Marguerite Perey (1909–1975): A Personal Retrospective Tribute on the 30th Anniversary of Her Death

Jean-Pierre Adloff[†] and George B. Kauffman*

Université Louis Pasteur,63 Rue Saint Urbain, Strasbourg, France F-67100, jpadloff@noos.fr and Department of Chemistry, California State University, Fresno, Fresno, CA 93740-8034,georgek@csufresno.edu

Abstract: On the occasion of the 30th anniversary of the death of French radiochemist Marguerite Perey (1909–1975), her life and achievements are recounted from her earliest youth through her selection as Marie Curie's assistant, her collaboration with Curie, her research on actinium, discovery of francium (atomic number 87), her career after Curie's death, her appointment as Professor at the Université Strasbourg, her protracted final illness, and death. Her similarities to and differences from her mentor Madame Curie and other female scientists are discussed. Excerpts from her unpublished letters are also included.

Marie Curie (1867–1934) is the symbolic figure of radioactivity, the science for which she coined the word. There is no country outside of France where she is as much adulated for her scientific fame, her courage in adversity, her radiological services during World War I (1914–1918) [1], and her eagerness to work for the benefit of mankind. Her saga was taught to the younger generations in elementary and high schools and illustrated in numerous ways for the public at large. It is therefore not surprising that in the decades of the 1920s and 1930s the chance for a student to approach and to join Madame Curie at the Institut du Radium founded in 1919 was an almost unthinkable dream. Among the few selected for this singular honor was Marguerite Perey (1909–1975), a young woman, who became famous for her discovery of the element francium (atomic number 87), four decades after Pierre and Marie Curie's discoveries of polonium and radium. It is appropriate that on the occasion of the 30th anniversary of Perey's death we recount her life and achievements.

Childhood and Family Life

Marguerite Catherine Perey, the daughter of Émile Louis Perey and Anne Jeanne Perey (née Ruissel), was born in Villemomble, near Paris, on October 19, 1909. She was the youngest of five children and had one sister and three brothers. Her parents were descendants of two ancient families from Alsace in France and Vaudois in Switzerland; the latter, on her mother's side, traced its origins back to 1398. A close relative was Henri Dunant (1828–1910), founder of the Red Cross and recipient of the very first Nobel Peace Prize (1901). Marguerite's father owned a flour mill. A stock market crash and his death on March 12, 1914 created serious financial difficulties for the middle class Protestant family. Perey's mother helped to support the family by giving piano lessons. Their maid, Marie, a Breton who had served the family for 30 years, renounced her salary and even helped support the family with her own earnings.

The children grew up in a rigorist home environment in which both work and religion were equally respected. Marguerite was a monitor in a Sunday school and a responsible member of several organizations for youths. The family's precarious financial situation did not permit the children to pursue any higher education. Marguerite was forced to abandon her wish for a career in medicine, but with the help of a scholarship and additional small earnings that she received as a tutor for schoolchildren she began studies in chemistry at the École Féminine d'Enseignement Technique, a private but state-recognized Parisian school for technicians (Figure 1).

When Marguerite had become famous, she was asked, "And now a husband? What about children?" Her eldest brother replied, "When a young woman asserts herself, she becomes unavoidably exacting. Then when the prime youth is over, one has to question the future" [2].

Perey never married but had a profound affection for her three brothers Jean, Jacques, and Paul and particularly for her sister Madeleine. They each founded families, and Perey loved her familial encounters with her numerous nieces and nephews, who called her "Tante Guite." One nephew, François Perey, settled in the United States and was a physicist at the Oak Ridge National Laboratory. The Perey family was a very extended and close one. During the 1980s a visit to Marguerite's laboratory and the museum dedicated to the discovery of francium in Strasbourg was organized. Three buses were needed to carry all her relatives from many countries.

The Encounter with Marie Curie

When funds were available, Marie Curie customarily asked the Director of the École Féminine d'Enseignement Technique for permission to hire the best female chemist of the graduating class. This was the case for Perey, who received her Diplôme d'Etat de Chimiste in June, 1929. At the commemoration of Marie Curie's centenary Perey recalled her first encounter with the legendary Madame Curie**:**

> In 1929 I was a young and timid student, not yet 20 years old. I had an appointment for an interview with Madame Curie. The interview was for the same day that the results [of my examinations] were to appear; I did not have them yet, although this would have been useful for me in the impending encounter that I viewed with considerable apprehension.

[*] Series Editor contribution

[†] Marguerite Perey's first research student and successor

Figure 1. The Technical School for Women. Perey is the fourth student from the left, 1928.

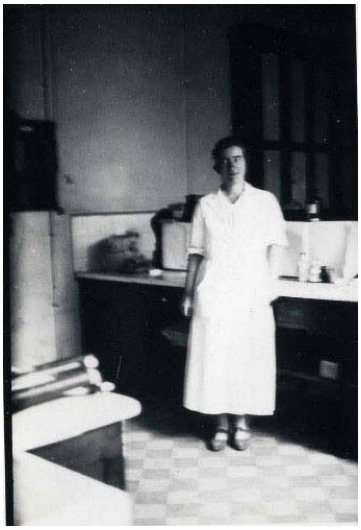


Figure 2. Perey at the Institut du Radium, about 1931.

