Female Scientists Whom Nobuo Yamada Encountered：Early Years of Radio Chemistry and the Radium Institute

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Introduction

"Recently, I've been attending Professor Curie's lecture once a week. She seems quite smart, though aged." [1] Nobuo Yamada (1898–1927), a 27-year-old chemist, wrote this in 1923 to his wife in Tokyo, soon after going to Paris to study. He was the first Japanese scientist to join the Radium Institute and receive the guidance of Marie Curie (1867–1934). He jointly conducted research with Irène Curie (Mme Joliot, 1897–1956), Marie's eldest daughter, and published five articles on this collaborative research. Yamada was one of the few Japanese scientists working in the early field of radio chemistry, and his experience was even more unique, as he was the first Japanese male scientist to have a female teacher and female colleagues. Unfortunately, since Yamada died young due to radiation injury, the above-mentioned letter is the only description that he provided of his teacher.[2]

Shocked by the news of Yamada's death just two years after his return to Japan, Marie and Irène, respectively, wrote condolatory letters to Yamada's supervisor and his wife. The Curie Museum in Paris houses copies of those letters. These were the first such letters sent to Japanese recipients by female scientists, as opposed to the wives or daughters of male scientists. Yet Marie and Irène Curie were not the only female scientists that Yamada met in Paris. In the 1920s, the Radium Institute employed many female scientists, including Catherine Chamié (1888–1950), Sonia Słobodkine (Mme Cotelle, 1896–1945).

This paper discusses women of the Radium Institute, with a focus on the period when Yamada was in Paris (1923–1925). In the world, it was the only institute where male and female scientists, who came from various countries, working together under a female leader. The fame of Marie Curie—the first two time Nobel Prize winner (1903 in physics; 1911 in chemistry)—attracted disciples from across the world and stimulated a dramatic increase in the number of women conducting scientific research, especially in radio chemistry. In fact, the fields of atomic science, besides astronomy and crystallography, had a higher ratio of female scientists' involvement. Moreover, as Marie Curie's two Nobel Prizes indicate, this field enabled chemists and physicists to work together closely.

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1 Post card of Nobuo Yamada, dated November ? 1923. By courtesy of Mr. Mitsuo Yamada.

2 On Nobuo Yamada, see Keiko Kawashima, "Deux savants japonais et la famille Curie, Nobuo Yamada et Toshiko Yuasa," *Actualité chimique*, mai 2012, n.363 (2012): 51-55.

How did the female disciples work in Marie Curie's laboratory? And what did Marie's existence and role mean for those female scientists? This paper analyses these points from the gender perspective.

1. Curie's First Laboratory and the Radium Institute

From the time when she opened her first laboratory in 1906 to her death in 1934, Marie accepted more than 40 female researchers. This period can be divided into three segments. The first one was the period of the two-room laboratory (from 1906 to June 1914). The second (from July 1914 to November 1918) and third (from December 1918 to May 1934) ones, are during and after World War I.

Even before Pierre and Marie Curie won the Nobel Prize in 1903, their studies into radioactivity attracted the world's attention, but the French government would not give them an independent laboratory. It becomes almost a myth that the couple discovered radium in "a dilapidated shed."[3] After receiving the Nobel Prize, Pierre became a professor at the Sorbonne in 1904, but the post did not give him a new laboratory. Only in 1906, just before his death, Pierre was given the narrow two-room laboratory.[4]

Fig.1 Marie Curie in the Radium Institute (about 1923) Musée Curie (coll. ACJC)

Radium, the element they discovered, was expected to have medical and industrial applications. Yet it was not until 1909 that the government implemented a plan to build the Radium Institute. The Institute, consisting of a medical department and basic research department, opened in July 1914. So, the first period started after Pierre's death in 1906, when Marie succeeded his post as a teacher at the Sorbonne, and started accepting researchers in the two-room laboratory.

When Henri Becquerel discovered the radioactivity of uranium in 1896, radiation was a complete mystery. But α, β and γ-rays were distinguished before World War I. It became clear that radioactivity research meant probing the atom.

Research should be further developed when the new building opened in 1914, but soon after that, World War I broke out. Up until the end of the war in 1918, the Radium

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3 Eve Curie, translated by Vincent Sheean, *Madame Curie* (London & Toronto: William Heinemann Ltd., 1938), p. 165.

