who could not understand his devotion to scientific research, but some newspapers accused the foreigner Curie of breaking up a good French home. Returning to France from a meeting of scientists, Curie found a mob in front of her house. She scooped up her terrified daughters and took refuge with friends.

Many people felt that Curie, a woman and a foreigner, must never become a member of the famous Academy of Sciences. This newspaper pretended to analyze her face and handwriting to expose bad racial characteristics.



In autumn 1911, Curie was the only woman to attend an important international physics conference in Belgium. During her absence a French newspaper got hold of intimate letters Curie had exchanged with Paul Langevin.

In the middle of this trial Curie became the first person to win a second Nobel Prize. She pulled herself together and traveled to Sweden to accept the 1911 Nobel Prize for Chemistry for her discovery of radium and polonium. The following month, she collapsed from depression and kidney problems. Many months passed before Curie was able to work again.

Curie finally returned to work in late 1912. She never remarried, devoting her life to the Radium Institute. By August 1914, the building was nearly completed. She expected its work to improve the human condition would begin immediately.

Help for the Wounded

In August 1914, Germany invaded France. Nearly all of Curie's staff at the Radium Institute enlisted in the war effort. Scientific research had to halt during the World War, and Curie looked for ways her science could help. She knew that doctors could use X-rays to save the lives of wounded soldiers by revealing bullets, shrapnel, and broken bones. The problem was to get the X-ray machines to the doctors near the Front. Curie talked wealthy people into donating their cars, and assembled a fleet of 20 mobile X-ray stations as well as 200 stationary stations.

The Radium Institute on the Rue Pierre-Curie in Paris.

Curie in one of the vehicles that French soldiers called "petites Curies" (little Curies), 1917. They brought life-saving X-ray equipment to the battle front.

Curie chose her teenage daughter Irène as her first assistant. For a year Irène worked by her mother's side. Like her mother, she refused to show emotion at the sight of the terrible wounds. Soon Curie allowed Irène to direct an X-ray station by herself. Meanwhile Marie thought of another way for radioactivity to help save soldiers' lives. At the Radium Institute she prepared tiny glass tubes containing a radioactive gas (radon) that comes from minerals containing radium. Hospital doctors inserted the tiny tubes into patients at spots where the radiation would destroy diseased tissue.

X-rays on Wheels

The dominant duty imposed on everyone at that time was to help the country in whatever way possible during the extreme crisis that it faced. No general instructions to this were given to the members of the University. It was left to each to take his own initiative and means of action....

During the rapid succession of events in August 1914, it was clearly proved that the preparation for defense was insufficient. Public feeling was especially aroused by the realization of the grave failings which appeared in the organization of the Health Service. My own attention was particularly drawn to this situation, and I soon found a field of activity which, once entered upon, absorbed the greatest part of my time and efforts until the end of the war, and even for some time thereafter....

It is well known that the X-rays offer surgeons and doctors extremely useful means for the examination of the sick and wounded....

However, at the beginning of the war, the Military Board of Health had no organization of radiology, while the civil organization was also but little developed. Radiologic installations existed in only a small number of important hospitals, and there were only a few specialists in the large cities. The numerous new hospitals that were established all over France in the first months of the war had, as a rule, no installation for the use of X-rays.

To meet this need I first gathered together all the apparatus I could find in the laboratories and stores. With this equipment I established in August and September, 1914, several stations of radiology, the operation of which was assured by volunteer helpers to whom I gave instruction. These stations rendered great service during the battle of the Marne. But as they could not satisfy the needs of all the hospitals of the Paris region, I fitted up, with the help of the Red Cross, a radiologic car. It was simply a touring motor-car, arranged for the transport of a complete radiologic apparatus, together with a dynamo that was worked by the engine of the car, and furnished the electric current necessary for the production of the rays. This car could come at the call of any of the hospitals, large or small, in the surroundings of Paris. Cases of urgent need were frequent, for these hospitals had to take care of the wounded who could not be transported to more distant places.

—from Autobiographical Notes pp. 208-211.

From *Radiology in War*

The story of radiology in war offers a striking example of the unsuspected amplitude that the application of purely scientific discoveries can take under certain conditions.

