Rutherford's Nobel Prize and the one he didn't get

Ernest Rutherford received the Nobel Prize in Chemistry in 1908, but why chemistry? Why didn't he win a prize for his outstanding discoveries in physics? **Cecilia Jarlskog** investigates.

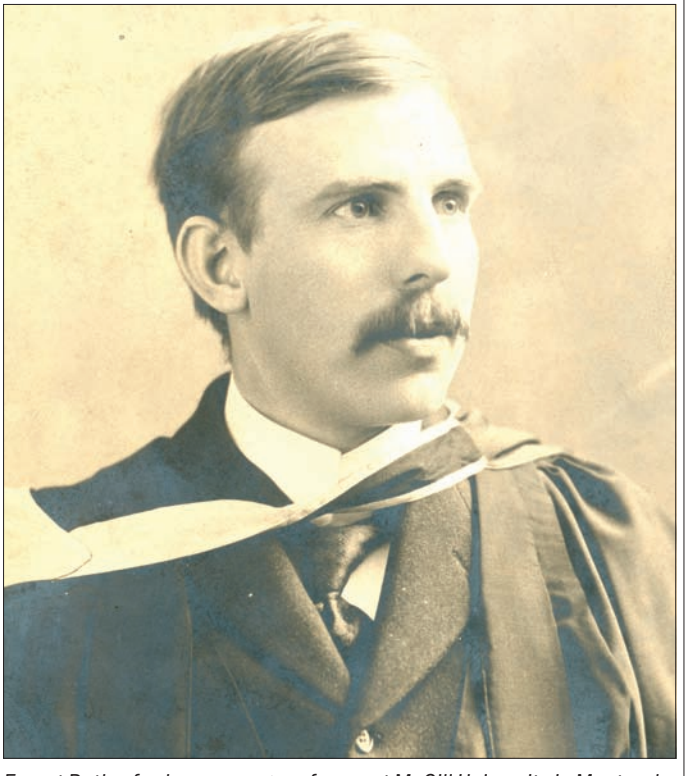
"I have dealt with many different transformations with various periods of time, but the quickest that I have met was my own transformation in one moment from a physicist to a chemist."
Ernest Rutherford (Nobel banquet 1908).

I have always been fascinated by Ernest Rutherford. He came from a poor scientific environment and yet rose to occupy "the highest position in the British Empire" (Arrhenius 1924). He was an exceptionally impressive physicist – detector-constructer, experimentalist, theorist – and a Nobel laureate in chemistry. To put the issue of his Nobel Prize into context, I will briefly describe his history.

Born in New Zealand in modest surroundings, Rutherford was one of a large family but was exceptionally talented and "had no difficulty in obtaining scholarships and prizes" (Eve 1939). In October 1895 we find the 24-year-old Rutherford in Cambridge, England, where he is welcomed to the Cavendish Laboratory by its leader, Joseph John Thomson (1906 Nobel Prize in Physics). Rutherford's exceptional talents are quickly recognized, and he is invited to give talks at several distinguished gatherings, including the Royal Society. He demonstrates his magnetic detector for sensing electrical waves at what were then large distances.

Late in 1898, at the age of 27, Rutherford becomes Macdonald professor of physics at McGill University, Montreal, Canada. Here he makes a sensational discovery: atoms are not necessarily eternal but can transform into one another. This is transmutation of the elements. He proposes the "genealogical tree" of the uranium family where he postulates the existence of a yet unseen intermediate state in the chain. This is a revolutionary idea.

A great authority at the time, William Thomson (later Lord Kelvin), and Scottish physicist Peter Tait had reported (1867): "The inhabitants of the Earth cannot continue to enjoy the light and heat essential to their life for many million years longer, unless sources now unknown to us are prepared in the great storehouse of creation." However, Rutherford applies his findings in radioactivity and discovers that the Sun will shine much longer than that. He makes the front pages with headlines such as "Doomsday postponed". He is also the guest of honour at important events, receives prizes and medals, and is elected into distinguished societies such as the Royal Society.