4 For the definition of "Curie laboratory", see Natalie Pigeard-Micault, "The Curie's Labo and its Women (1906-1934)," *Annals of Science*, 70-1 (2013): 71-100, pp. 2-3: J.L. Davis, "The Research School of Marie Curie in the Paris Faculty, 1907-14," *Annals of Science*, 52 (1995): 321-355, p. 324.

Institute did something unusual. Since the men were off fighting the war, it became a female-centred institution.

However, the war did not completely stop the radioactivity research. In Berlin, Lise Meitner (1878–1968) and Otto Hahn (1879–1968), who later became Irène's rivals, discovered a new radioactive element, protoactinium, in 1917. Moreover, although the announcement was made after the war, Ernest Rutherford (1871–1937), Marie's friend, confirmed that bombarding the nucleus of a nitrogen atom with an α-ray would result in an oxygen nucleus and hydrogen nucleus (proton).

The third period, from the end of the war to 1934, was the most prosperous time for the Radium Institute during Marie's lifetime. Especially in the 1920s, when Yamada was there, France enjoyed favorable business conditions, called *les années folles*, when people from around the world, visited France. Such trends led to the development of the Institute. In addition to aid from the Carnegie Foundation that had been given before the war, Marie gained substantial funds from wealthy supporters and many business enterprises, and she made the Institute the world's centre of radioactivity research.[5]

The great breakthrough of this period was James Chadwick's (1891–1974) discovery of the neutron in 1932, revealing the major components of the atom. As seen in Rutherford's above-mentioned experiment, the scientists were beyond searching to define radiation or the atom, and were introducing the idea of changing the atom. Irène and Frédéric Joliot-Curie's (1900-1958) discovery of artificial radioactivity was also an attempt at achieving the transmutation of the atom. Though nuclear fission had yet to be discovered, the neutron became a new tool for creating additional artificial substances.

2. Curie's First Laboratory (1906–1914) and distinctive features of Marie's female disciples

What did Marie do before 1906? When her husband was alive, she was a physics teacher at Sèvres Higher Normal School for Women since 1900. After Pierre became a professor of the Sorbonne, she held the additional post of *chef de travaux*, laboratory chief of her husband's lab. She was the only woman working in this laboratory at the time.

Now, let's discuss the students of Sèvres, though they were not members of Curie Laboratory. Even after moving to the Sorbonne, Marie arranged for the students of Sèvres to attend her lecture. Among them, her most notable student was Eugénie Feytis (Mme Cotton, 1881-1967), who became a scientist and a famous educator. Later, she became the principal of Sèvres and struggled to realize gender equality in education, especially promoting science education for women. She was also awarded the *Légion d'honneur*.

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[5] As for the development of the Radium Institute and the Curie Institute, see Curie Museum's site:
http://musee.curie.fr/media/files/04_De%20l'institut%20du%20radium%20%C3%A0%20l'institut%20curie.pdf

In the first period—even when Marie Curie had the two-room laboratory—there were always young, female researchers in the laboratory. By what standard did Marie accept these researchers? The pattern was basically as follows. She would accept a person if he or she had an adequate recommendation letter and his or her research theme fit with the work being carried out in her laboratory. Later, ceasing to work hard would mean the discontinuation of one's acceptance.[6] No gender discrimination occurred; Marie judged men and women by the same standard. In fact, this was an amazing standard. As Meitner's case reveals, discrimination against women was common at the time.[7] The idea of not distinguishing between the sexes itself was exceptionally rare. So, the news of the establishment of a laboratory led by a woman was a boon to female researchers globally, especially those who wanted to work in radioactivity.

Fig.2 Marie and Irène Curie, and Students of Sèvres. Eugénie Feytis is on the extreme right. (1903) Musée Curie (coll. ACJC)

What did those women, or men, come to Curie to do? Most of them were there to gain a PhD or a DES, the qualification for a PhD. Indeed, Yamada earned a Doctorate of Science from Tokyo Imperial University with dissertations he wrote in Paris. The Institute also had many people intending to pursue what would now be called a postdoctoral fellowship. Thus, staying there for about a year, often for only a few months, was common. Such researchers usually remained there on scholarships and paid registration fees to a university and the Institute. Thus, Irène and Marguerite Perey (1909–1975), paid by the Institute and worked there for a long time to make great discoveries, were exceptions. Therefore, many of the young researchers were disciples of Marie as well as Rutherford and/or Stephan Meyer (1872-1949).