> I was directed toward a small, very gloomy, waiting-room. Alone in this dismal atmosphere, the passing minutes seemed like hours to me. Then, without a sound someone entered like a shadow. It was a woman dressed entirely in black. She had grey hair, taken up in a bun, and wore thick glasses. She conveyed an impression of extreme frailty and paleness. At first I thought it was a secretary, but then I realized to my great embarrassment that I was in the presence of Marie Curie in person!
> Following a conversation during which I had the impression that I was completely inhibited, I heard as from a distance the statement, "I shall inform you in the course of the summer whether or not the research grant promised by the Mining Union of Upper-Katanga will be accorded." I found that this was a very polite way of closing the interview, and it was with a sigh of relief that I left this dark house, persuaded that it was for the first and last time. Everything had seemed melancholy and somber, and I was relieved to think that I would undoubtedly not return there [3].

A few days later, on July 9, Perey received a letter from Mrs. Hélène Galabert on behalf of Marie Curie**:**

> This morning I had a talk with Madame Curie who is now quite decided to hire you in her laboratory from October 1st. Hence you may be reassured on your future [4].

Perey concluded,

> And so it was that I began my career in the Curie Laboratory. I was so much impressed by Marie Curie, the prevailing atmosphere of comradeship, and by the work which interested me that what I thought to be a term of several months turned out to be a research period of 20 years at the Institut du Radium [3].

The Marie Curie-Marguerite Perey Team

The collaboration between these two women was limited to the few years between October, 1929 and Marie Curie's death in July, 1934 (Figure 2). Of course, initially Perey knew nothing about radioactivity. She had been trained for simple chemical operations and the utilization of kitchen recipes for analysis and the preparation of common chemicals. She had to learn the rudiments of handling and measuring radioactive substances. Although Marie Curie worked on many committees in France and abroad—in 1932 she traveled to the United States for a second time—she found enough time to train the young technician herself. Her teaching was facilitated by Perey's skill and eagerness to learn. Perey remembered:

> For several years I had the immense privilege of working under Marie Curie's direction as her private assistant (*préparateur*). I had to prepare all material required for an experiment under Curie's attention. It was marvelous to be guided by Marie Curie, to receive her advice and explanations. What a mutual joy when we succeeded in the preparation of a [radioactive] product of high purity…[3].

Assuming a period of two years for Perey to become acquainted with the handling and measuring of radioactive material, the Curie–Perey team was operative for 2 or 3 years.

The team's scientific work can be inferred from Marie Curie's last publications and one of her laboratory notebooks, surprisingly kept in Japan (Figures 3 and 4). From 1930 on, Curie's experiments dealt primarily with the spectroscopy of α-rays emitted in the radioactive actinium series. The research was carried out in collaboration with Salomon Rosenblum (1895–1959), the discoverer of the emission of long-range α-particles, a phenomenon that revealed the existence of excited states of nuclei and that gave a definitive impulse to the field of nuclear spectroscopy.

Thus from the beginning of her professional life Perey worked on actinium (^{227}Ac), one of the most dangerous radioelements, which became the *Leitmotiv* of her scientific career. Once incorporated into the body, the element concentrates irreversibly in the bones. Within three months actinium is in equilibrium with its daughter products; later, the activity decreases with the 22-year half-life of actinium. Perey's collaboration with Curie is a premonitory sign of destiny and the first step toward a major discovery, francium (element 87), and—alas!—of the premature interruption of Perey's brilliant scientific career.

Marie Curie was undoubtedly helped by Perey in seven of her last ten publications beginning with 1930. All of the experiments required clean separations of radioisotopes of various elements, sometimes in a matter of minutes. Significantly, Perey was acknowledged as early as June, 1931 in the first of Curie and Rosenblum's extended publications [5].

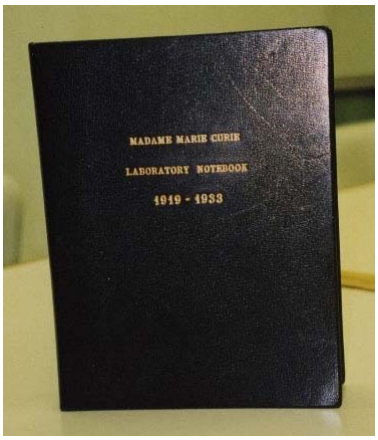


Figure 3. Marie Curie's Laboratory Notebook with Experiments Performed with Perey from 1930 to 1933. The document is preserved in the Kodama Library at the University Meisei near Tokyo. It was purchased in 1979 by Professor Kodama for $110,000 from a dealer in New York, who bought the document from a mysterious "physicist." No information is available on the robbery of the book from the Institut du Radium. According to Hélène Langevin, Marie Curie's granddaughter, certain documents disappeared from the laboratory after Marie Curie's death. (Courtesy, J.-P. Adloff).

Figure 4. Jean-Pierre and Madeleine Adloff consulting the Curie-Perey notes at Meisei, December, 1998. (Courtesy J.-P. Adloff).

