THE DISCOVERY OF RADIOACTIVITY AND RADIUM

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BECQUEREL'S DISCOVERY

Just over three months after Röntgen's discovery of X rays, radioactivity was discovered in a stunningly similar combination of fortuitous circumstances and deductive reasoning. Understandably, the discovery of X rays had aroused immense interest among the physicists of the generation, including Antoine Henri Becquerel (Fig 1). Becquerel came from a family of prominent scientists, having succeeded his father, who had previously succeeded his grandfather, as Professor of Physics at the Museum of Natural History in Paris. As Röntgen discovered X rays by the fluorescence associated with their production, many scientists, including Becquerel, wondered whether X rays or other similar rays might be produced by other fluorescent or phosphorescent substances. Becquerel experimented with crystals of an uranium salt called potassium uranyl sulphate, which were known to be highly fluorescent. Like Röntgen, Becquerel wrapped a photographic plate in black paper and placed the uranium crystals immediately outside the covered photographic plate. First he exposed crystals and the plate to sunlight for several hours. When the photographic plate was subsequently developed, dark spots which were present on the plate corresponded with the position of the uranium crystals. Becquerel initially concluded (wrongly) that the radiation which had passed through the wrapping and exposed the photographic plate was due to phosphorescence produced by the effect of sunlight on the uranium crystals. This initial discovery occurred sometime in February 1896.

Towards the end of the same month, Becquerel was trying to repeat his experiments but was unable to do so because of poor weather. The sky had become cloudy and dark, hence there was no sunlight for him to expose the uranium crystals to. As a consequence, he stored both the uranium crystals and the covered photographic plate inside a drawer in his laboratory for safe keeping. By 1st March 1896, there still being insufficient sunlight, Becquerel decided to develop the plate kept in the drawer. To his great surprise, he saw the blackened images of the crystals exposed on his photographic plate. He deduced that neither sunlight, fluorescence, phosphorescence, nor an external factor was responsible for this effect and that a spontaneous emission of radiation had occurred. Unlike X rays, this new radiation was produced by the mineral itself. Becquerel presented his discovery the following day at the weekly meeting of the French Academy of Science. Ten days later, his findings were published in a paper entitled "On visible radiations emitted by phosphorescent bodies".

THE CURIES AND RADIUM

One of the many scientists who was deeply impressed after reading Becquerel's paper was a young lady by the name of Marie Curie. At that time, Marie Curie (born Marie Sklodowska in Warsaw, Poland) was a budding but brilliant physicist just married

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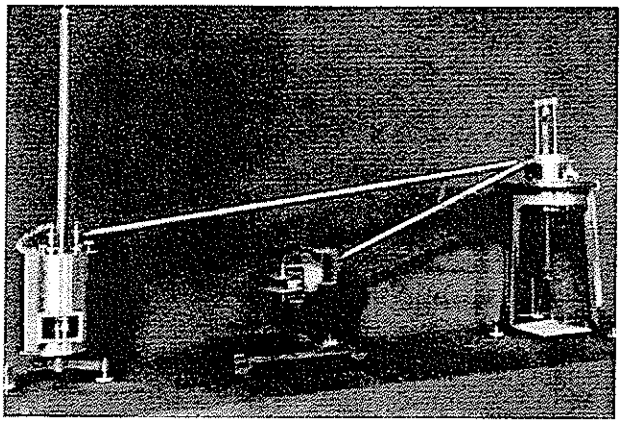
Fig 1 – Antoine Henri Becquerel (1852-1908)

to Pierre Curie, who was already famous and well-regarded in France (Fig 2). Marie Curie reasoned that other elements may also give out the new type of rays discovered by Becquerel and soon found that the substance thorium emitted these rays. She coined the term "radioactivity" to describe the new form of energy produced by uranium and thorium.