For example, Harriet Brooks (Mme Pitcher, 1876–1933) from Canada, the first female researcher at Curie Laboratory, was also Rutherford's disciple, of whom he was proud. Brooks was the first researcher in the world to observe the phenomenon of radioactive recoil. As Rutherford stated, her "work on radioactivity has been of great importance in the analysis of radioactive transformations and next to Marie Curie."[8] There were also many women

6 Suzan Quinn, *Marie Curie* (New York: Simon & Schuster, 1995), pp. 402-403.

7 However, this standard does not explain why Marie denied Lise Meitner the opportunity to work at the Radium Institute. Meitner was an exception; it is true that the Radium Institute was easy to enroll in, but there was a rigorous selection of people after acceptance. On Lise Meitner, see Ruth Lewin Sime, *Lise Meitner. A Life in Physics* (California: Univ. of California Press, 1996).

8 On Harriet Brooks, see Marelene F. Rayner-Canham & Goeffrey W. Rayner-Canham,

working in Rutherford's laboratory. Rutherford and Marie recommended their disciples to each other according to their specialties. Marie accepted many foreigners. Having been a poor, foreign student herself, she was kind to foreign student. Among her female disciples, more than half were foreigners.[9]

At that time, besides Brooks, other female researchers included Ellen Gleditsch (1879–1968) from Norway, Eva Julia Ramstedt (1879–1974) from Sweden and May Sybil Leslie (Mme Hamilton-Burr, 1887-1937) from England. The trio went on to become great friends.

Gleditsch studied chemistry at the University of Oslo and worked in Curie Laboratory for five years, beginning in 1907. In the lab, she learned fractional crystallization, a difficult technique, and also started measuring the half-life of radium. She returned to Oslo once, and then went to Yale University where she established the half-life of radium as 1,686 years (now adjusted to 1,620 years). She also played a major role in confirming the existence of isotopes. Gleditsch became the second female professor in Norway. She also joined Oslo's Academy of Science. She had been eager to support female scientists; for example, she recommended her two female disciples to the Radium Institute, and she treasured her bond with Marie and other ex-colleagues in Paris for the rest of her life.

Ramstedt worked in Curie Laboratory for one year, from 1910. After returning to Sweden, she became a professor at Stockholm University. While she was president of Sweden Women's High School Committee, she also contributed toward improving women's education internationally.

Leslie belonged to Curie Laboratory for one year, from 1909. She worked on the molecular weight of thorium's emanation and decomposed thorium compounds, about which she published articles. After returning to England, she continued her research in Rutherford's laboratory and also researched emanation from actinium. Later, she found a job in another university's chemistry laboratory in England. During World War I, she worked in the manufacturing of explosives. She continued in her career by taking up various teaching jobs and conducting research until just before her death.

As for people with unique careers, there was Jadwiga Szmidt (Mme Tshernyshev, 1889-1940) from Poland. She belonged to Curie Laboratory for one year, from 1910, and later continued her research under Rutherford in England. Her research focused on comparing α-rays from various sources of radiation and the α-ray absorption ratio difference between various gases. After she married Tshernyshev, a physicist, she worked on the research and development of oscillograph technology for television in Russia. However, the couple

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Harriet Brooks, Pioneer Nuclear Scientist (Montreal & Kingston, London, Buffalo: McGill-Queen's University Press, 1992).

9 The basic information of the research school of Marie Curie and her female disciples, such as name, nationality and years of birth and death, are based on Pigeard-Micault, (note 4); *Les femmes du laboratoire de Marie Curie* (Paris: Editions Glyphe, 2013). For the period before the WWI, Davis' article (note 4) is also helpful.

mysteriously died in 1940.