The runs with the spectrometer were sporadic and lasted from a few minutes to several hours or days depending on the half-life of the radioactive substances. Meanwhile Perey had to prepare the material for Marie Curie's dream—the optical spectroscopy of element 89, actinium. After the Curies announced their discovery of radium in 1898, the irrefutable proof for its existence was advanced by Eugène Demarçay (1852–1903), who detected two characteristic rays in the optical spectrum of the new element [6]. Similarly, Marie Curie succeeded in preparing enough polonium to observe its spark spectrum. This occurred 12 years after the discovery of polonium, and it required the treatment of several tons of pitchblende residues left after the separation of uranium [7].

Now it was actinium's turn. Although this element had been discovered three decades earlier, the preparation of a sample large enough for optical spectroscopy had never been attempted. In the ore residues actinium is mixed with rare earths, in particular, lanthanum, and it had to be concentrated by tedious fractional precipitations. Marie Curie asked her young assistant to prepare the most concentrated actiniferous sample. The spectroscopy was planned at the Pieter Zeeman (1865–1943, 1902 Nobel physics laureate) laboratory in Amsterdam, where Perey spent four months during 1934. Unfortunately, the project, although now ready, was delayed by Curie's death. Three years later the spectrum was measured in Amsterdam by W. A. Lub with a source that had been prepared by Perey and supplied by Curie. The sample was actiniferous lanthanum oxide with the astonishingly high concentration of 0.053 mg. of ^{227}Ac in 5 mg. of oxide. Lub concluded the publication thus:

> this work was proposed by Madame Curie, who participated personally in the experiments, in the measurements and calculations until a few days before her death [8].

André Debierne (1874–1949) was officially acknowledged for the samples, but Perey, who had carried out the work, received only handwritten "*mille remerciements*" from Lub. Perey's contamination with actinium occurred most probably during the years that she spent in handling this particular sample, among others [9].

After Marie Curie's Death

Marie Curie died on July 4, 1934—a terrible loss for Perey. She had become accustomed to her mentor's more or less extended leaves, but now she was really alone. Perey now worked under the direction of André Debierne, the new Director of the Institut du Radium, and Irène Joliot-Curie (1897–1956), Marie's daughter and 1935 Nobel chemistry laureate, who were both interested in actinium. Perey was not involved in the discovery of artificial radioactivity at the Institut du Radium in 1934, but she pursued the work on actinium [10]. In fact, she was considered the leading authority on this element; she retained this responsibility for more than 15 years and was Rosenblum's coauthor on her first two publications [11, 12].

The turning point in Perey's life took place in January, 1939 when she discovered a new element with atomic number 87 produced in the decay of actinium, which she named *francium* [13]. The discovery was the topic of a thesis that she submitted to the Université de Paris on March 21, 1946. Meanwhile she had undertaken university studies to obtain the degrees required for the diploma.

University Professor

Having attained her doctorate, Perey was eligible to pursue research as a professional *maître de recherches* at the Centre National de la Recherche Scientifique (CNRS). She held this position from 1946 to 1949. The initial enthusiasm accorded the discovery of francium had faded with the rapid development of new topics following the discoveries of nuclear fission and the first of the transuranium elements. Perey felt progressively isolated at the Institut du Radium and had no opportunity to assume responsibilities for supervising young research students. She was placed in charge of teaching spectroscopic methods, in particular, emission spectroscopy, for CNRS technicians and researchers. This task was not very prestigious and posed a problem for Perey's future at the institute.

The dilemma was resolved in 1949 with Perey's nomination for a Chair of Nuclear Chemistry, established especially for her

Figure 5. Meeting of the Scientific Committee of the Institut de Recherches Nucléaires in Strasbourg, 1951. Left to right: Jules Guéron, Director at Euratom; Jacques Thirion, physicist; Marguerite Perey; Frédéric Joliot; Serge Gorodetsky, Director of the Institute; last person unidentified.

Figure 6. Inaugural Lecture of Marguerite Perey in the Auditorium of the Institut de Chimie, Université Strasbourg, November 8, 1949. A specially drawn periodic chart emphasized the positions of francium and other radioelements.

at the Université Strasbourg; she simultaneously became the Director of a newly created associated laboratory. This unexpected and extraordinary promotion in such a short time after her thesis was probably helped by the intervention of university and academy members who befriended her. Previously, the only Chair of Nuclear Chemistry was that of 1935 Nobel chemistry laureate Frédéric Joliot (1900–1958), Marie Curie's son-in-law, at the prestigious Collège de France in Paris, and Perey's new position certainly contributed to her fame and reputation. Perey later commented,

> I accepted this nomination in a spirit of fidelity, trying to communicate to a new team the eagerness of rigorous and joyful work and in this way to do homage to Marie Curie, my beloved and venerated Master [3].

Nuclear research at Strasbourg began in 1941 when Alsace was annexed by Germany to the Third Reich [14]. The university became one of the three *Reichsuniversitäten* created by the Nazis in occupied countries to promote the supposed supremacy of German culture. A laboratory for nuclear physics was established at the Faculty of Medicine, and a 1.5 MeV Cockroft-Walton type accelerator was constructed. The accelerator was to be used for the production of neutrons and research on the fission of uranium and biological applications of radionuclides [15]. It was ready in June, 1944 but could hardly be used because of sporadic bombardments. When Allied troops liberated Strasbourg in November, 1944, the German scientists and engineers had already fled or were captured. After the war the accelerator was incorporated into the newly created Institut de Physique Nucléaire headed by Serge Gorodetsky (1907–1999; Académie des Sciences, 1971), a collaborator of Joliot's and Professor of Nuclear Physics at the university (Figure 5). Officially, Perey's mission was to complete nuclear physics research with the application of radioactive isotopes in chemistry and in biology.

