My Dear Eve...

The Letters of Ernest Rutherford to Arthur Eve, 1907 - 1908

by

Montague Cohen

When Ernest Rutherford moved from McGill to Manchester University in 1907, he began an extensive but irregular correspondence with his colleague and friend Arthur Eve, a physicist who remained at McGill and later wrote the official biography of Rutherford. A collection of 37 hitherto unknown letters from Rutherford to Eve, written during the period 1907-1926, has recently been discovered at McGill. This article contains annotated transcripts of the first seven of these letters, spanning a period of 19 months (June, 1907 - December, 1908). This set includes an important letter (Dec. 22, 1908) in which Rutherford describes his visits to Stockholm (to receive the Nobel Prize) and to institutions in Berlin and Leyden. Annotated summaries of seven interleaving letters from Eve to Rutherford are included; these letters are in the Cambridge University collection.

Lorsqu'Ernest Rutherford quitta l'université McGill pour l'université de Manchester en 1907, il entama une longue correspondance, encore qu'irrégulière, avec son collègue et ami Arthur Eve, physicien demeuré à McGill qui rédigea plus tard la biographie officielle de Rutherford. Un recueil de 37 lettres de Rutherford à Eve inconnues jusqu'ici, écrites entre 1907 et 1926, a récemment été découvert à McGill. Cet article contient des transcriptions annotées des sept premières de ces lettres qui couvrent une période de 19 mois (juin 1907 à décembre 1908). Cette série englobe une lettre importante (22 décembre 1908) dans laquelle Rutherford décrit ses visites à Berlin et à Leyden. On a inclus des résumés annotés de sept lettres de Eve à Rutherford; ces lettres font partie des collections de l'université de Cambridge.

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Introduction

In May, 1907 Ernest Rutherford left Montreal to take up the post of Langworthy Professor of Physics at Manchester University in England. He was not yet 36 years of age, but had already accomplished more than most scientists achieve in a lifetime. In less than nine years as Macdonald Professor of Physics at McGill University--he arrived in Montreal in September, 1898--Rutherford had laid the foundations of the science of radioactivity, demonstrated the spontaneous transformation of one element into another and the existence of radioactive series, established the exponential law of radioactive decay, measured the properties of the alpha-particle (although the identity of the particle with the helium atom was not proven until 1908) and initiated studies which later resulted in the nuclear model of the atom. Rutherford's work at McGill earned him a Nobel Prize (in chemistry, not physics) in 1908. In addition, he left McGill as a Fellow of the Royal Society of London (1903) and a recipient of the Society's coveted Rumford Medal (1905).

General accounts of Rutherford's life and work in Montreal and Manchester may be found in the biographies by Eve[1], Feather[2] and Andrade[3]. A recent biography by Wilson[4] is the most comprehensive study of Rutherford so far published, and includes an extensive bibliography. Del Regato[5] has written a series of short biographies of Rutherford and other pioneers in radiation and atomic physics. Among the numerous specialized studies and essays on Rutherford, the reminiscences of Hahn[6], articles by Feather[7] and Shea[8], and a collection of papers edited by Bunge and Shea[9] are worthy of special mention.

Arthur Stewart Eve (1862-1948) was born in England and graduated in Physics and Mathematics at Cambridge. Eve's initial career was in teaching at the secondary level, but the published accounts of Rutherford's research inspired him to move to Canada in 1903, at the age of 41, with a view to making a new start as a research scientist. He obtained a post at McGill as a Lecturer in Mathematics and Physics and was made an Assistant Professor in the Physics Department in 1905. A photograph of the staff of the Physics Department of McGill University, taken at this time, includes both Rutherford and Eve (Figure 1).

From about 1904 onwards, Eve worked under Rutherford's guidance, carrying out many experiments in radioactivity, including measurements of the radioactivity of air, water and rocks, and investigations of secondary radiations produced by β- and γ-rays. However, Eve and Rutherford were never joint authors of a paper, unless a note added by Rutherford at the end of one of Eve's early papers (*Phil. Mag.* Ser. 6, Vol. 9, 1905, pp.708-711) is counted.*

Eve's interest in radioactivity continued long after Rutherford's departure from McGill. The two scientists became close personal friends and Rutherford formed a high regard for Eve's abilities. Indeed, Badash[10] [p. 116] noted that "When asked what was his greatest scientific discovery at McGill, Rutherford is reported to have said 'Arthur S. Eve'." Again, Otto Hahn[6] states: "During my stay in Montreal, A. S. Eve seemed closest to him of all his colleagues." Perhaps this was because Rutherford was instinctively drawn to the maturity of the older man.