Marie Curie developed an apparatus, the electroscope, for measuring radioactivity more accurately, as the photographic plate method was too crude (Fig 3). Its basic components were an ionization chamber, electrometer and a piezo-electric quartz. She demonstrated that the intensity of radioactivity was proportional to the amount of uranium, that is, it was an atomic property unrelated to its chemical structure and other outside factors. One exception to this rule, however, was a crude form of uranium called pitchblende. Pitchblende was far more radioactive than the uranium that could be extracted from it, leading Marie Curie to conclude that pitchblende must contain tiny amounts of an unknown substance which was very radioactive. Both the Curies embarked on a tedious and systematic chemical analysis of pitchblende and on 18th July 1898, announced the discovery of a new element which they named "polonium" after Marie Curie's country of birth. The Curies proceeded to discover a second highly radioactive substance, which emitted two million times as much radiation as uranium. They called the substance "radium" and announced

Fig 2 – Photograph of Pierre and Marie Curie, taken shortly after their marriage in 1895.

Fig 3 – Device for measurement of radioactivity, consisting of an electrometer (left), condenser (centre) and piezo-electric quartz (right).



its discovery in December 1898.

The French chemists of the day were however critical and insisted that the two elements be isolated and their atomic weights determined before official status be granted to these elements. As only one part of radium is found in about 5 million parts of pitchblende, it was obvious that huge amounts of the latter substance would be required to isolate a tiny amount of radium. At that time, the only known uranium mine, owned by the Austrian government, was located in Bohemia. An influential Austrian geologist, Eduard Suess, was instrumental in helping the Curies get started by successfully persuading the Austrian State to donate 10,000 kilograms of pitchblende to them. The Curies also had two other problems, namely lack of a suitable laboratory and insufficient funds to continue their work. After numerous attempts to find premises, they returned to a dilapidated former dissection room in the basement of the School of Physics in Paris (Fig 4). In 1902, after working for 45 months in horrendous conditions, Marie and Pierre Curie succeeded in preparing 100 milligrams of radium. To supplement their meagre income, Marie had to teach physics at a high school for girls.

While working on the isolation of radium, the Curies noted that radium was "contagious" whereby objects exposed to radium would develop "activities" of their own. Even to this day, the notebooks used by the Curies continue to emit radioactivity (Fig 5). Marie Curie's office and laboratory had to be decontaminated before it could safely be opened as a permanent museum. Two years after the discovery of radium by the Curies, German scientists Friedrich Oskar Giesel and Friedrich Otto Walkhoff reported that the rays emitted by radium had a destructive action on human skin. Pierre Curie, after hearing of this, placed a radium sample on his arm for 10 hours to test its effect on his own skin. This resulted in an area of reddening similar to a sunburn, which later became a wound and eventually healed after 4 months. Becquerel also suffered a similar radiation burn in an accidental way. He travelled to London to give a lecture to the Royal Society, while carrying a tube of radium in his waistcoat pocket. On returning to Paris, he developed a large wound on his skin beneath the location of his waistcoat pocket. This wound took some time to heal and apparently greatly upset him. Marie and Pierre Curie soon started animal experiments which led to the treatment of

Fig 4 – Inside of the shed, a former dissection room, used as a laboratory by the Curies.

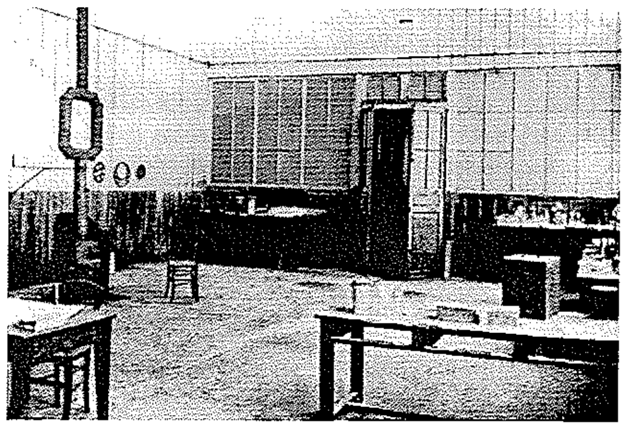
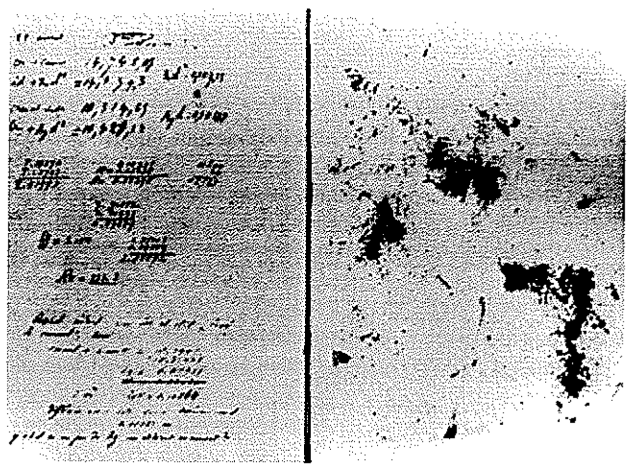