Perey delivered her inaugural lecture on November 9, 1949 (Figure 6) [16], and the following academic year she began a regular course, "Chemistry and Physics of Radioelements," attended by students in physics, chemistry, and biology, completed with practical training. Perey had never lectured before her professorship, and she was not at ease in front of an audience. She was humble enough not to consider herself a clone of Marie Curie. As teaching material she used exclusively Marie Curie's monumental *Radioactivité* published in 1935 [17] and the postwar monograph *Les Radioéléments Naturels* of Curie's daughter Irène [18]. Consequently, the natural radioelements and the radioactive families formed the hard core of Perey's lectures. On the other hand, Perey excelled in the laboratory teaching of the handling, purification, and measurement of radioactive compounds that she had learned from Marie Curie. Her pride and joy was to demonstrate the separation of francium from actinium and to transmit to the younger generation what she had learned from Marie Curie.

A modest research laboratory was installed and inaugurated by Irène Joliot-Curie on January 31, 1951. Perey was assisted by a young physicist, André Coche (1922–1997), with whom she shared part of the fundamental and practical training, in particular, in the mathematics of radioactive transformations, nuclear physics, and instrumentation. Technicians in electronics and mechanics and a secretary were hired, and the same year Perey recruited her first research student, Jean-Pierre Adloff (b. 1930) (Figure 7). This team of about ten people constituted the embryo of the Nuclear Chemistry laboratory at the Université Strasbourg.

Perey was now interested in the biological application of francium:

> It is my great hope that francium will be useful for the establishment of an early diagnosis of cancer. My unconditional wish would be to accomplish this task someday [19].

Perey thought that the short half-life of francium was convenient for this purpose. With the help of colleagues at the Faculty of Medicine she investigated the uptake of francium and other alkali metal elements in healthy and cancerous rats. She observed that francium concentrated two to four times faster in tumorous tissues [20]. Despite the encouraging result, the project was abandoned because of a lack of sufficient actinium (The bulk of this element prepared by Perey was kept at the Institut du Radium.) and because of the little interest shown by physicians. The association of francium with cancer in the media following Perey's election to the Académie des Sciences [21] raised excessively optimistic reports in the

Figure 7. Marguerite Perey (right) with Jean-Pierre Adloff (left) seated at the Quadrant Electrometer Used in the Discovery of Francium, 1952.

media, for example, "with francium cancerous tumors can be detected at an early stage" [22, 23].

In 1955 the Université Strasbourg and the CNRS decided to group together all laboratories dealing with nuclear sciences and scattered in various localities into a Centre de Recherches Nucléaires, which included four sections headed by University Professors: nuclear physics, corpuscular physics, nuclear chemistry, and biological applications. Perey was the Director of the Département de Chimie Nucléaire; she had enthusiastically contributed to the construction and organization to the detriment of her teaching and research activities. This occurred during the "golden age" of nuclear research, when funds and new positions seemed to be unlimited. Perey, in particular, obtained strong support from the Commissariat à l'Energie Atomique, whose High Commissioner was her friend Francis Perrin (1901–1992), son of 1926 Nobel physics laureate Jean Perrin (1870–1942). With this assistance she worked untiringly for the creation of the largest French academic establishment for radiochemistry outside of Paris.

Perey benefited much from Marie Curie's prestige. To students, collaborators, and colleagues she inspired respect and admiration. In the laboratory liberties or use of first names among the staff were not appreciated. On the other hand, Perey was very attentive to personal problems and helped to solve difficult situations as much as possible. She liked a studious atmosphere of friendship and gaiety. The ritual afternoon tea, a tradition from the Institut du Radium and exported to Strasbourg, was the occasion for relaxed and pleasant breaks around Perey, unfortunately for only short periods of time.

Perey was conscious of her dignity as a famous scientist and as a professor, and she also used her status as a woman to circumvent intermediates and apply directly to the Ministries of Education, Research, and Defense for laboratory funds, research positions, or to advance the careers of her collaborators.

Marguerite Perey's Illness

Two years after her nomination at the Université Strasbourg, Perey was subject to overwork and stress while setting up the research laboratory and organizing her first teaching duties. Perhaps she thought she might not be able to cope with these responsibilities, and this resulted in periods of depression. The first vicissitude was the death in February, 1951 of her mother, who had settled with Marguerite in Strasbourg. During the first months of 1952 Perey entered several clinics in Strasbourg and later convalescent homes in Switzerland until the end of the academic year.

We may wonder if Perey's depression was not the first sign of a more serious ailment due to radiation exposure. As early as her first years at the Institut du Radium Perey noticed skin burns on her hands and fingers. In reply to questions from relatives, she stated that the burns were due to handling acids and other chemicals. Of course, she was aware of the biological effects of radiation such as dermatitis and other affections that frequently occurred in radiochemical laboratories. Later she recognized that the radiodermatitis had originated in 1933. In the years following the discovery of francium Perey had concentrated on her studies and thesis so that she was less exposed to radiation, but she ignored the fact that the subtle and latent effects of radiation were irreversible.