Margaret von Wangell (Mme Andronikov, 1876-1932), Russian aristocrat, was forced to flee to Germany during the Russian Revolution. She belonged to Curie Laboratory from 1911 to 1912, and her specialty was thorium. However, later, she turned to the field of agriculture (research on seeds and/or fertilizer). As a nutrition botanist, she became the first female university professor in Germany in 1923. As for the first female professor, there was Irén Götz (Mme Dienes, 1889-1941) in Hungary.

Many of these women joined the Federation of University Women and played active roles in it. This evidences the increase in the number of women who entered, and graduated from universities, and went on to secure relatively good positions in society.

3. The opening of the Radium Institute and World War I (1914–1918)

The Radium Institute with dedicated buildings, which Marie had long awaited, opened in July 1914. But in August, World War I broke out. When the men were sent to the battlefields throughout Europe, it stimulated the social progress of the women. The importance of female researchers also increased at the Institute. Yet as women were engaging in war back-up activities, basic research hardly progressed.

As mentioned previously, Marie organized troops of medical X-ray cars active on the front lines. Many ordinary women were trained at the Institute and worked as X-ray technicians.[10] Researchers including Irène, Suzanne Veil (1886–1956), Marthe Klein (Mme Weiss, 1885–1953) and Madeleine Monin (Mme Molinier, 1898–1976) taught many women the photographic technique of X-ray, and also played an active role in the battlefields. Monin acquired her nursing license after marriage. She received a medal from the Red Cross.

The exceptional research conducted during the war concerned the measurement of radioactive substances against the international radium standard. The Radium Institute had a measurement department. It functioned efficiently during the war, and Irène and Klein developed various measurement methods.

The four women at that time, including Irène, who became an official member in March 1918, were all French. The war influence can be clearly seen in this absence of foreigners.

4. Development of the Radium Institute (1918–1934)

France was victorious in the war, but it lost many human resources. Many women who had made social advancements during the war, and the following generation, continued to work. Women's university enrolment also increased. In fact, in the Sorbonne, almost 30 per

[10] As for the Radium Institute during the WWI, see Anaïs Massinot & Natalie Pigeard-Micault, *Marie Curie et la grande guerre* (Paris: Edition Glyphe, 2014).

cent of the students enrolled in the faculty of science were female. Therefore, scientist became a career option for women. By this time, most of the women at the Radium Institute had already earned a PhD. This tendency was especially pronounced among the foreigners, among whom 40 per cent had PhDs. Moreover, the total number of researchers at the Institute increased. When Pierre died, there were only seven men and Marie in his laboratory, but when Yamada was there in the 1920s, there were almost 40 researchers in Marie's laboratory, about 10 of whom were female.

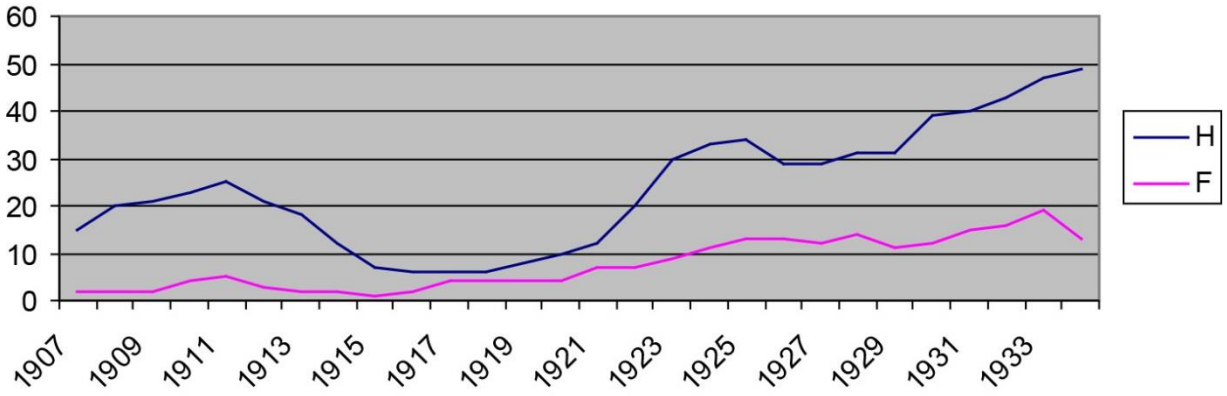

Fig 3. Evolution by sex of person in the Curie laboratory (1906 – 1934) in Natalie Pigeard-Micault, "The Curie's Lab and it's Women (1906-1934), Le laboratoire Curie et ses femmes (1906-1934)," *Annales of Science*, Vol.70, No.1: 71-100, p.80.