In 1905 Eve married Elizabeth Brooks, younger sister of Harriet Brooks[11], who was one of Rutherford's brightest graduate students and co-author of papers published in 1901 and 1902. In a letter to his wife, dated February 11, 1905, Rutherford mentioned the "startling news" of Eve's engagement and commented "I don't know how he has managed to see much of her and have not yet seen him to gain particulars. Nobody had the slightest suspicion of the coming event. I feel we are both responsible for the event, as he would not have known the Brooks without our intermediacy." (Letter quoted by Eve[1]).

After Rutherford's departure from McGill, Eve became an Associate

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*It may be relevant to note that, in the period covered by this article, the great majority of scientific papers had but a single author, the minority two authors, and virtually none at all more than two authors.

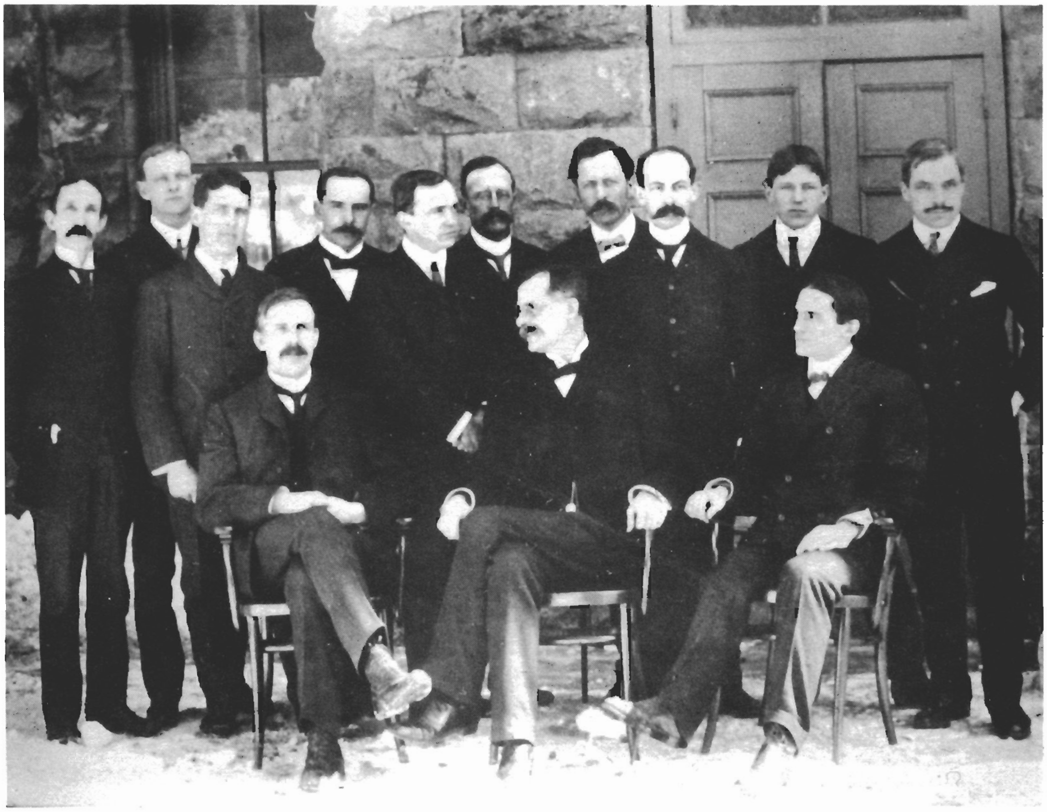


Fig. 1. Group portrait of the staff of the Macdonald Physics Building, 1904-05. Back row (L to R): L. Legrow, G. H. Cole, H. L. Bronson, T. Godlewski, A. W. Sheldon, A. S. Eve, H. M. Tory, R. K. McClung, G. Dunn, J. O. Jost. Front Row (L to R): E. Rutherford, J. Cox, H. T. Barnes. (Courtesy of McGill University Archives)

Professor (1909) and, very quickly, a Full Professor (1910). From 1919 to 1935 Eve was Chairman of the Physics Department at McGill and Dean of the Faculty of Graduate Studies (1930-35). He was elected a Fellow of Royal Society in 1917 and was President of the Royal Society of Canada from 1919 to 1930. Most important of all, for our present purpose, after Rutherford's death in 1937, Eve was asked to write the official biography, which was published in 1939 under the title *Rutherford. Being the Life and Letters of the Rt. Hon. Lord Rutherford, O. M.*[1].