Perey could neither fully assume her duties during the following two academic years. Periods of intense work were regularly interrupted by several months of rest and convalescence in appropriate establishments. From 1955 on, a longer period of apparent remission occurred, perhaps due to the stimulus caused by the creation of the Centre de Recherches Nucléaires. The stress was too strong, and at the beginning of 1959 Perey suffered a new painful breakdown from which she never recovered completely. The symptoms were those of acute neuralgia, particularly in both hands and head; the origins, at first, could not be ascertained. It was even suggested that her pains were imaginary, and this added a further, moral stress to the patient.

Eventually it was found that Perey's body, in particular, her bones, emitted radiations characteristic of the element actinium and its radioactive daughters. The physicians considered the mild climate of the French Riviera to be the most appropriate for their illustrious patient. Therefore Perey settled in Nice in 1959 with sporadic and short visits to Strasbourg and more or less extended admissions to various hospitals.

From 1959 on, until her death, Perey expressed a constant interest in her laboratory and concern for her former students and collaborators. She corresponded regularly with Jean-Pierre Adloff, who was in charge of the Department of Nuclear Chemistry [24]. The laboratory expanded rapidly with new equipment, including a research reactor, and with recruitment of doctoral students and postdoctoral fellows from many countries.

In Perey's mind her exile in Nice was only temporary, and for years she anxiously expected permission to resume her activities. As early as October, 1959 she was desperate:

> I am terribly distressed…the doctors forbid [me] to do any work for several months.

Two years later the verdict was the same:

> I am still going through a very hard ordeal, of which you will unfortunately be feeling the effects. I know that I cannot take up my work again to the extent I did previously. I had thought that these months of dreary isolation would now give way to the chance of being with you again. You can well understand how much this decision affects me.…(September 11, 1961) [24].
> Above all, it is my hope that you will not experience the feeling of isolation and separation from a home that is dear

Figure 8. Library of the Curie Laboratory, July, 1930. In the front row Marguerite Perey is first on the left, and Sonia Cotelle is the last on the right. In the second row Frédéric Joliot is the last on the right. Both women died from radiation sicknesss. (Archives Université Louis Pasteur Strasbourg).

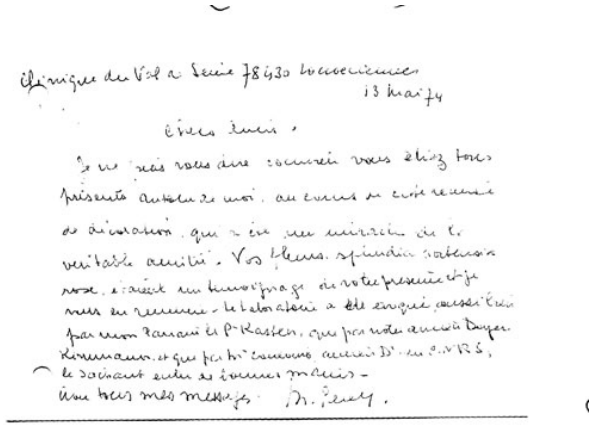


Figure 9. The Last Handwritten Message from Marguerite Perey, Confined to Her Bed, Sent to Her Laboratory. She thanks everyone for sending flowers on the occasion of her ultimate distinction as *Commandeur de l'Ordre National du Mérite* delivered by Alfred Kastler. "You cannot imagine how much you were present at the ceremony, a miracle of veritable friendship." Perey died on the same day (May 13) the following year [25]. (Courtesy, J.-P. Adloff).

> to you and that has become part of your life. I therefore request that you take great care of your health and of that of your collaborators and that all precautions be taken. Please be conscientious in this respect; the consequences of carelessness are dreadful. At present the dangers of radiation are known, and the means of protection are available (November 28, 1961) [24].

Perey alluded to the working conditions at the Institut du Radium, where safety was not the prime priority. Compared to present regulations, incredible amounts of radioactive substances were manipulated. Perey witnessed the death of her friend Sonia Cotelle, who had been contaminated by polonium after the explosion of a bulb containing a large amount of the element (Figure 8). Both scientists figure in a report on the early victims of radioactivity [25].

But the disease progressed ineluctably with increasing suffering:

> I still have severe pain in my hands and arms, and this occurs in periods of violent crises….Unfortunately, nothing can be done to heal the radio-necrosis of the left medius [middle finger]; I can only hope that this condition will not spread into the bone as it did in the right hand (January 6, 1966) [24].

A few events provided Perey with occasions to meet outside of Nice with friends and former colleagues from the Curie laboratory. The highlight was the centenary of Marie Curie celebrated in October, 1967 with great pomp in Warsaw and in Paris, where she met another "nuclear" heroine, Lise Meitner (1878–1968). At the same venue she encountered her Norwegian friend Ellen Gleditsch (1879–1968), also a former collaborator of Marie Curie and 1948 Honorary Professor at the Université Strasbourg. Two years later Perey was an honored guest at the panel held in Strasbourg for the centennial of the periodic table, which, by chance, coincided with the thirtieth anniversary of the discovery of francium [13].