The Institute also gained economic strength. Paris brilliantly flourished as a city of sciences and arts. Though Marie criticized the atmosphere of Paris, saying, "Our society, in which reigns an eager desire for rich and luxury, does not understand the value of science,"[11] this economic boom largely contributed to the Institute's development by facilitating the acquisition of research funds and/or scholarships.

It was during this period that Missy Melony, an American journalist, mobilized a women's group to collect funds to invite Marie to the United States. Thanks to the one gram of radium donated on their first visit to the United States (1921), the Institute gained a strong radioactive source. American women also seemed to be encouraged by Curie's visit. In 1920, the year before her first trip to the United States, only 41 women had been granted PhDs in science. But in 1932, three years after her second visit in 1929, there were 138.[12]

Yet 1929 was also the year of the world economic crisis. As the number of unemployed men increased, public opinion became conservative, and the social advancement of women was regarded as an "invasion." Consequently, women's enrolment in university started to decline gradually. And the world plunged into World War II.

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[11] Marie Curie, translated by Charlotte and Vernon Kellog, *Pierre Curie* (New York: Macmillan, 1923), p. 145.
[12] Quinn (note 6), p.396-397.

During the brilliant era between the two world wars, Marie had the largest number of disciples, and she accepted more than 30 women to the Institute. The most brilliant female member after World War I was Irène. While she was a university student, she became already her mother's right hand. In the 1920s, Irène was preparing a doctorate, and she jointly conducted research with Yamada and analyzed the α-ray of polonium from various angles. Later, she married Frédéric Joliot, who had been accepted as Marie's assistant when Yamada was there. The couple conducted a joint study and discovered artificial radioactivity in 1934, for which they were awarded the Nobel Prize for chemistry the following year. This made Irène the second woman to win the Nobel Prize in a scientific field.[13]

Someone in France who was a match for Irène would be Marguerite Perey, who discovered francium, a new radioactive element. Perey, after graduating from a school for female technician workers, joined the Radium Institute as Marie Curie's assistant. That is, she did not initially intend to become a scientist, but Marie recognized her talents. After Marie's death, thanks to the recommendation of André Debierne, the second director of the Institute, Perey enrolled in university in 1936, ultimately receiving her PhD in 1946. Similar to Marie, who named polonium after her country of origin, Perey named the new element after her homeland. This achievement earned her the *Légion d'honneur* award, and she was made the head of the Department of Nuclear Chemistry at the Institute of Nuclear Research of Strasbourg. In 1962, she became the first female corresponding member of the Paris Academy of Science—an organisation which rejected Marie Curie as its member 50 years earlier because she was a woman.[14]

Among the foreigners, Marietta Blau (1894–1970), born in the Austro-Hungarian Empire, was nominated for the Nobel Prize many times. She was highly evaluated by Erwin Shlödinger (1887–1961) and received the award bearing his name. Blau was the first scientist to use nuclear emulsion to search for neutrons. Using this method, she confirmed the decay of the atomic nucleus caused by cosmic rays.[15]

Alicja Dorabialska (1897–1975), Marie's Polish junior, specialized in calculating the energy released by nuclear reactions and measured the heat from polonium with Irène. She became the first female professor at Ukraine University. Many of Curie's disciples, especially foreigners, became the first female professors, heads of research centres or members of academies after they returned to their home countries. Antonia Elisabeth Korvezee (1899–1978), a Dutch, was the first female professor at Delft University of Technology. Branca Edmée Marques (Mme Torres, 1899–1986) was also the first female university professor in Portugal.

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13 On Irène Joliot-Curie, see Louis-Pascal Jaquemond, *Irène Joliot-Curie* (Paris: Odile Jacob, 2014).

14 The first woman who became an official member of Paris Academy of Sciences was Yvonne Choquet-Bruhat (the physics department in 1979). As for the chemistry department, Odile Eisenstein became the first female member in 2013.