Ernest Rutherford as a young professor at McGill University in Montreal, where he carried out most of the research that earned him his 1908 Nobel Prize in Chemistry. (Courtesy McGill University Archives.)

To be eligible for a Nobel Prize in Physics or Chemistry, the candidate must have been nominated for the year in question. All that is required is one valid nomination (i.e. from someone who has been invited to nominate). In 1907, Rutherford has seven nominations for the Nobel Prize in Physics and one for the chemistry prize. His nominators for the physics prize are Adolf von Baeyer (1905 chemistry Nobel), Hermann Ebert, Vincenz Czerny, Emil Fischer (1902 chemistry Nobel), Philipp Lenard (1905 physics Nobel), Max Planck (1918 physics Nobel) and Emil Warburg. All of these nominations come from Germany. His nominator for the chemistry prize is Svante Arrhenius from Sweden, a member of the Nobel Committee for Physics from 1900 to 1927. ▷

In 1908 Rutherford receives five nominations for physics and three for chemistry. His nominators for the physics prize is Arrhenius, John Cox, Lenard, Planck and Warburg. The "newcomer", Cox, is a professor at McGill. Rutherford is nominated for the 1908 Nobel Prize in Chemistry by Arrhenius, Oskar Widman (a Swede) and Rudolf Wegscheider (an Austrian).

Most of these nominations are composed of just a few lines. Some of the nominators attach references, but others assume that the Nobel committee know Rutherford's work. The nominations state that he deserves the prize for his work on radioactivity. Planck nominates him for his experiments and research on radioactivity and "for having to some extent swept away the blanket of darkness that still enwraps the nature of these processes". Wegscheider writes: "This Rutherfordian idea is of such importance to chemistry that I have no problem recommending him for the chemistry prize even though he is a physicist." The chemistry nomination from Widman differs from the others because he proposes that Rutherford should share the prize with his former research student Frederick Soddy.

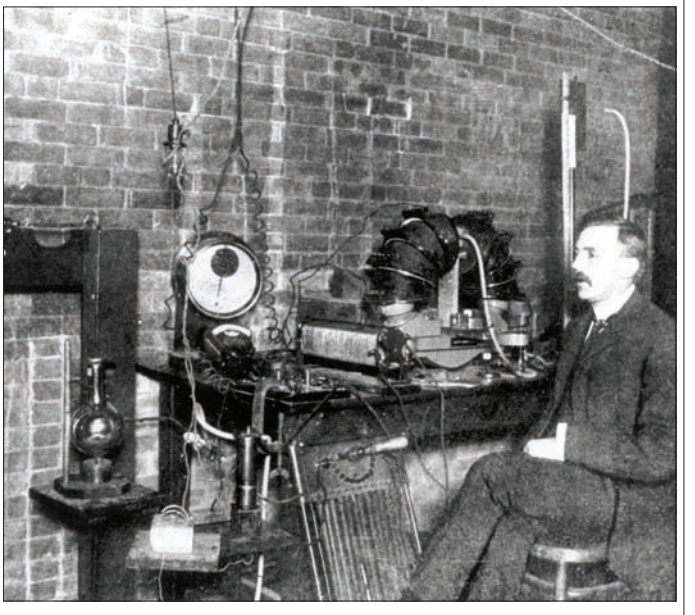
The longest nomination letter is from Cox, one of the two headhunters who had interviewed Rutherford for the professorship at McGill. Dated 8 February 1907, the letter arrives after the 31 January deadline and so is not valid for 1907. It is saved as a nomination for 1908.

You may wonder about Thomson, who was always supportive of Rutherford. Why doesn't he nominate his great student? Actually, he does. He submits a nomination in 1908, but this also arrives too late and is therefore saved for 1909. By then, however, Rutherford has received the 1908 prize, making Thomson's nomination invalid. The Nobel rules do not allow the nomination of someone who has received the prize within the previous two years. Thus in 1907, Rutherford had no nominations from England or France, where his work was well known and where there were qualified nominators, among them several Nobel laureates.

