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Ernest Rutherford's AMBITIONS

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One of the pioneers of radioactivity research, Rutherford feared his work would be overlooked—and changed his publishing strategies to make sure it wasn't.

At the turn of the 20th century, Ernest Rutherford (see figure 1) was a rising star in the fast-moving field of radioactivity physics. As a member of Cambridge University's storied Cavendish Laboratory in the 1890s, Rutherford had discovered alpha and beta radiation, coauthored papers with the legendary J. J. Thomson, and developed a reputation for designing simple yet ingenious experiments. In 1898, at age 27, he left the Cavendish for a professorship at McGill University in Montreal. Rutherford continued his remarkable record in Canada, churning out paper after paper that explored different types of emissions from radioactive elements.

Yet a March 1901 letter from Rutherford to his mentor Thomson reveals that Rutherford was deeply dissatisfied with the state of his career—and particularly unhappy with the location of his job. In the early 20th century, the most important physics laboratories in the world were concentrated in Europe; by comparison, North American institutions were scrappy upstarts at best and irrelevant backwaters at worst. Rutherford felt isolated and frustrated by his distance from the centers of the physics world. "After the years in the Cavendish I feel myself rather out of things scientific, and greatly miss the opportunities of

meeting men interested in Physics," he told Thomson. "I think that this feeling of isolation is the great drawback to colonial appointments."¹ He asked Thomson to let him know if any professorships were likely to open up in the UK. But Thomson had no positions to recommend; a move seemed unlikely.

Rutherford's distance from other major physics laboratories was especially worrisome given how competitive radioactivity research was in the early 1900s. Other researchers were working on the same questions as Rutherford, and he worried that his work would be ignored or overlooked



The Cavendish Laboratory at Cambridge University.
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ERNEST RUTHERFORD

because of his separation from the European physics community. To avoid that fate, Rutherford revamped his publishing strategies. He began looking for ways to ensure that his discoveries would get into print faster than those of rival scientists and be seen by colleagues in Europe. Rutherford's efforts not only secured his future in the field, they also shaped the rise of one of the 20th century's most influential scientific journals, *Nature*.

Rutherford's training

Born on 30 August 1871 on New Zealand's South Island, Rutherford was the fourth child of James, a Scottish-born wheelwright, and Martha, an English-born schoolteacher. They brought their children up in a relatively remote area, but they took pains to ensure that their children received a good education. Rutherford quickly distinguished himself as a talented student with a gift for physics and mathematics. In 1894, after earning his BSc from New Zealand's Canterbury College (now the University of Canterbury), Rutherford applied for and won an 1851 Exhibition Scholarship from the British Crown. Awarded to support doctoral and postdoctoral work, the scholarships were some of the most prestigious in the UK. Rutherford happened to graduate in the first year the competition was open to students born in the colonies.² He chose to continue his work in physics at the Cavendish Laboratory under the supervision of Thomson, who was known for his work on cathode rays.

Thomson took a special interest in Rutherford. He and his wife, Rose, looked for potential lodgings on Rutherford's behalf before his arrival. Once Rutherford reached Cambridge, Thomson took care to introduce the young New Zealander to longtime residents and fellow newcomers. He was intrigued by Rutherford's scientific work and offered him support and advice on his experiments. In a letter home to his parents, Rutherford wrote that "I admire Thomson quite as much as I thought I would, which is saying a great deal."³

Despite Thomson's congeniality, Rutherford did not find his laboratory entirely welcoming. The Englishmen working at the Cavendish treated Rutherford as an outsider and an interloper. In his letters home, Rutherford complained that he was ostracized and mocked by his colleagues, and that they attempted to place obstacles in his way, such as preventing him from using the laboratory's equipment. Rutherford also struggled with the distance from his fiancée, Mary Newton, who was still living in New Zealand.

Nevertheless, Rutherford quickly made his scientific mark studying the transmission and detection of radio waves. He had developed a novel radio-wave detector back in New Zealand and brought it with him to Cambridge. After only six months, he prepared a paper on the subject for the Royal Society of London. Meanwhile, Thomson grew more and more impressed with his protégé's talent and promoted Rutherford's work to his colleagues in the physics world. Even though Rutherford initially faced a chilly welcome from fellow junior colleagues, his talents and Thomson's mentorship soon helped him find a place in the UK's physics community.