The Rutherford - Eve correspondence

Both Rutherford and Eve were prolific letter writers. Indeed, this is generally true of scientists in the late 19th and early 20th centuries. This was an era of relatively slow communication: there were no air services (although trains were frequent, reliable and fast) and communication by telephone between cities, let alone between countries, was the exception rather that the rule. There was no practical alternative to the mail service for keeping in touch with relations, friends and colleagues. Fortunately, many people were in the habit of keeping private correspondence, much as nowadays we file business correspondence, and there are several collections of letters to and from Rutherford in universities and other institutions. The major collection is undoubtedly that at Cambridge University, given to the University by Mrs. Rutherford after her husband's death.

The Cambridge collection suffers the obvious disadvantage of containing primarily letters *to* rather than *from* Rutherford, the main exception being letters from Rutherford to his wife. Rutherford's own letters naturally became the property of the recipients and many have found their way into the archives of institutions in Britain, Canada, the United States, Germany, Denmark, Holland, Israel and Japan. A Catalog of the known correspondence of Rutherford was compiled by Lawrence Badash on behalf of the Center for History of Physics of the American Institute of Physics, and was published by the Institute in 1974[12]. However, it is probable that many letters written by Rutherford, not included in the Catalog, are still extant in various locations and await discovery. The present article concerns a set of such letters from Rutherford to Arthur Eve.

Some justification is needed of the term 'prolific' used above in connection with the letter-writing activities of Rutherford and Eve. The *Rutherford Correspondence Catalog*[12] lists approximately 3450 items in the period October 1895 to October 1937**. A simple calculation, assuming that half of the letters were written *by* Rutherford and the other half *to* him, yields an average of 41 letters a year in each direction, a number which scarcely merits the description 'prolific'. However, the arithmetic can be misleading. A study of the Correspondence Catalog shows that fewer than one in three of the listed letters were written by Rutherford. Furthermore, a

**The Catalog lists about 20 letters dated before October, 1895 or after October, 1937 but none of these were written by Rutherford. In addition, the Catalog includes a few items of correspondence between third parties, i.e. neither from nor to Ernest Rutherford.

breakdown of the figures into five-year periods (Table 1) reveals a marked variation in time both in the total number of letters and in the proportion originating with Rutherford. The volume of correspondence peaks in the period 1905-1920, especially the middle years 1910-1915. This was, in fact, a very important period in Rutherford's scientific career, in which he and his team in Manchester were making major advances relating to the nuclear atom. The 1920's were relatively unproductive, but the volume of correspondence increased again in the 1930's.

In the pre-1900 period, the proportion of the extant correspondence written by Rutherford himself is very high. This was the time when he wrote regularly to his mother and his fiancée, Mary Newton, in New Zealand and they were wise enough to preserve his letters for posterity. After 1900 the "Rutherford fraction" falls drastically, averaging only 25% between 1900 and 1920. After 1920 the proportion rises again, to an average of about 40% for the remainder of Rutherford's life (Table 1). This change in the "Rutherford fraction" calls for some explanation.

The simplest explanation of the low "Rutherford fraction" is that Ernest Rutherford received considerably more letters than he wrote - in other words that he did not reply to a high proportion of the incoming letters and/or did not himself initiate correspondence. However, the available evidence points in the opposite direction. One of Rutherford's most faithful correspondents was the American chemist Bertram Boltwood. An annotated edition of the Rutherford/Boltwood correspondence, covering the period 1904-1933, was prepared by Lawrence Badash and published in 1969[10]. This volume contains about 150 letters, 90 of which were written *by* Rutherford. Indeed, at one stage (November 20, 1911) Rutherford was moved to open his letter as follows: "I have come to the conclusion that getting a letter out of you is like pulling your best tooth, for I think I have sent two or three without even the courtesy of a reply."

In the case of the Rutherford/Eve correspondence which is the subject of the present article, the flow seems to have been about the same in each direction, although the Catalog entries are overwhelmingly in favour of Eve.

The clue to the problem of the "missing" Rutherford letters is probably to be found in a comment by Professor Norman Feather[12], who noted that one of Rutherford's characteristics was that he very rarely destroyed any document, however trivial its contents. "From his early days as a research student, to his last years as Cavendish Professor, a great bulk of material has been carefully preserved: almost the whole of his personal correspondence, it must be presumed, and all his notebooks and papers." Feather also stated that (at least in his later years at the Cavendish), Rutherford received many letters from "misguided persons who imagine that they have made some startling discovery or that they have discovered some flaw in commonly-accepted arguments." Feather noted that Rutherford almost always acknowledged these letters briefly but kindly and "occasionally he put himself to considerable trouble to do his best to satisfy these people that he was not treating them as beneath consideration." If this was Rutherford's attitude towards strangers, it is inconceivable that he would neglect his friends and colleagues.