Fig 5 – Page from the Curies' laboratory log (left) and its autoradiograph (right) taken 50 years later, still showing the presence of radioactive contamination.

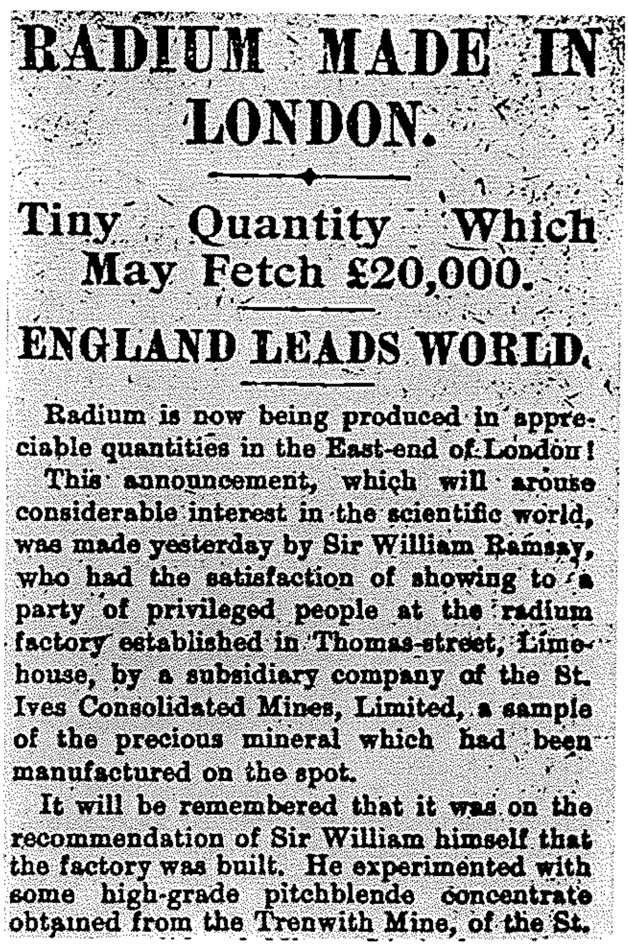


patients by what became known as Curie therapy.

In 1903, both the Curies and Becquerel shared the Nobel Prize in Physics for their work in radioactivity. In delivering the Nobel lecture, Pierre Curie emphasized the importance of biological effects of the radiation produced by radioactive substances, although at that time no therapeutic results had yet been obtained. In 1905, Pierre Curie was finally appointed to a Professorship at Sorbonne University in Paris, and was also elected to the Academy of Science. In 1911, Marie Curie became the only person to be awarded two Nobel Prizes when she obtained the Nobel Prize for Chemistry. Twenty-four years later, the Nobel Medal tally for the Curie family rose to 5 when her daughter Irene, together with her husband Frédéric Joliot, were given the Nobel Prize for the discovery of artificial radioactivity.