Röntgen rays and radioactivity

Rutherford's time at the Cavendish coincided with a remarkable period of discovery in the physics world. In 1895 physicist

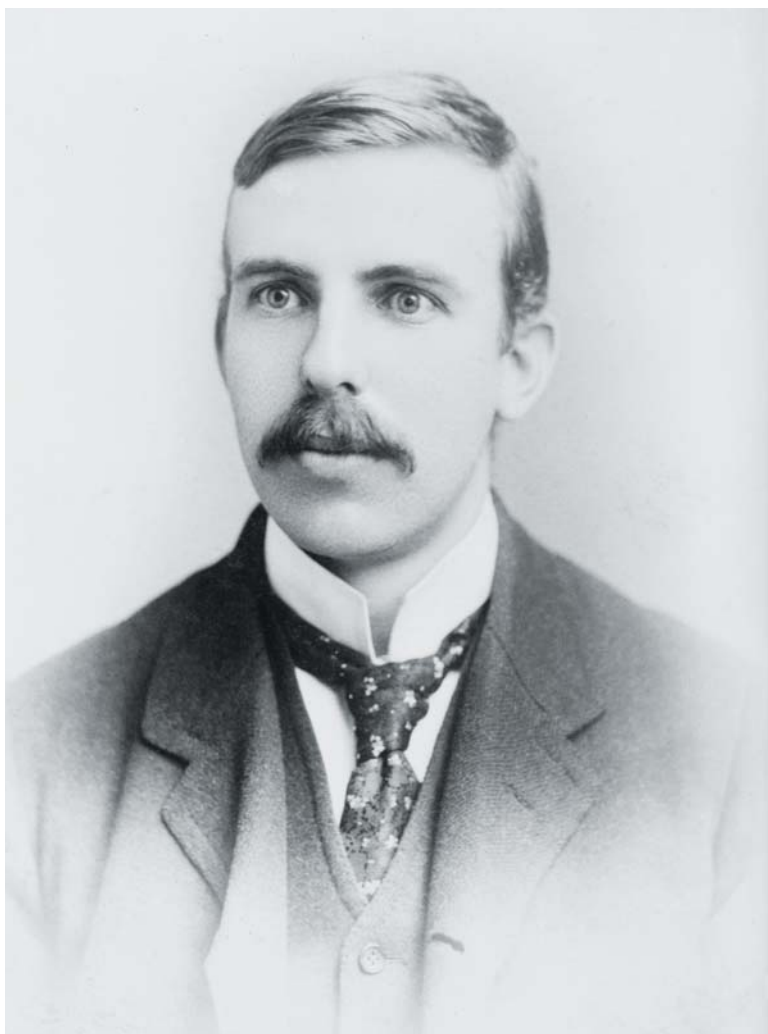


FIGURE 1. A PORTRAIT of Ernest Rutherford in 1908. (Courtesy of the Library of Congress, Prints and Photographs Division, George Grantham Bain Collection, LC-B2-707-6.)

Wilhelm Conrad Röntgen noticed an interesting phenomenon while experimenting with a vacuum discharge tube: When he placed his hand between the tube and a screen coated with barium platinocyanide, the darkened image of the bones in his hand appeared on the screen. It quickly became apparent that Röntgen had discovered a new kind of wave, and "Röntgen rays" became a scientific and popular sensation. Most Anglophone scientists eventually adopted Röntgen's preferred name for his discovery, "x rays."

One of the many scientists inspired to study Röntgen's new phenomenon was Henri Becquerel, a professor at the prestigious École Polytechnique in Paris. Becquerel was interested in whether naturally phosphorescent minerals also produced x rays or emitted other unknown rays. In March 1896 he reported an unusual finding to the French Academy of Sciences: One night, he placed uranyl potassium sulfate in a drawer with wrapped photographic plates, and by the next morning, a silhouetted image of the salts was visible on them. Subsequent experiments revealed that the salts developed photographic plates even when the salts had not been exposed to sunlight—meaning that the production of what Becquerel termed "uranium rays" was not linked to the salt's phosphorescence.

The new discoveries sparked Rutherford's scientific imagi-



FIGURE 2. ORIGINAL ENTRANCE to the Macdonald Physics Building (now the Macdonald-Stewart Library Building) at McGill University. (Photo by Selbymay/Wikimedia Commons/CC BY-SA 3.0.)

nation. He and Thomson collaborated on an influential paper, “On the passage of electricity through gases exposed to Röntgen rays,” published in 1896 in the British monthly journal *Philosophical Magazine*. However, it was Becquerel’s discovery that most intrigued Rutherford, and he turned his attention to studying the mysterious emanations from uranium salts.