X rays had had only a limited usefulness up to the time of the war. The great catastrophe which was let loose upon humanity, accumulating its victims in terrifying numbers, brought up by reaction the ardent desire to save everything that could be saved and to exploit every means of sparing and protecting human life.

At once there appeared an effort to make the X ray yield its maximum of service. What had seemed difficult became easy and received an immediate solution. The material and the personnel were multiplied as if by enchantment. All those who did not understand gave in or accepted; those who did not know learned; those who had been indifferent became devoted. Thus the scientific discovery

achieved the conquest of its natural field of action. A similar evolution took place in radium therapy, or the medical application of radiations emitted by the radio elements.

What are we to conclude from this unhoped-for development shared between the new radiations revealed to us by science at the end of the nineteenth century? It seems that they must make our confidence in disinterested research more alive and increase our reverence and admiration for it.”

—from Madame Curie p. 306.

From Marie's letters to Irène Curie

Paris, Monday, 31 August 1914
[At this time the German Army was threatening Paris]

Dear Irène,

I've just received your sweet letter of Saturday and I wanted so much to hug you that I almost cried. This morning I was able to make my way to the train station where Fernand and Margaret were to leave—and I didn't manage to see them. I wonder if they've left.

Things are not going very well, and we all have a heavy heart and disturbed spirit. We need great courage and I hope we will not lack it. We must keep the firm hope that after these bad days, good times will return. It's in that hope that I lock you in my heart, my beloved daughters.

Mé [Mom]

Poperinghe, 24 January 1915
[Near Dunkirk]

Dear Irène,

After various wanderings, we've arrived here, but we can't make an attempt at working until we've made some modifications at the hospital. They want to build a shelter for the car and a partition to create the radiology room in a big ward. That all holds up the work, but it's difficult to do otherwise. In Dunkirk, German planes dropped some bombs that killed a few people, but the populace is scarcely frightened. At Poperinghe too these accidents happen, but less often. We hear the guns grumbling almost constantly. It's not raining, a bit of frost. We were welcomed at the hospital with extreme cordiality, I have a nice room and they give me a fire in a stove at the side. I'm better off than at Furnes, I'll eat at the hospital. With a hug,

Mé

—from Correspondance pp. 129, 158.

Irène (in center) and Marie Curie gave training in radiation medicine to these American officers and many others, both during World War I and after.

Organizer, Promoter, Legend

After the war ended in 1918, Marie Curie went back to doing whatever she could to raise money for the Radium Institute. She was becoming a living legend, and she resolved to make the most of her fame. The tale of her early struggles could inspire people to give scientists more help. As the tale was retold, it sometimes sounded as if she had done everything single-handed, although in fact she had relied, like nearly all scientists, on private and government funds and assistants.

Marie and Irène Curie in the Radium Institute.

Curie's best opportunity came when a magazine article led to a "Marie Curie Radium Campaign" in the United States. The trip tired her out, and she was happy to let her daughters take her place at some functions. The effort paid off. She returned with a gram of radium—only a speck, but so fiercely radioactive that it could fuel thousands of experiments—as well as expensive equipment and cash for the Radium Institute.

Appearing in Public

Prague, Sunday, 14 June 1925

Dear Irène,

I got your letter of June 5 which arrived in Warsaw the 12th. I find that [delay] excessive... I arrived in Prague this morning and will leave tomorrow evening for Jachymow. I'm bewildered by the life I'm leading and incapable of telling you anything intelligent. I ask myself, what fundamental vice is there in the organization of humanity that makes this sort of agitation, to a certain degree, necessary? Mrs. Meloney [the American journalist who encouraged Marie to expose herself to the press] would call it, "Dignifying science." And what's undeniable is the sincerity of everyone who does these things and their conviction that they are necessary.