15 On Marietta Blau, see Brigitte Stronhmaier & Robert Rosner, English Edition Ed. By Paul F. Dvorak, *Marietta Blau* (Riverside, California: Ariadne Press, 2013).

Fig.4 In the Radium Institute (1930)
Musée Curie (coll. ACJC)

As for someone with a unique background, there was Catherine Chamié, who was born in the Russian Empire to an exiled Lebanese father and a Russian mother. She escaped to Paris during the Russian Revolution and later became naturalized in France. She worked in the measurement department of the Radium Institute and later became director of the department. In addition to creating various radioactive sources and providing them to other researchers, she wrote more than 40 articles.

This was also the period during which the problem of radiation injury increased slightly. In 1925, Margaret Carlough, an American factory worker who painted dials with radium-mixed fluorescent paint, sued U.S. Radium Corporation for causing health hazards. During the lawsuit, the responsible investigators concluded that the dial painters' deaths were due to radiation. However, this news did not spread immediately throughout the world to raise people's awareness about the risk of radioactivity.[16]

Yet, among these female disciples, there were wide individual differences in presenting symptoms. Monin, who was much exposed to X-rays during World War I, and Erzsébet (Elisabeth) Róna (1890–1981), who was involved in the Manhattan Project, lived long lives. Incidentally, the average lifespan of the female disciples was about 70 years; therefore, we cannot say that they died young. Considering that more than half of these women were born in the nineteenth century, it is difficult to judge the harm of the radioactive rays on the basis of their lifespans.[17]

Furthermore, World War II had a huge impact on both the male and female disciples. Quite a few disciples, because they were Jews, were forced to go into exile to escape Nazi persecution. On Einstein's recommendation, Blau left Vienna for Mexico, and then moved to the United States. She returned to Vienna in 1960 and died there. The person who witnessed the most dramatic scene was Róna, born in the Austro-Hungarian Empire. At the Radium Institute, she learned from Irène how to create a strong source of polonium. Later, in 1933, she was awarded the Haitinger Prize from the Vienna Academy of Science for creating radioisotopes through neutron irradiation. However, she immigrated to the United States in

[16] On the industrial health problem of radioactivity before WWII, see Claudia Clark, *Radium Girls* (Chapel Hill & London: Univ. of North California Press, 1997).

[17] Needless to say, there were several researchers died of radiation injury. On this question, see Anne Fellinger, "Women radio-chemists facing radioactive risks in France," *The Global and the Local: The History of Science and the Cultural Integration of Europe, Proceedings of the 2nd ICESHS* (Cracow, Poland, September 6-9, 2006), ed. by M. Kokowski: 534-539; "Femmes, risqué et radioactivité en France," *La Découverte/ Travail, genre et sociétés*, n.23 (2010): 147-165.

1941 and, like other exiled Jewish scientists, was asked by the U.S. government to back up the war. Róna is said to have been the only female scientist who participated in the Manhattan Project.

This war largely changed the meaning of science. Marie herself died without knowing about the damage that the atomic bombs caused, but many of her disciples were forced to face this reality. The most famous activity regarding war and science was the appeal for the peaceful use of atomic energy by Irène and Frédéric. Apart from them, the activities of Gleditsch and Feytis-Cotton were remarkable. They were deeply involved in anti-Nazi activities during the war and continued the peace movement activities after the war. Specifically, Feytis-Cotton became the vice chairman of the World Peace Council, and received the Stalin Peace Prize in 1951.

While guiding her female disciples, Marie Curie worked actively as a researcher until the end of her life. What did Marie leave to her disciples of the same gender?

Conclusion

"What great model and what encouragement for other women did Marie Curie give!" said Feytis-Cotton.[18] She and her classmates witnessed Marie Curie's oral defense for her PhD, and she was impressed by the attitude of "their teacher," who delivered a dignified speech in front of distinguished scientists. Further, she confirmed that Marie's role for her female students was one of "model and encouragement."

This person, who was a great role model and source of encouragement for women, had other factors that attracted people's attention, such as being the first female Nobel Prize winner or "a tragic widow." Thus, Marie Curie's presence dimmed other female scientists. Besides having many able and talented female disciples, Marie's other aspects as a leader and her female disciples' achievements are not well-known.