Although Becquerel’s discovery attracted far less immediate interest than Röntgen’s, Rutherford was not the only physicist who saw the emanations’ potential. Marie Skłodowska Curie, working in her husband Pierre’s laboratory at the *École Municipale de Physique et de Chimie Industrielles* in Paris, took up the study of Becquerel’s uranium rays. She soon discovered that several materials—most famously, pitchblende—also emitted uranium rays. Curie adopted the term “radioactivity” instead of uranium rays to describe the phenomenon she was studying. In 1898 the Curies and chemist Gustave Bémont announced the discovery of two new elements, polonium (named for Marie Curie’s native Poland) and radium, both of which were hundreds of times more radioactive than uranium.

Rutherford’s “colonial appointment”

Discovery after discovery flowed from the Curies’ Paris lab, and Rutherford soon had one of his own to add. In 1898 he

demonstrated the existence of two distinct types of uranium rays, which he called “alpha” and “beta.” Alpha rays were positively charged and readily absorbed by most substances, but beta rays were negatively charged and could pass through metal unhindered. His experiment was elegant in its simplicity: He covered a piece of uranium with an increasing number of thin aluminum sheets and measured the uranium’s ability to ionize gas after each successive layer was added. The positively charged alpha rays could not pass through more than 3 layers of foil, but beta rays were able to ionize gas through more than 12.

That same year, Rutherford was hired as a professor of physics at McGill. The appointment came as something of a surprise. Despite Thomson’s enthusiastic recommendation, Rutherford knew there would be fierce competition for the job and was uncertain of his chances. McGill had one of the best-equipped research laboratories in the world, the Macdonald Physics Building (see figures 2 and 3), which received international attention when it opened in 1893 for its architecture, enviable library, expensive collection of experimental equipment, and the generous endowment of Can\$150 000 meant to pay for the building’s maintenance.⁴ “There would probably be big competition for it, all over England,” he wrote to Newton on 22 April 1898. “I think it is extremely doubtful that I will compete for it.”⁵

But McGill chose Rutherford, and for the second time in his young life, he packed up his belongings and moved to a new continent. Rutherford quickly

resumed his work on radioactivity with the help of two significant collaborators: Harriet Brooks, his first graduate student, and chemist Frederick Soddy, who joined him at McGill from Oxford University in 1900. Rutherford and Brooks began investigating the particles and rays being emitted by radioactive elements.⁶

Building on that work, Rutherford and Soddy in 1903 published a paper showing that radioactivity was the result of atomic disintegration. Old-guard physicists such as Lord Kelvin had dismissed the idea that radioactivity could change one element into another and said it was no better than alchemy. But Rutherford and Soddy convinced all but the most determined naysayers that radioactive atoms did indeed change their elemental identity after releasing alpha, beta, and gamma rays. They used the Macdonald Building’s liquid-air machine—a state-of-the-art piece of equipment available to only a handful of laboratories at the time—to cool the emanations from radium and thorium into liquids. As Rutherford and Soddy demonstrated, the liquefied emanations had different elemental identities from radium and thorium. That work earned Rutherford and Soddy each a Nobel Prize in Chemistry: Rutherford in 1908 and Soddy in 1921.

The major disadvantage of Rutherford’s job at McGill was its location. Although he found productive collaborators in Soddy and Brooks, the young physicist felt far from the centers of the physics universe. All the expensive equipment in the world was not enough to replace the sense of intellectual community he had experienced at the Cavendish—and soon both

Brooks and Soddy left Montreal for the UK. Rutherford arranged for his protégé Brooks to take a fellowship at the Cavendish Laboratory in 1901, which reflected his belief that a physicist had to work in the UK or Europe to truly matter in physics. Brooks did return to Montreal in 1903, but by that time Soddy had left for a position at University College London.