Rutherford is nominated for his work on radioactivity, the essential issue being the decay of radium. The Nobel Committee for Physics, in its 1907 report to the Royal Swedish Academy of Sciences (referred to here as the Academy), brushes him aside quickly by stating: "his observation of the decay of a chemical element (radium) should be awarded with the chemistry prize rather than the physics prize. Therefore, we deem we should not suggest him as a recipient of this year's Nobel Prize in Physics." In other words, radium is a chemical element and that's chemistry. This matter is not trivial. The 1904 Nobel Prizes in Physics and Chemistry are awarded to John William Strutt (Lord Rayleigh) and William Ramsay, respectively. Both of them receive the prize for the discovery of chemical elements (inert gases); Strutt is a physicist and Ramsay a physical chemist.

The Nobel Committee for Chemistry, in its 1907 report to the Academy, states: "Rutherford has been nominated for his studies of radioactivity, by seven nominators for the physics prize and by one nominator for the chemistry prize. This is understandable, taking into account that Rutherford uses physical methods while the results, so far as they are concerned with chemical elements, must be considered to be of fundamental importance for chemistry as well." The committee then opts for a wait-and-see strategy.

In 1908 the Nobel committees for physics and chemistry meet and decide that Rutherford's work is more relevant to chemistry than to physics. Arrhenius is worried that Rutherford might fall between two stools at the academy's plenum, where the final decision is made. He writes to the academy proposing: "If the Academy should decide that it is not appropriate to give him the chemistry prize, he should be awarded the 1908 physics prize."



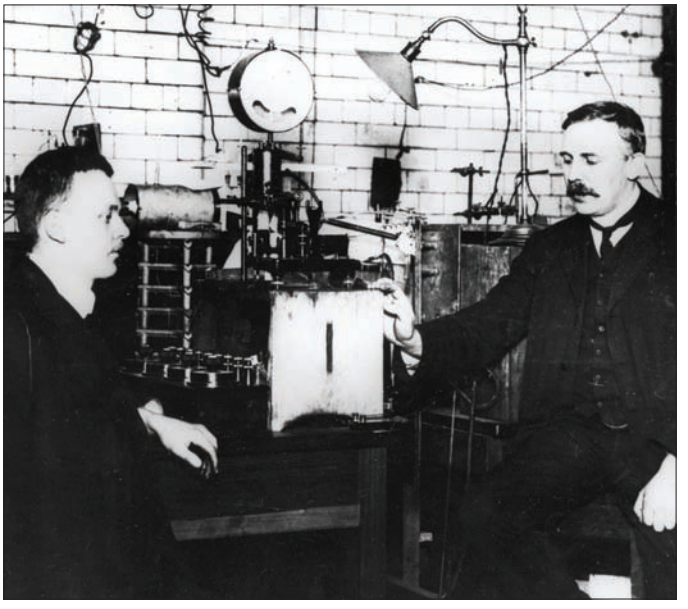
Rutherford at work at McGill University, where he made his Nobel Prize-winning discoveries. (Courtesy McGill University Archives.)

Nobel deliberations

Contrary to the physics committee, the chemistry committee takes Rutherford's candidacy very seriously. Their report to the academy contains about 15 pages about him, so I will give only a few excerpts. For example, the committee says: "Rutherford's theoretical work contains the formulation and development of the so-called decay hypothesis, for describing the transformation of elements and deducing the laws that govern them; he has proposed that alphas are doubly charged helium atoms; [he] has insisted on the material nature of the emanation process, and has done experiments to verify his hypothesis." The chemistry committee's report continues on and on about Rutherford's ingenious experiments and his deep insight regarding what was going on in the complicated chain of the emanation processes. Rutherford has shaken the foundations of chemistry by replacing its assumption of the immutability of chemical elements with a new and more general hypothesis.

The report also describes the theory of Rutherford and Soddy, and their introduction of the exponential decay law, lifetimes, etc. Ultimately it states: "Rutherford deserves the Nobel Prize in Chemistry without a shadow of doubt. A more difficult question concerns whether any of Rutherford's collaborators should share the prize with him."