For lengthy periods of time Perey became unable to continue writing or taking care of herself. She was attended by her older sister Madeleine (Mme. Jean François) (1900–1995), who pursued the correspondence:

> Since May (1973) she has been suffering from troubles with her eyesight from which it became evident that a tumor was present. Once more she was sent to the Curie Hospital….A series of about twenty local treatments with a betatron produced only extreme fatigue, again with no apparent benefit. Quite exhausted without any sign of improvement (August, 18, 1973) [26].

Two months later Mrs. François had no better news:

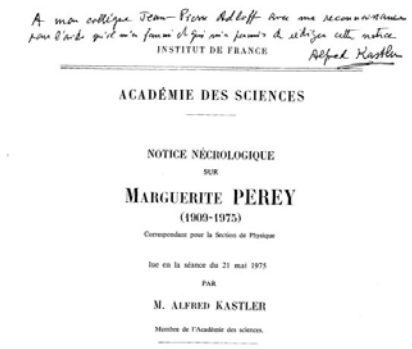
> I found her very very tired….I wonder if it would now be reasonable to try a chemo-therapeutical treatment as has been talked about. She is always admirably courageous and calm, and when the drugs do not unduly cloud her mind, she is present and open to everyone, as you well know. Of course, it is out of the question for her to go elsewhere or return to Nice (October 14, 1973) [26].

Perey was later moved to a last clinic at Louveciennes, a resort near Versailles, where on May 13, 1974 she received in her bed the ultimate distinction, *Commandeur dans l'Ordre National du Mérite,* from her friend and 1966 Nobel physics laureate Alfred Kastler (1902–1984). She had recovered sufficiently to give a full account of the ceremony. This was followed by several weeks of rest in the Alps, from where she wrote:

> It has now been confirmed that I have a serious disease of the blood; it is of professional origin and responsible for both the tumor that had to be treated with the betatron and the multiple lesions of the cranium. There are days of remission followed by days of violent and unbearable crises. I am profiting from moments of respite to write you (August, 28, 1974) [24]. (Figure 9).

The remission was momentary. Back in Louveciennes Perey felt the final effects of her disease. Her last letter is dated January 2, 1975:

> My writing is becoming increasingly hindered by my affected eye; it is clear that my condition is the result of a serious illness of the blood and marrow caused by noxious radiations together with numerous complications. If only I could walk, but I have lost my sense of equilibrium, and after several falls I am not allowed to get out of bed without



A mon collègue Jean-Pierre Adloff avec ma reconnaissance pour l'aide qu'il m'a fournie et qui m'a permis de rédiger cette notice.
Alfred Kastler

INSTITUT DE FRANCE

ACADÉMIE DES SCIENCES

NOTICE NÉCROLOGIQUE
SUR
MARGUERITE PEREY
(1909-1975)
Correspondant pour la Section de Physique

lue en la séance du 21 mai 1975
PAR
M. ALFRED KASTLER
Membre de l'Académie des sciences.

Figure 10. Title Page of the Obituary Notice for Marguerite Perey Presented at the Académie des Sciences by Alfred Kastler (Courtesy, J.-P. Adloff).

Figure 11. Bronze Tableau in Front of the Auditorium of the Nuclear Research Center in Strasbourg. The decay of actinium to francium is depicted.

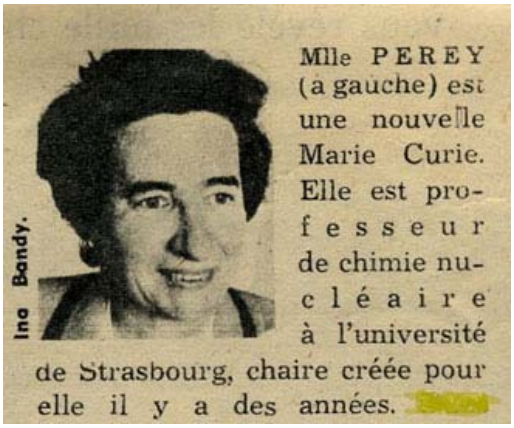


Figure 12. "Marguerite Perey (at left) is a new Marie Curie. She is Professor of Nuclear Chemistry at the University of Strasbourg, a chair established specifically for her years ago."

> the aid of my nurse. Where is my so cherished independence? With great caution, the doctors have progressively increased the doses of sedatives in order to alleviate my violent crises, but that produces such a state of torpor that I cannot contend with certain days, or write. My eyes and hand no longer want to continue, and so I must stop [24].

It was a matter of a few months until Perey's last days. On May 13, 1975 Mme. François announced the sad news:

> My sister is passing through her last days. The decline is rapid, the cancer has metastasized….Perhaps it is in her head where the illness has progressed less rapidly, at least in appearance. It is only because of the enormous doses of administered drugs that she does not seem to be suffering excessively. She appears to be without pain and in a state of numbness, and remains immobile....Her regard is distant and expressionless, and it is extremely difficult to understand what she sometimes wants to say; her lips move but the voice is usually inaudible. It is certain that she is only conscious at short moments.
>
> Please pray with us that this long and cruel ordeal will soon cease and that she may rest in peace. She has fought so hard for many years that she merits well this final repose. Please be assured of my faithful and profound friendship in memory of the affections of my sister for you and for her laboratory [26].