Intellectual isolation was not the only perceived drawback of Rutherford's "colonial appointment"—he also feared being beaten to the punch by the Curies. He didn't want to be just another physicist trailing the Parisian couple in the quest to learn about radioactivity; he wanted to be in the lead. A letter Rutherford wrote to his mother reveals both his competitive spirit and his desire to publish his work quickly: "I have to keep going as there are always people on my track. I have to publish my present work as rapidly as possible in order to keep in the race. The best sprinters in this road of investigation are Becquerel and the Curies in Paris who have done a great deal of very important work in the subject of radioactive bodies during the last few years."⁷

But taking the lead in a scientific race with "sprinters" like Becquerel and the Curies was difficult, and Rutherford often found himself falling behind. In November 1899, for example, he was preparing a paper for *Philosophical Magazine* outlining how radioactive thorium could induce radioactivity in other substances, a phenomenon he called "excited radioactivity." But the Curies had been working on the same phenomenon, and their work reached print first. When Rutherford's paper appeared in the February 1900 issue of *Philosophical Magazine*, it ended with a morose footnote acknowledging that the Parisians had been first to publish: "As this paper was passing through the press the *Comptes Rendus* of Nov. 6th was received, which contains a paper by Curie and a note by Becquerel on the radiation excited in bodies by radium and polonium."⁸

Being scooped was a blow to both Rutherford's career ambitions and his ego. He placed much of the blame on his location. Because he was far from where the most widely read physics journals were published, Rutherford often had to wait a month or more for his articles to cross the Atlantic Ocean and reach the editorial offices and then another month or more for those journals to send back page proofs. Those delays added up. His early work with Brooks, for example, was conducted in 1899–1900 but did not make it into print until 1902. When competing against "sprinters" like Becquerel and the Curies, who could get their manuscripts to the top-tier *Comptes Rendus de l'Académie des Sciences* in a matter of days, that simply would not do. Rutherford began searching for a way to get his work into print as quickly as possible, and he soon set his sights on

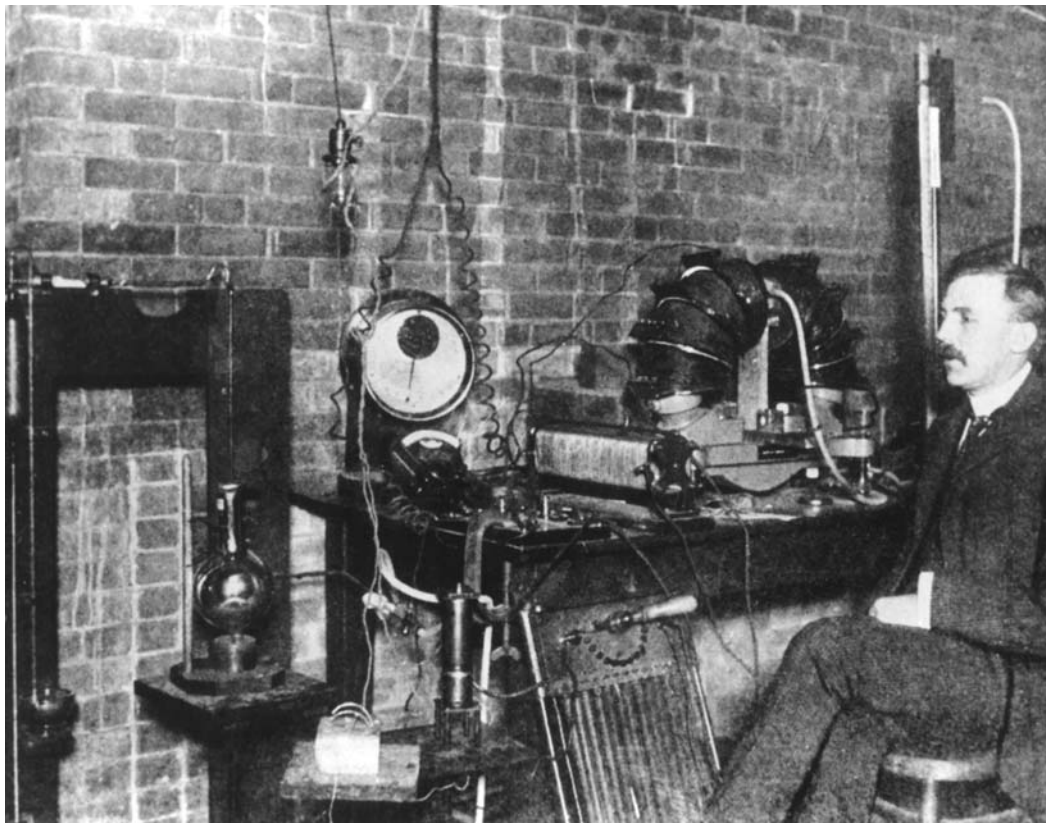


FIGURE 3. ERNEST RUTHERFORD in his laboratory in the Macdonald Physics Building at McGill University, 1905. (Courtesy of McGill University, Rutherford Museum, the AIP Emilio Segrè Visual Archives.)

one of the UK's most widely read scientific periodicals: the weekly magazine *Nature*.