Moreover, it is truly unfortunate that some people tried to erase the imprints of these female scientists, as in the case of Brooks. Brooks' negative view on the role of women[19] in nuclear science is completely wrong. There is no doubt about the contributions of women, such as Gleditsch, Perey and Blau, to this field. On top of that, Brooks herself was a person of great achievement, having discovered the recoil of a radioactive atom. The fact is, as mentioned previously, many of Marie's female disciples followed their teacher and became role models for junior female scientists. Those who did not become scientists also inherited Marie's spirit in their own careers, such as in teaching and nursing.

Marelene and Geoffrey Rayner-Canham, who co-wrote Brooks' biography, said that a case like that of Brooks, who abandoned research after marriage and became a full-time housewife, was a typical gender problem.[20] This may be true among women as a whole, but

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18 Eugénie Cotton, *Les Curies* (Paris: Seghers, 1963), p. 48.

19 Rayner-Canham (note 8), p. 88.

20 Regarding this question, see Rayner-Canham, (note 8); *A Devotion to Their Science,*

not among Marie's disciples. Besides seven people whose lives after they left the Radium Institute are unknown due to a lack of documents, the number of people who abandoned research to fulfil a "woman's role", such as marriage, child-bearing or nursing, was only 4 out of 37. In other words, the majority of those disciples continued to work using their scientific skills, whether as scientists, nurses or teachers. Further, most of them, besides being career women, worked toward achieving world peace and/or improving women's social status. Brooks herself, who became a "bourgeois wife," conducted activities for women with various organizations, including the Canadian Federation of University Women.

From the gender perspective, Marie Curie's contribution as an active scientist as well as in leading the radioactivity research, merits special attention. As the first female researchers who had the world-renowned female scientist as their teacher, Marie's female disciples could think of their own potential for becoming teachers of both male and female students. It was impossible for male scientists, such as Rutherford, to do this, no matter how faithfully they might have guided their female disciples. Gender is undeniably the most important point with respect to a role model.

For example, when Irène was single, a journalist asked her if being a scientist was a difficult occupation for a woman. She asserted, "I believe that the scientific aptitudes of men and women are exactly the same." And as for housework, she answered promptly that we should abandon it "on the condition that it is accepted as an additional burden."[21] Furthermore, Mme Tonnerat, Marie's student at the Sorbonne, purposely used the words "male scientists and female scientists" at the commemorative lecture for the fiftieth anniversary of Marie's first class at the university.[22] Irène and Tonnerat had a firm belief that scientific research is for both sexes. We can consider that behind this confirmation was the fact that they knew Marie Curie personally and had colleagues of the same gender.

Lastly, I would like to mention a Japanese female scientist for whom Marie Curie was a spiritual mentor. Toshiko Yuasa (1909-1980) conducted her research in France during World War II. Yuasa, who had been an associate professor at Tokyo Higher Normal School for Women, was the first Japanese woman to receive the French government's scholarship in science. She studied under Frédéric Joliot-Curie and had a close friendship with Irène. In 1943, she obtained a doctorate in science in France. She was forced to return to Japan in 1945, but went back to France after the war, and finally became a researcher at the National Center for Scientific Research. She then spent the rest of her life in Paris.

Even after she became a permanent resident of France, Yuasa continued to encourage her juniors in Japan. After her death, her old school (Now Ochanomizu University)

Pionner Women of Radioactivity (Montreal et. al.: McGill University Press, 1997).

21 Robert Reid, *Marie Curie* (New York: The New American Library, 1974), p. 247.

22 M.A. Tonnelat, "Discours de Mme T.A. Tonnerat, Professeur de Physique Mathématique à la Sorbonne," *Cinquantenaire du premier cours de Marie Curie à la Sorbonne* (Paris: A. Coueslant, 1957): 38-39, p. 38.

established a scholarship in her name for female scientists in 2002.[23] We can say that this is part of the heritage passed down from Marie Curie's laboratory, from a female scientist to her juniors.

[23] On Toshiko Yuasa, see *Catalog of Toshiko Yuasa's (1909–1980) Archives* (Tokyo: Institute for Gender Studies, Ochanomizu University, 2009): Kawashima (note 2).