A closer study of Rutherford's work shows that most of his assistants help him with specific tasks and that their contributions are secondary to his. The only exception is Soddy, who is not only a collaborator on some of Rutherford's most important experimental studies from 1902 to 1903 but also participates in formulating the theory of disintegration of elements. Naturally, the question of their individual contributions in formulating this theory cannot be accessed by outsiders, but it is remarkable that none of the nominators other than Widman suggests that Soddy should share the prize with Rutherford. Finally, the committee argues against honouring



In the lab at Manchester with Hans Geiger (left), in around 1908. (Courtesy AIP Emilio Segrè Visual Archives, Physics Today *Collection.)*

Soddy together with Rutherford because "a shared prize could easily be misinterpreted as an underestimation of the eminent importance of Rutherford's work for chemistry and more generally for modern natural sciences, especially since the chemistry prize, up to now, has only been awarded to one laureate at a time."

In the end, Rutherford "eclipses" his competitors for the chemistry prize. He is judged to be an epoch maker; a solid, precise scientist; and an undisputed leader. We don't know what goes on at the academy when the case of Rutherford is brought up by the physicists and chemists because no minutes are taken on such occasions. The outcome is all we know: Rutherford is awarded the 1908 Nobel Prize in Chemistry "for his investigations into the disintegration of the elements, and the chemistry of radioactive substances".

The nucleus and more

At McGill in 1901, Rutherford writes to Thomson: "The laboratory is everything that can be desired (I) greatly miss the opportunities of meeting men interested in physics." So when the opportunity of a professorship at the University of Manchester arises, Rutherford takes it. Here, he is, in his own words, very fortunate to find a most competent assistant, Johannes (Hans) Geiger.

In a letter to Otto Hahn in 1911, Rutherford writes: "I have been working recently on scattering of alpha and beta particles and have devised a new atom to explain the results, and also a special theory of scattering. Geiger is examining this experimentally, and finds so far it is in good agreement with the facts." This alludes to Rutherford's famous model of the atom, with a compact nucleus inside, and to his scattering formula.

Rutherford then makes another striking discovery. On bombarding nitrogen with his beloved alpha particles, he discovers a new particle, which he calls the proton. He publishes this just before leaving Manchester in 1919 to return to Cambridge, where he succeeds Thomson as director of the Cavendish Laboratory. He continues his work on protons by shooting alpha particles at light atoms. Rutherford predicts the existence of the neutron, deuteron, tritium and helium-3.

Having received the 1908 Nobel Prize for Chemistry, Rutherford subsequently makes even more stunning discoveries in physics. So, one might have expected him to be nominated for the physics prize. After all, Marie Curie was awarded both prizes. However, Nobel laureates are not usually nominated for a second prize: Albert Einstein, for example, was never nominated again after he received the 1921 physics prize.

The archives reveal that Rutherford is nominated for a second prize, in physics, but by only three people: Theodor Svedberg in 1922 and 1923; David S Jordan in 1924; and Johannes Stark in 1931, 1932, 1933, 1935 and 1937. He also receives a nomination for a second prize in chemistry, from the 1911 Nobel laureate in physics Wilhelm Wien. This nomination is marked as invalid because the discoveries for which Rutherford is nominated are considered to be outside the realm of chemistry.

Svedberg, a distinguished member of the academy, nominates Rutherford in 1922 for his atomic model. He wants Rutherford to be awarded the physics prize before Niels Bohr (11 nominations), because Bohr was being nominated for his atomic model, which is based on Rutherford's model. The award committee argues against Svedberg's proposal on the grounds that "giving Rutherford a prize in physics would imply that the 1908 decision to award him the prize in chemistry was wrong because the methods used in these discoveries are similar and the Bohr model of the atom is superior to Rutherford's". The outcome is that Bohr gets the 1922 Nobel Prize for Physics and Einstein (17 nominations) receives the 1921 prize.