Rutherford and *Nature*

In 1900 *Nature* (see figure 4) was just over 30 years old and still under the editorship of its founder, astronomer Norman Lockyer. In its first decades of existence, *Nature* had made its mark as a host for scientific disputes. The magazine's weekly publication schedule—and the speed of the 19th-century Royal Mail—made *Nature*'s Letters to the Editor column an ideal platform for arguments between scientists. British readers intrigued by a discussion in that week's *Nature* could dash off a letter, mail it to *Nature*'s London offices, and expect to see their response in print the following week. In the late 19th century, the section was filled with discussions and debates about scientific issues ranging from the age of Earth to the latest evolutionary theories.

The explosion of interest in x rays inspired *Nature*'s readers to use the column for a new purpose: the announcement of exciting new research results. Specialist weeklies like *Nature* and its competitors *The Electrician* and *Chemical News* were able to capitalize on the intense interest in Röntgen's discovery because of their publication speed. They offered researchers a forum where preliminary observations and theories about the nature of the rays could reach an audience of scientific specialists within a week of submission and thus minimize the chances that other researchers would beat them to the punch. *Nature*'s pages were soon filled with letters from physicists who had



FIGURE 4. TITLE PAGE of an issue of *Nature* from 1896, during the age of early radioactivity research. (Courtesy of the Wenner Collection, AIP Niels Bohr Library and Archives.)

tried something new with x rays and wanted to report their findings. Most famously, *Nature* printed the first English translation of Röntgen's paper and the first x-ray photograph taken in England.⁹

Prior to being scooped by the Curies in 1899, Rutherford had not contributed to *Nature*, perhaps because he had focused on publishing lengthy papers in prestigious venues such as the Royal Society's journals. That would soon change. Rutherford contributed more than a dozen short letters to *Nature* between

1901 and 1908 on subjects such as the heating effects of radioactivity, the amount of helium emanating from radium, the dependence of radioactivity on the concentration of radioactive materials, and the electrical charge on the alpha rays emitted from radium. He continued directing papers to *Philosophical Magazine* and *Proceedings of the Royal Society of London* as well, but he saved those publications for longer write-ups of his best work. Promising preliminary results were sent to *Nature* to prevent the kind of disappointment he had experienced with excited radioactivity.

Interestingly, Rutherford's desire to publish quickly did not lead him to seek out other weeklies besides *Nature*. He and Soddy coauthored a multipart article on thorium emanations¹⁰ for *Chemical News* in 1902, but after Soddy left McGill, Rutherford ceased to contribute articles to that journal, and he never became a regular contributor to *The Electrician*. That choice seems to have stemmed from Rutherford's strong sense of himself as a physicist. *Chemical News* catered to Britain's chemists; *The Electrician* aimed itself at an audience of engineers and industrial scientists. But Rutherford always considered himself a physicist, not an engineer or chemist. He was famously baffled when he received the Nobel Prize in Chemistry rather than his preferred discipline.

North American journals did not play a large role in Rutherford's publishing strategy. He did not send his work to the US weekly *Science*, which had a correspondence column like *Nature's* and whose New York editorial offices were closer to Montreal than *Nature's* London offices. He seems to have rejected the idea of publishing in Canadian journals, and he never attempted to fight the Curies on their own turf by publishing in France.

Rutherford's Britain-focused publishing strategy suggests that in addition to concerns about priority, he sought to reach a specific

national audience. Publishing in British journals retained the advantage of publishing in Rutherford's native language, English, and it also increased the likelihood that his work would be noticed by British physicists seeking a new colleague. Notably, Rutherford turned down offers of physics professorships from Victoria University College in New Zealand, the University of Western Australia, and Columbia University in New York, indicating that his goal was not simply to leave McGill but to move back to the UK.¹¹

Rutherford's choice of *Nature* shaped not only his professional trajectory but *Nature* itself. The practice of publishing quickly to secure priority was not new to science; the *Comptes Rendus*, for instance, had long been a place where French scientists could get their work into print quickly. But *Nature* was

not a major site for priority claims until x rays and radioactivity. Furthermore, Rutherford's frequent contributions took *Nature* from a journal that had been only peripheral to the world of radioactivity—little was in it about the Curies and their work, for example—to a publication that was required reading for anyone working on the topic.