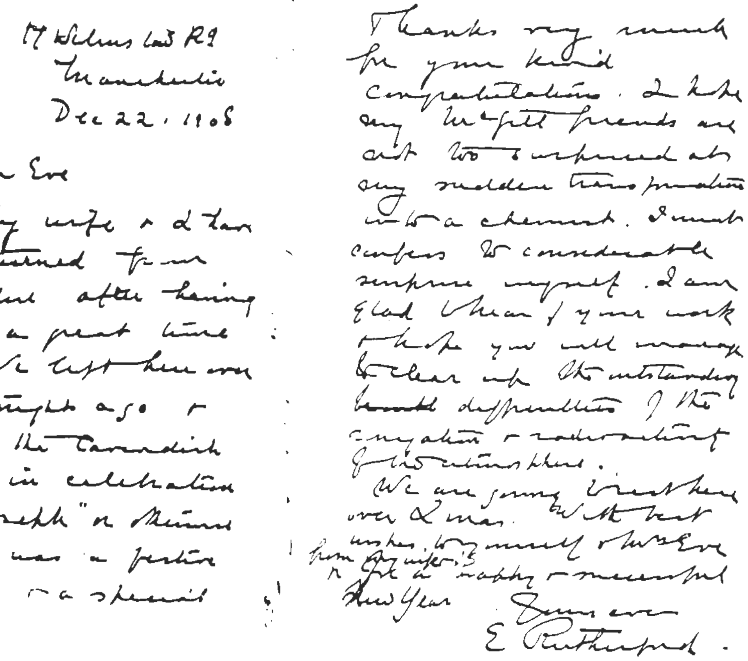
The most probable explanation of the imbalance in the rates of incoming/outgoing letters is that many of Rutherford's correspondents did not share his habit of preserving everything. We must conclude from Table 1 that at least 1000, and possibly up to 1500, letters written by Rutherford have either been destroyed or - knowingly or unknowingly - are in private hands such as the offspring of the original recipients and are unavailable to scholars. The increase in the proportion of extant Rutherford letters in the latter half of his career presumably reflects the fact that a personal letter from someone of Lord Rutherford's stature and fame was too valuable a commodity to be mislaid or destroyed. It is hoped that the present publication of the first seven of a set of 34 hitherto uncatalogued letters from Rutherford will encourage others to search for the "missing" letters- those that have not been destroyed - and to transfer them to the public domain.

It is reasonable to conclude that, throughout his adult life, Rutherford wrote each year between 30 and 150 personal letters, many of which included some discussion of his own and/or his respondent's scientific investigations. This writing was in addition to his published papers, books, popular articles and lectures, as well as routine office correspondence. This output surely merits the description 'prolific.'

The Nature of the Letters

The letters written by Rutherford and Eve are in no sense literary masterpieces and they must not be judged purely on their literary merit. On the other hand, they are readable, by and large grammatical and avoid repetition. The punctuation tends to be erratic, but rarely to the extent of obscuring the meaning. All of this fits a picture of personal letters composed fluently but hastily, with few corrections or afterthoughts. Up to about 1911 Rutherford wrote his letters by hand and his handwriting was not easy to decipher, even for his contemporaries (see, for example, Figure 2). In 1910 Rutherford began to use an 'amanuensis' (a person who writes from dictation or copies manuscripts), probably his wife. In a letter to Boltwood, dated 27 September, 1910, Rutherford comments "You will see how my handwriting has improved. My amanuensis is responsible." Boltwood replied (2 November, 1910), "The effect of your amanuensis on your handwriting is certainly wonderful. It adds a new pleasure to the receipt of your letters, that of being able to read them on the first trial." (See note 10, pp. 228, 231). Evidently Rutherford's amanuensis was not always available, since his letters to Eve of 30 September, 1910 and 20 October, 1910 are in his own handwriting. However, he soon acquired a typewriter and from 14 June, 1911 onwards all of Rutherford's letters to Eve were typewritten, apart from a few handwritten insertions (where the typist was unsure of a word) or additions. Eve's handwriting (Figure 3) was somewhat more legible than Rutherford's, although it varied from letter to letter to a surprising extent, both in style and in size. Eve wrote by hand throughout the period covered by this article (1907-1908) and for several years thereafter.