Here I'm in a magnificent apartment, bedroom, sitting-room and bathroom, overlooking the river bordered by hills, and full of flowers they gave me at the train station—mostly roses since it's their season. Unfortunately it's gray, and I'm afraid it will rain.... With hugs,

Mé

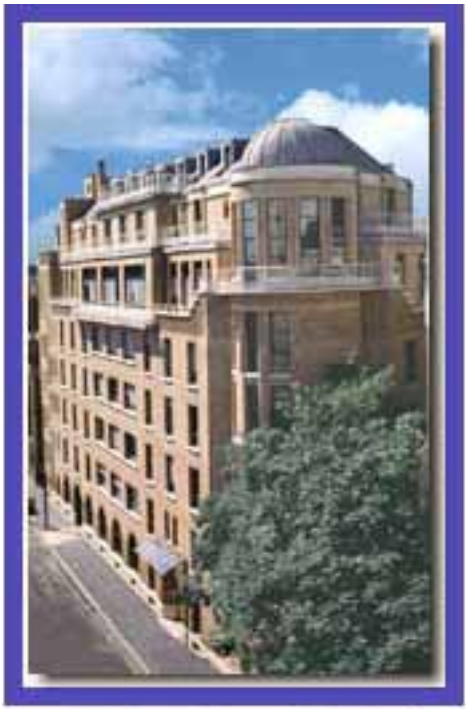
—from Correspondance p. 255.

Curie in New York in 1920, surrounded by newsmen. Although she was shy and hated emotional attention, she put up with the press, since sympathetic newspaper articles could help her task. Always practical, she wore the same black dress she had worn to both Nobel ceremonies.

Curie continued to do research on radioactivity, but her main focus shifted to running the Radium Institute. She made the Institute a center for measuring the radium content of various products used by doctors and others. She also made it a world center for research, carefully selecting several dozen scientists and keeping up with the progress of each. Her researchers made many discoveries. In 1934, she was delighted when her daughter Irène and Irène's husband, Frédéric Joliot-Curie, discovered artificial radioactivity at the Radium Institute.

Curie did not live to see Irène and Frédéric receive the 1935 Nobel Prize for their discovery. As early as 1920 she had been suffering from medical problems, probably caused by her many years of exposure to radioactive materials. On July 4, 1934, Marie Curie died of aplastic anemia, a blood disease that often results from getting too much radiation. She was buried next to Pierre. In 1995 the remains of the pair were transferred to the majestic Pantheon in Paris, where they now lie alongside France's greatest citizens. The president of France declared that the transfer demonstrated the nation's respect for all those, like the Curies, "who dedicate themselves to science."

Marie Curie with her daughter Irène, her son-in-law Frédéric Joliot-Curie, and other family members.

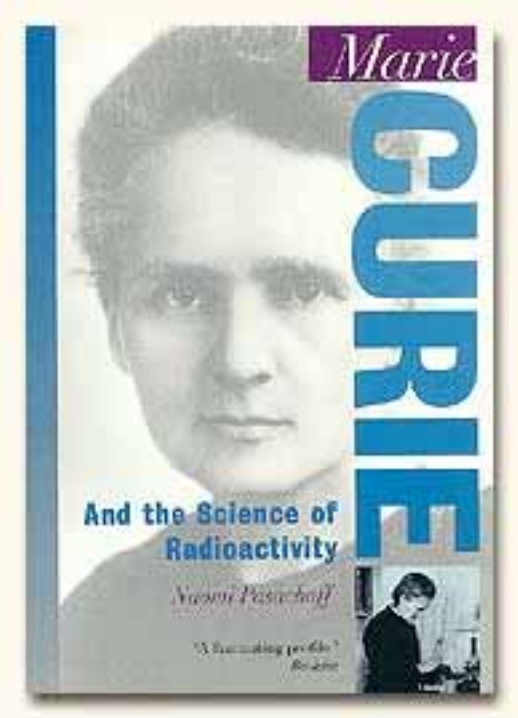


The Curie Foundation hospital, opened in 1936 in Paris. It is only one of many thousands of hospitals and institutions that are still building on Marie Curie's work to heal patients and carry on research.

. . .

The End

Information About this Exhibit



This exhibit is based on the book by Naomi Pasachoff, *Marie Curie and the Science of Radioactivity*. New York and Oxford: Oxford University Press, 1996.

The exhibit was constructed by the Center for History of Physics with support from the American Institute of Physics and the Friends of the Center.