Rutherford's contributions also helped expand *Nature's* international influence. In the 19th century, it was a journal by and for members of the British scientific community; it found a small audience in the US but had few subscribers in European scientific centers. Its contributors were almost entirely British. By 1910, however, physicists worldwide were reading *Nature* and sending their work to the journal. In the correspondence between Rutherford and US physicist Bertram Borden Boltwood, for example, both men frequently mentioned *Nature* as a place to print their own articles and an important source of information about others' research.

Boltwood was arguably the most important radioactivity physicist in the US at that time, and like Rutherford, he struggled with the disadvantages of being at a distance from major research centers like Paris and Cambridge. *Nature* proved invaluable as a source of pertinent abstracts and as a place to publish his work. He had a habit of sending preliminary results both to US journals and to *Nature*, as he mentioned in a 1906 letter to Rutherford: "I have sent off a brief communication to the Editor of *Nature* and a note for the December number of the *Am. Jour. [American Journal of Science]*."¹² Rutherford's letters also refer to sending early results to *Nature*; in October 1906 he wrote, "I have done a few expts. [experiments] recently which show that the emanations are completely absorbed in cocoanut [*sic*] charcoal at ordinary temperatures. . . . You will see an account in *Nature* of the same in a week or so."¹³

Other international radioactivity scientists followed Rutherford and Boltwood into the pages of *Nature*. The most notable among them was Otto Hahn, a future Nobel Prize recipient (for the discovery of uranium fission), who worked at McGill with Rutherford in 1905–6. Like Rutherford and other Anglophone colleagues, Hahn soon adopted the practice of writing to *Nature* about interesting preliminary results.

Rutherford's ambitions realized

Rutherford's publishing strategy paid off. In December 1906 he wrote to his mother to tell her that he had been offered a position in the UK: "I have received the offer of the Physics