Marguerite Perey passed away that same day at 2:40 PM. The funeral was held on Friday, May 16, 1975 in the Reformed Church in Versailles, in the presence of her family, close collaborators, and Alfred Kastler. On May 21 Kastler read Perey's obituary notice at the Académie des Sciences on May 21, 1975 (Figure 10). In Strasbourg the Marguerite Perey Auditorium at the Institut de Recherches Subatomiques, the present name of the Nuclear Research Center, the street named in her honor (Rue Marguerite Perey), and the University Physics Archives serve to remind us of a brilliant and tragic destiny (Figure 11).

Marguerite Perey without Francium?

Perey discovered francium scarcely ten years following her admission to the Institut du Radium. Her success was achieved at the expense of a thirty-year period of suffering. Was it worthwhile? Perey did not initially seek to discover element 87 [13]. Let us imagine that she did *not* discover francium. The ordeal and the fatal result would have been the same because Perey was contaminated by actinium *before* her discovery. She would probably have pursued her work at the institute for years with further exposure to radiation. At least, thanks to francium, her suffering was compensated by numerous awards and distinctions [27] with the supreme honor being the first woman to be elected *correspondant* of the Académie des Sciences on March 12, 1962 [21]. Furthermore, her disease was officially recognized as the consequence of professional duties, and thus she was entitled to keep the status of University Professor with full emoluments until the end of her life.

Marguerite Perey, Marie Curie, and Others

"Marguerite Perey, another Marie Curie" (Figure 12). This provocative affirmation in media reports recalls Einstein's referring to Lise Meitner "as our Marie Curie" although he would have expressed the opinion that "Meitner was a more talented physicist than Marie Curie herself" [28]. The comparison of Perey to Marie Curie is actually more flattering than appropriate.

Two highlights emerge in Perey's life: the few happy years under Marie Curie's guidance ("I owe everything to Marie

Curie" [29]) and the fortuitous discovery of francium in the period of a few months, accompanied by glory mixed with suffering. The core of Perey's achievements extends over a decade beginning with 1938 and is essentially concentrated on francium, whereas Curie published 60 papers and several books from 1898 to 1933.

The two women had little in common. Perey's scientific background was elementary, while Curie had university degrees in mathematics and physics, and her knowledge encompassed the most recent theories and findings of her time. Curie's discoveries of polonium and radium resulted from pure reasoning based on previous observations, while the discovery of francium is a perfect example of serendipity, that is, the finding of things not sought. In contrast to Curie, Perey acknowledged honors and distinctions with pleasure, was fond of parties, and enjoyed all aspects of femininity, while Curie was unconcerned with fashion. Curie was a free-thinker, Perey a Protestant believer; according to her pastor in Nice, "Perey honored not only France but also French Protestantism" [30]. Both scientists suffered from radiation sickness and died at nearly the same age, but Curie worked until the last weeks of her life, while Perey struggled for 16 years against the disease.

Other women are considered pioneers in nuclear science [31]. Among these, the most famous is undoubtedly Lise Meitner, active in the field from 1907 until the end of World War II, who participated closely in the discovery of fission. An impartial reviewer would add the name of Ida Noddack-Tacke, who suggested in 1934 the nuclear disintegration, that is, fission of uranium and the existence of the transuranium element 93. The four women cited possess a common achievement—they are the only women discoverers of elements: polonium and radium (Curie, 1898), protactinium (Meitner, 1917), rhenium (Noddack-Tacke, 1925), and francium (Perey, 1939).

Acknowledgment. References 2, 4, 16, 19, 22, and 30 and Figures 1, 2, 4–8, 11, and 12 are reproduced from the Perey Archives collected by Jean-Pierre and Madeleine Adloff, collaborators of Marguerite Perey, and transferred to the Physics Archives of the Université Louis Pasteur, Strasbourg (Courtesy, Sébastien Soubiran, Archives scientifiques, Mission culture scientifique et technique de l'Université Louis Pasteur, 7 rue de l'Université, 67100 Strasbourg, France).