In 1923, Svedberg repeats his nomination, adding another superb discovery of Rutherford's: the proton. This means that the matter has to be considered more seriously, and Arrhenius is charged with looking into it. He produces a report for the academy in which he argues against a second prize for Rutherford. The report includes the following statements: "There is very little sympathy for giving the same person two Nobel prizes." "None of Rutherford's countrymen have nominated him for the prize." "Sir Ernest's meritorious contributions are so great and widely known that his standing and possibilities to do research would hardly be affected by a second prize." and "He already occupies the highest position in the British Empire."

For the 1924 prize, Rutherford receives a nomination from Jordan, an ichthyologist and the first president of Stanford University. Then there are no further nominations until 1931, when Stark (1919 physics Nobel) nominates Rutherford for his work on alpha rays and atomic structure. The response of the committee to this nomination is strange, to say the least: "With all due respect for the importance of Rutherford's work, the committee is of the opinion that these lie so close to the work for which he has been given the chemistry prize that the awarding of a further prize is not justified." Stark repeats his nomination four times (1932, 1933, 1935 and 1937) – that is, until Rutherford dies.

Was Rutherford disappointed at not receiving a second prize? We don't know, but I believe that if he had wanted one, he could have given a hint to his distinguished colleagues. He was a generous person who gave a great deal of credit to his collaborators, such as James Chadwick and Soddy, as well as many other people. His Nobel nominations for these and for other scientists testify that he played down his own role. Those who knew him seem to have really "loved" him. His research fellows admired him, and several of them rose to great heights in society – for example, Sir Ernest Marsden ▷

in New Zealand and Sir Mark Oliphant in Australia. Many would have gladly nominated him, but only one person from the then British Empire – Cox – nominated him for his first Nobel Prize, and no one did so for a second. He was knighted in 1914, appointed to the Order of Merit in 1925 and in 1931 he was created First Baron Rutherford of Nelson (in honour of his birthplace in New Zealand). His ashes were interred in London's Westminster Abbey in 1937, where they joined the remains of William Thomson and Sir Isaac Newton.

Further reading

The Nobel Prize materials referred to in this article come from the Nobel Archives at the Centre for History of Science, the Royal Swedish Academy of Sciences, Stockholm. These contain the annual reports that the Nobel committees submit to the academy, although, as previously mentioned, there are no minutes taken during the Nobel deliberations at the academy's plenums. The archives also contain letters written by members of the academy who wish to state their (often conflicting) opinions. Whenever I quote this material, which is originally in Swedish, I am giving my own simple translation. In addition, the Nobel archives contain the original nominations and related correspondence. In the case of Rutherford, most of the nominations are in German and, again, I have given my own simple translation.

S Arrhenius 1924 Report to the Royal Swedish Academy of Sciences (Nobel Archives, Stockholm).

A S Eve 1939 *Rutherford* (Cambridge University Press).

Ernest Rutherford's 1908 Nobel Lecture http://nobelprize.org/.

W Thompson and P G Tait 1867 *Treatise on Natural Philosophy* (Oxford University Press).

● This is an extract from a longer article that is to be published in the Proceedings of the Neutrino 2008 conference, which was held in Christchurch, New Zealand, in May.

Résumé

Ernest Rutherford : pas le Nobel qu'on croit

Ernest Rutherford a obtenu en 1908 le prix Nobel de chimie, mais pourquoi dans cette discipline? Et pourquoi n'a-t-il pas reçu un second prix pour les remarquables découvertes qu'il a faites plus tard en physique? Lauréat du prix Nobel de chimie pour ses travaux sur la radioactivité, qui ont mis en évidence la transmutation des éléments, Ernest Rutherford n'a toutefois jamais été distingué en physique, alors qu'on lui devra par la suite la découverte du noyau atomique et du proton. Cecilia Jarlskog a exploré les archives de l'Académie royale des sciences de Suède pour savoir qui avait proposé Ernest Rutherford pour le prix Nobel, dans quel domaine et pour quelles raisons. On trouve dans ces archives les propositions originales et la correspondance qui s'y rapporte, ainsi que les rapports annuels que les comités Nobel soumettent à l'Académie.

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