Cancer of the cervix, a very common cancer afflicting women, was first treated with Curie therapy in 1905. The treatment of this form of cancer remained the chief therapeutic application of radiation produced by radium up till the 1960s when it was superceded by newer radioactive substances (Fig 6 and 7). Marie Curie derived immense satisfaction from the successful medical applications of radium. Although the Curies could have become wealthy by patenting the process of producing radium, they did not do so. Like Röntgen, they unselfishly published the protocols of their experiments for all to read and benefit from. Pierre Curie died tragically in 1906, at the age of 47 years, when he was knocked down by a horse-drawn wagon. Marie Curie was initially devastated by this tragedy but eventually continued her research work (Fig 8). When the First World War broke out in 1914, she was responsible for equipping the first ever radiological "ambulance" and establishing 200

Fig 6 – Early newspaper report on the manufacture of radium in London. Note the high cost of radium.



RADIUM MADE IN LONDON.

Tiny Quantity Which May Fetch £20,000.

ENGLAND LEADS WORLD.

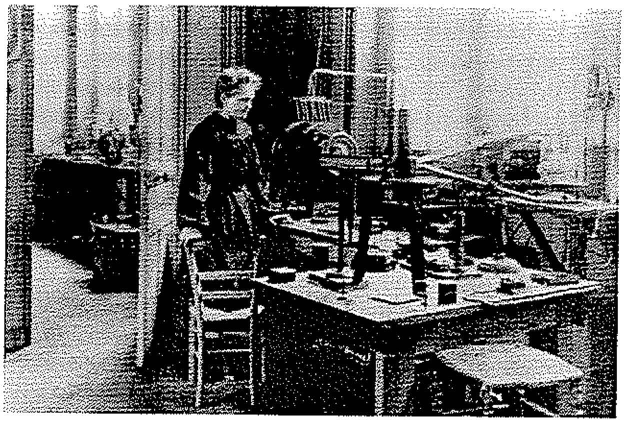
Radium is now being produced in appreciable quantities in the East-end of London!

This announcement, which will arouse considerable interest in the scientific world, was made yesterday by Sir William Ramsay, who had the satisfaction of showing to a party of privileged people at the radium factory established in Thomas-street, Limehouse, by a subsidiary company of the St. Ives Consolidated Mines, Limited, a sample of the precious mineral which had been manufactured on the spot.

It will be remembered that it was on the recommendation of Sir William himself that the factory was built. He experimented with some high-grade pitchblende concentrate obtained from the Trenwith Mine, of the St.

Fig 7 – Old advertisement for radium from Siemens Brothers & Co., London

Fig 8 – Marie Curie in her laboratory

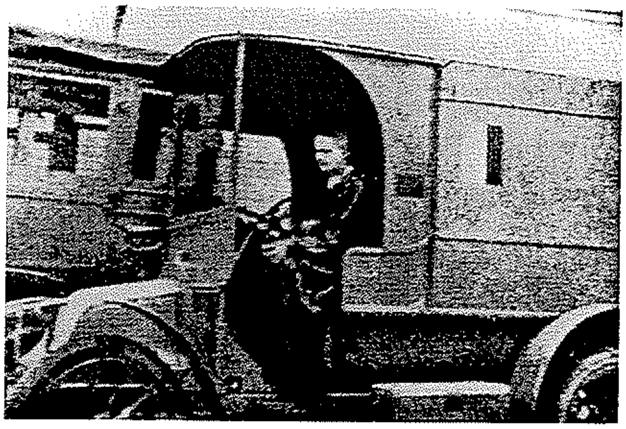


radiological posts near the battlefields, contributing to saving of countless lives. Twenty of these radiological cars, each containing a dynamo for generating electricity, an X ray unit, photographic equipment and screens, entered service during the war and were nicknamed "little Curies" in the army zones (Fig 9). Marie Curie died in 1934 of aplastic anaemia, a disease due directly to her long hours of exposure to radium. She remains possibly the greatest woman scientist of this century.

CONCLUSION

The therapeutic benefits of radioactivity were realized very soon after the landmark discoveries of Becquerel and the Curies. It was to be some 20 years later, however, before the development

Fig 9 – Marie Curie in one of her World War One radiological ambulances



of the subspecialty of Nuclear Medicine was to follow the birth of Radiation Oncology.

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