References and Notes

1. "I am resolved to put all my strength at the service of my adopted country, since I cannot do anything for my unfortunate native country [Poland] right now." (letter from Marie Curie to Paul Langevin, January 1, 1915).
2. *France-Soir*, December 26, 1960.
3. Perey, M. En souvenir de Madame Curie. Remembrance at the occasion of the centenary of Marie Curie, Archives Jean-Pierre Adloff.
4. Galabert, H. letter to M. Perey, July, 8 1929.
5. Curie, M.; Rosenblum, S. Spectre magnétique des rayons α du dépôt actif de l'actinium. *J. Phys. Radium* **1931,** *2,* 309–312.
6. Demarçay, E. Sur le spectre d'une substance radioactive. *Compt. rend.* **1898,** *127,* 1218.
7. Curie, M.; Debierne, A. Sur le polonium. *Compt. rend.* **1910,** *150,* 386–389.
8. Lub, W. A. Le spectre optique de l'actinium. *Koninkl. Akad. Wetenschap. Amsterdam* **1937,** *40,* 584–589.
9. Actinium is no longer extracted from uranium ore residues. It is produced carrier-free by neutron irradiation of radium, and the separation from rare earths is avoided.
10. Pierre and Marie Curie were not chemists. They were assisted in the chemical separations by Gustave Bémont (1867–1932) and André Debierne. Frédéric Joliot and Irène Curie were both physicists *and* chemists, and they had no need for technicians in their work on artificial radioactivity.
11. Rosenblum, S.; Guillot, M.; Perey, M. Sur l'intensité des groupes de structure fine des spectres magnétiques α du radioactinium et de ses descendants. *Compt. rend.* **1936,** *202,* 1274–1276.
12. Rosenblum, S.; Guillot, M.; Perey, M. Sur les spectres magnétiques α dans la famille de l'actinium. *Compt. rend.* **1937,** *204,* 175–177.
13. Adloff, J.-P.; Kaufman, G. B. Francium (Atomic No. 87), the Last Discovered Natural Element. *Chem. Educator* **2005,** *10,* 387–394; DOI 10.1333/s00897050956a.
14. Casel, R. *La recherche nucléaire à Strasbourg. Les dix premières années 1941–1951.* Gersulp, Université Louis-Pasteur: Strasbourg, 1962.
15. Walter Noddack (1893–1960) and his wife Ida Tacke, discoverers of rhenium and the pseudoelement masurium (atomic number 43), were appointed Professors of Inorganic Chemistry at the university by the occupying power. In 1945, when the French chemists returned, they found the symbol "Ma" painted on the wall of the lecture room in a large representation of the periodic system. (Paneth, F. A. The making of the missing chemical elements. *Nature* **1947,** *159,* 8–12). Noddack never acknowledged the discovery of technetium by Carlo Perrier and Emilio Gino Segré (1905–1989) in 1937 (Perrier, C.; Segrè, E. Some Chemical Properties of Element 43. *J. Chem. Phys.* **1937,** *5,* 712–716; Chemical Properties of Element 43. II. *J. Chem. Phys.* **1939,** *7,* 155–156). For a recent biography see Habashi, F. *Ida Noddack (1896–1978): Personal Recollections On the Occasion of 80th Anniversary of the Discovery of Rhenium;* Métallurgie Extractive Québec: Saint-Foy, Québec, Canada, 2005.
16. "Leçon Inaugurale à Strasbourg. L'enseignement de la chimie Nucléaire. Mlle. Perey est officiellement installée comme titulaire de la nouvelle chaire" (Inaugural Lecture in Strasbourg. Teaching of Nuclear Chemistry. Mlle. Perey is officially installed as titular in the new chair). *Dernières Nouvelles d'Alsace*, November 9, 1949.
17. Curie, M. *Radioactivité,* 2nd ed.; Hermann: Paris, 1935.
18. Joliot-Curie, I. *Les Radioéléments Naturels;* Hermann: Paris, 1946.
19. *Nice-Matin,* March 13, 1962.
20. Perey, M.; Chevalier, A.; Lausecker C. Sur la fixation comparée de l'actinium K, du césium 134 et du rubidium 88 dans les sarcomes et les granulomes expérimentaux chez le rat. *Compt. rend. Soc. Biologie* **1952,** *146,* 1141–1143.
21. Adloff, J.-P.; Kauffman, G. B. Triumph over Prejudice: The Election of Radiochemist Marguerite Perey (1909–1975) to the French Académie des Sciences. *Chem. Educator* **2005,** *10,* 395–399; DOI 10.1333/s00897050955a.
22. *Paris-Presse,* March 15, 1962.
23. The project was utopian and could not have any future prospects. *In vivo* diagnosis in humans would have required unrealizable amounts of actinium; furthermore, daughter products of francium are themselves harmful. In any case a single 2-page publication, and one set of experiments could not have solved the problem!
24. Perey, M., letters to Jean-Pierre and/or Madeleine Adloff (1959–1975). Archives J.-P. Adloff.
25. Rona, E. Laboratory Contaminations in the Early Period of Radiation Research. *Health Physics* **1979,** *37,* 723–727.
26. François, M., letters to Jean-Pierre and Madeleine Adloff (1973–1975. Archives J.-P. Adloff.
27. *Officier de la Légion d'Honneur* (1960); *Grand Prix Scientifique de la Ville de Paris* (1960); *Commandeur de l'Ordre des Palmes Académiques* (1960); Lavoisier Prize of the Académie des Sciences (1964); Lavoisier Medal de la Société Française de Chimie (1964); *Commandeur de l'Ordre National du Mérite* (1974).

28. Sime, R. L. *Lise Meitner, A Life in Physics*; University of California Press: Berkeley, CA, 1996; pp 75 and 412. For a review see Kauffman, G. B.; Kauffman, L. M. *Angew. Chem., Intern. Ed. Engl.* **1997,** *36,* 651–652.
29. Perey, M., in her *curriculum vitae* (Archives J.-P. Adloff) and several interviews.
30. Breton, Pastor Jean, In the Parish bulletin of Côte d'Azur, April, 1962.
31. Rainer-Canham, M. F.; Rainer-Canham, G. W. Pioneer Women in Nuclear Science. *Am. J. Phys*. **1990,** *58,* 1036.