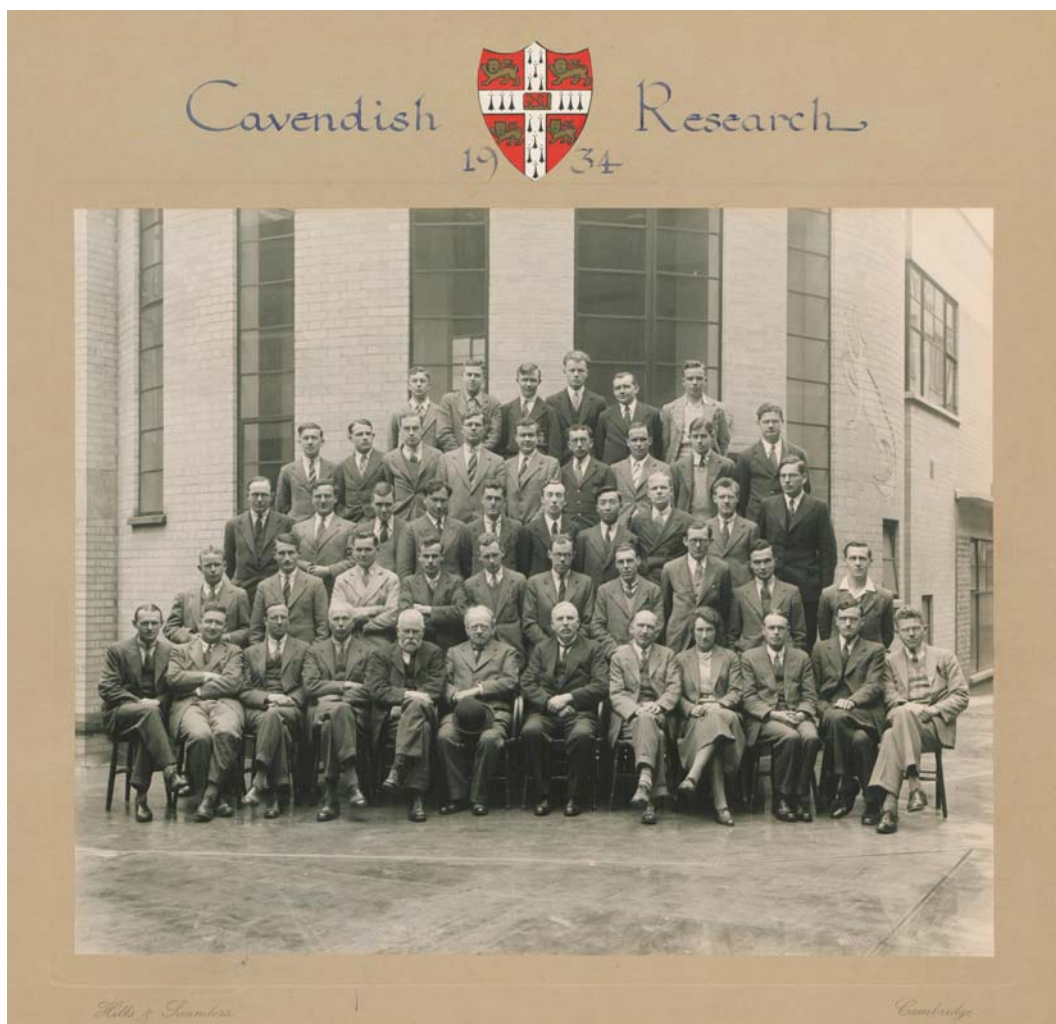


FIGURE 5. CAVENDISH LABORATORY group photo from 1934, including James Chadwick (front row, third from left), J. J. Thomson (front row, sixth from left), and Ernest Rutherford (front row, seventh from left). Photograph by Hills and Saunders, Cambridge. (Courtesy of Cavendish Laboratory, Cambridge University, the AIP Emilio Segrè Visual Archives, Bainbridge Collection.)

Chair at Manchester. I think it quite likely I shall accept. I think it is a wise move for a variety of reasons. I shall receive a better salary and be director of the laboratory and what is most important to me, will be nearer the centre of things scientifically."¹⁴

At the University of Manchester, Rutherford resumed his work on alpha particles, hoping to find a way to determine if they were composed of helium or hydrogen atoms. In 1908 he successfully trapped enough alpha particles to analyze them spectroscopically; the spectrum showed that they were indeed helium atoms, as Rutherford had long suspected. In 1908–9, Rutherford collaborated with his visiting colleague Hans Geiger and an undergraduate named Ernest Marsden to aim a stream of alpha particles at a metal foil. To their surprise, a small percentage of the particles deflected back at them rather than passing easily through the foil as they had expected. That finding led to a revolution in atomic theory. Thomson's old "plum pud-

ding" model of the atom, which depicted positive and negative charge spread evenly throughout it like raisins in a dessert, was soon replaced with the nuclear model of the atom, in which positive charge was concentrated in a dense center.

Rutherford continued serving as a mentor to young physicists while at Manchester. He tried to persuade Brooks to come to the UK with him, but she decided to remain in Montreal after marrying in 1907. His protégés at Manchester included many notable physicists, among them Henry Moseley, who discovered that each element has a characteristic atomic number; James Chadwick, who discovered the neutron; and Niels Bohr, who revolutionized atomic theory and became one of the most influential figures in quantum physics.

In 1919, after the end of World War I, Rutherford received an even more desirable offer: To return to the Cavendish Laboratory as its new director (see figure 5). He brought Chadwick with him, and the pair studied radioactive disintegration in the 1920s. Despite his deep knowledge of radioactive decay and atomic structures, Rutherford famously dismissed as a pipe dream the idea of splitting the atom. He did not live to see Hahn, Fritz Straßmann, and Lise Meitner prove him wrong; in 1937 he died unexpectedly following surgery for hernia complications.

Rutherford left behind an impressive legacy. His work on radioactivity and atomic structure helped revolutionize the way physicists understood the world, and he mentored some of the 20th century's most influential members of the field. Rutherford also shaped the landscape of scientific publishing. Following his example, scientists from diverse disciplines across the

world adopted the practice of announcing exciting results in a letter to the editor in *Nature*.¹⁵ The British weekly might not have become one of the world's most sought-after publications had it not been for Rutherford and his dream of returning to the UK.

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