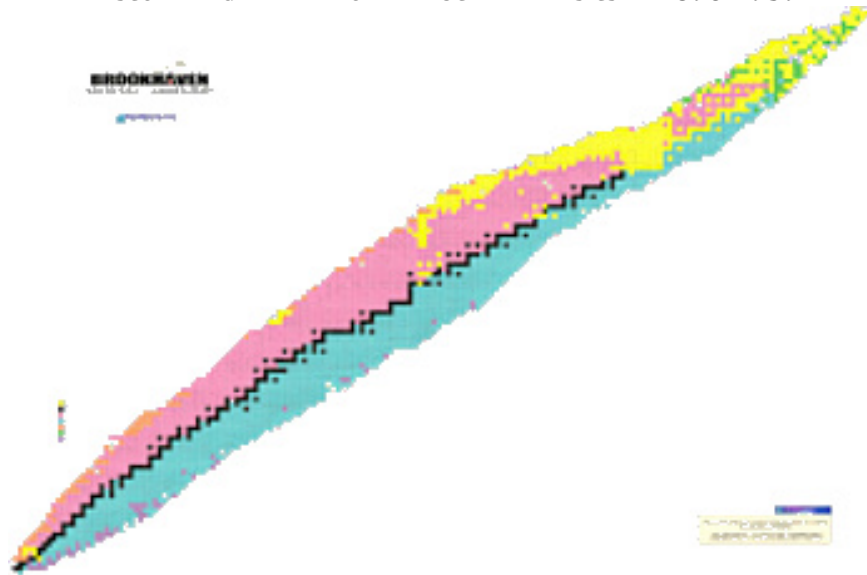


**DISCOVERING A NEW WORLD: NUCLEAR PHYSICS --- 1896-1939**



**2015 MAP OF SOME 4000 KNOWN NUCLEI (NUCLIDES)**

**FIVE WHO HELPED DISCOVER A NEW WORLD: NUCLEAR PHYSICS**

Pierre Curie	1859-1906	1903 Physics Nobel Prize
Marie Skłodowska Curie	1867-1934	1903 Physics Nobel Prize; 1911 Chemistry Nobel Prize
Irène Joliot-Curie	1897-1956	1935 Chemistry Nobel Prize
Frédéric Joliot-Curie	1900-1958	1935 Chemistry Nobel Prize
Lise Meitner	1878-1968	did not share the 1944 Chemistry Nobel Prize awarded to Otto Hahn

**SOME KEY DATES**

- 1896 Henri Becquerel discovers uranic rays = radioactivity
- 1898 Marie & Pierre Curie use radioactivity to discover two new chemical elements: Po (polonium) and Ra (radium)
- 1899 Rutherford distinguishes alpha and beta radiations; 1900 Villard names gamma rays
- 1902 Rutherford and Soddy propose disintegration theory
- 1905 Albert Einstein shows that  $E=mc^2$
- 1911 Ernest Rutherford discovers the atomic nucleus
- 1913 Frederick Soddy posits the existence of isotopes; J. J. Thomson separates and observes two isotopes of neon,  $^{20}\text{Ne}$  and  $^{22}\text{Ne}$ .
- 1914 Henry Moseley maps the periodic table of the chemical elements -- the atomic number Z
- 1918 Rutherford produces artificial transmutation of one element into another
- 1932 Carl Anderson discovers the positron, the anti-particle of the electron
- 1932 Cockcroft & Walton build the first particle accelerator, and use it to produce a nuclear reaction
- 1932 James Chadwick discovers the neutron; isotopes are now understandable
- 1934 Irène & Frédéric Joliot-Curie use alphas from  $^{210}\text{Po}$  to make a radioactive isotope of phosphorus:  $^{27}\text{Al} + ^4\text{He} \rightarrow ^{30}\text{P} + n \rightarrow ^{30}\text{Si} + e^+$
- 1938 Otto Hahn finds that  $n + \text{U} \rightarrow \text{Ba} + \dots$
- 1939 Lise Meitner explains Hahn's finding: a nucleus can break in two, releasing millions of times more energy than does a normal chemical reaction
- 1945 Trinity test in New Mexico detonates first atomic bomb. Its enormous energy comes from the fission of entirely man-made plutonium.

#### **FIVE INTERESTING URLS**

Everyone named in the list of key dates, except Moseley and Meitner, won a Nobel Prize. Short biographies, descriptions of the work for which they received the award, and texts of their Nobel lectures are available at <https://www.nobelprize.org>

The American Institute of Physics (AIP) has produced an excellent online exhibit and account of the life and work of Marie Curie at <https://history.aip.org/history/exhibits/curie/contents.htm>

The Wikipedia article on Lise Meitner is unusually thorough and well written. It is at [https://en.wikipedia.org/wiki/Lise\\_Meitner](https://en.wikipedia.org/wiki/Lise_Meitner)

If you can read French, you can read Mme. Curie's book *Traité de Radioactivité* (1910, 466 pp.). It describes her work in detail and is available online at <https://archive.org/details/traitderadioac01curi/page/130>.

The now decontaminated laboratory of the Curies has been made into a museum. You can visit this museum online at <https://musee.curie.fr/decouvrir/exposition-permanente>. Or if you are in Paris, you can go there. Then you can also examine Mme. Curie's papers from the archives, but you must wear protective clothing and sign a waiver of liability before they will let you take papers out of the lead lined box in which they are stored.

#### **FIVE BOOKS ABOUT THEM AND THEIR DISCOVERIES**

Ruth Lewin Sime, *Lise Meitner: A Life in Physics*, Berkeley: University of California Press, 1996. Excellent thorough and balanced account of Meitner's life and accomplishments in physics.

Ève Curie, *Madame Curie*, London: William Heinemann, 1937. The author is Marie Curie's daughter. What I have read of it has a vitality, a liveliness of color and vigor of style, that make it a pleasure to read.

Sharon Bertsch McGrayne, *Nobel Prize Women in Science*, New York: Birch Lane Press 1993. Contains nice essays about Curie mother and daughter, about Lise Meitner, and about other women who won or should have won Nobels including Maria Goeppert Mayer, the second woman to win a Nobel Prize in physics.

Roger Stuewer, *The Age of Innocence: Nuclear Physics between The First and Second World Wars*, New York: Oxford University Press, 2018. Somewhat more technical than the above books, it gives a nice account of the difficulties of getting an education and a laboratory for your research. The difficulties were greater for women than for men, but they were large for men.

Richard Rhodes, *The Making of the Atomic Bomb*, New York: Simon & Schuster, 1986. This is a wonderful book. The physics is correct and artfully embedded in a powerful narrative of how the discovery of the atomic nucleus led to the atomic bomb.

#### **MARIE CURIE'S EXPERIMENTAL TECHNIQUE**

Philippe Molinié and Soraya Boudia have redone Marie Curie's measurements and analyzed her laboratory technique. To see how the Curies minimized sources of experimental error and what hand-eye coordination she needed to make her measurements read the article (in English) at [https://www.academia.edu/33809782/Mastering\\_picocoulombs\\_in\\_the\\_1890s\\_The\\_Curies\\_quartz\\_electrometer\\_instrumentation\\_and\\_how\\_it\\_shaped\\_early\\_radioactivity\\_history](https://www.academia.edu/33809782/Mastering_picocoulombs_in_the_1890s_The_Curies_quartz_electrometer_instrumentation_and_how_it_shaped_early_radioactivity_history)