Author:	Naomi Pasachoff
Editor:	Spencer R. Weart
Web Design:	Linda Wooliever

We are also very grateful to: Lawrence Badash, Soraya Boudia, Hélène Langevin-Joliot, Pierre Radvanyi, Xavier Roquè, Bernadette Vincent-Bensaud, and Association Curie et Joliot-Curie and Musèe et Archives de l'Institute du Radium

Further reading and links: visit http://www.aip.org/history/curie/biblio.htm

Comments? Send us feedback. Email chp@aip.org

Help us make more exhibits! Visit http://www.aip.org/history/historymatters

Sign up to find out when we put more exhibits online.
Email us at chp@aip.org to be added to our email list.

Photo Credits

Images credited to ACJC are courtesy of and copyrighted © by either the Association Curie et Joliot-Curie or the Archives Curie et Joliot-Curie, Paris. Except as otherwise noted below, all other images are courtesy of and copyright © the AIP Emilio Segrè Visual Archives.

Polish girlhood: Czar Alexander II: Reproduced from N.G.O. Pereira, *Tsar-Liberator : Alexander II of Russia, 1818-1881*. Newtonville, MA : Oriental Research Partners, 1983. Cossacks parading in Warsaw: BBC Hulton Picture Library

A Student in Paris: Paris in 1889: Anonymous photo reproduced from *The Eiffel Tower : A Tour de Force*. New York : The Grolier Club, 1989. Paris Rooftops: Gustave Caillebotte, *Vue de toits (effet de neige)*, reproduced with permission of MusÈe d'Orsay, Paris

Research Breakthroughs: Pitchblende sample: Photo by Jay Pasachoff

Recognition and Disappointment: Mittag-Leffler: Reproduced with permission of The MacTutor History of Mathematics archive. Vanity fair cover from http://info.med.yale.edu/library/exhibits/curie/p-and-m-curie.html.

Tragedy and Adjustment: Childe Hassam painting: private collection

Scandal and Recovery: Branly and Curie: L'Excelsior, 23 January 1911. Langevin: Jean-Loup Charmet. Emile Borel: Reproduced with permission of The MacTutor History of Mathematics archive. Hertha Ayrton: From the Institution of Electrical Engineers Archives. Curie in Birmingham: New York Public Library, General Research Division, Astor, Lenox and Tilden Foundation

War Duty: Radium Institute: Reproduced from Curie, Eve. *Madame Curie.* New York: Doubleday, Doran & Company, 1938. Petite Curie: Photo by Jay Pasachoff. Marie and IrËne with X-ray equipment: Marie Sklodowska Curie Museum. Curie with x-ray workers: Marie Sklodowska Curie Museum

The Radium Institute: Henri de Rothschild: Bibliothèque nationale de France, Paris. Curie and Hoover: E Towpik and R. Mould. "Marie Sklodowska-Curie Memorial Issue," Nowotwory, *Polish Oncological Journal,* Warsaw, 1998. Poster for a campaign urging early detection of cancer: copyright La Ligue Nationale contre le Cancer. Curie busts: Photo by Jay M. Pasachoff. Reinterment of Pierre and Marie Curie: Photo by Jay M. Pasachoff

The Romantic Legend: Greer Garson as Curie: From the film *Madame Curie,* MGM, 1943. The facilities in the School of Industrial Physics and Chemistry shed: Photo by Jay M. Pasachoff

The End of the Curie Hold on French Science: Irène Curie photograph by William G. Myers, Ph.D., M.D., The Medical Heritage Center, The Ohio State University Prior Health Sciences Library, courtesy AIP Emilio Segrè Visual Archives

Sources

Marie Curie, Pierre Curie with Autobiographical Notes. Translated by Charlotte and Vernon Kellogg (New York: Macmillan, 1923).

Eve Curie, Madame Curie. Translated by Vincent Sheean (Garden City, NY: Doubleday, Doran, 1938), © Doubleday, Doran.

Marie and Irène Curie, Correspondence; choix de lettres, 1905-1934, edited by Gillette Ziegler. (Paris: Éditeurs français réunis, 1974), © Éditeurs français réunis. Translated by S. Weart.