As already indicated, the letters are a mixture of personal news, news of colleagues and mutual acquaintances (even a little gossip) and science. These ingredients are thrown together in no particular order and the science



17 Wilmslow Rd
Manchester
Dec 22. 1908

My dear Eve

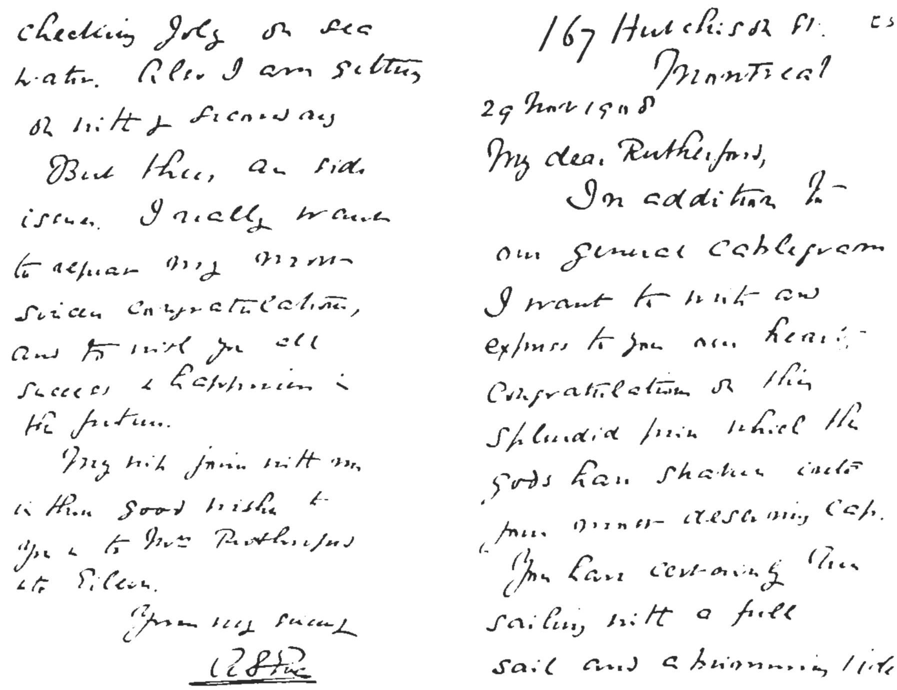
My wife & I have just returned from Stockholm after having had a great time of it. We left here over a fortnight ago & attended the Cavendish Dinner in celebration of "Sir Joseph" or "Mr J.J." It was a festive occasion & a special

Thanks very much for your kind congratulations. I hope my McGill friends are not too surprised at my sudden transmutation into a chemist. I must confess to considerable surprise myself. I am glad to hear of your work & hope you will manage to clear up the outstanding difficulties of the emanation & radioactivity of the atmosphere.

We are going to rest here over Xmas. With best wishes to yourself & Mrs Eve from my wife & I for a happy & successful New Year

Yours ever
E Rutherford.

Fig. 2. First and last pages of letter (R-6) from Rutherford to Eve, dated December 22, 1908.


167 Hutchison St.
Montreal
29 Nov 1908
My dear Rutherford,
In addition to
our general cablegram
I want to write and
express to you our hearty
congratulations on this
splendid prize which the
gods have showered onto
your over-deserving cap.
You have certainly been
sailing with a full
sail and a brimming tide

checking Joly on sea
water. Also I am getting
on with Ionization
But these are side
issues. I really want
to repeat my own
sincere congratulations,
and to wish you all
success & happiness in
the future.
My wife joins with me
in these good wishes to
you & to Mrs Rutherford
& to Eileen.
Yours very sincerely
A S Eve

Fig. 3. First and last pages of letter (E-7) from Eve to Rutherford, dated November 29, 1908. (Courtesy of the Syndics of Cambridge University Library)

component is often embedded, as it were, in other material. What is more important is the relationship between the two men revealed in the letters. At the personal level they were equals; indeed, Rutherford sought Eve's advice on financial matters relating to his investments in Montreal. At the scientific level, however, the discussion does not give the impression of an exchange of views beween equals. Although Eve was nine years older than Rutherford, this was not reflected in their scientific careers and Eve seems to have remained, in effect, Rutherford's junior colleague. In their correspondence, Eve reports his results and seeks Rutherford's comments and advice, but not the other way round. Rutherford *tells* Eve about his scientific work, but in a manner which does not invite comment. From the scientific point of view, the correspondence between Rutherford and Boltwood[10] is more enlightening than that between Rutherford and Eve.

One of the minor mysteries of the Rutherford-Eve correspondence is why Eve made so little use of it in his biography of Rutherford[1]. The volume includes many extracts, some quite extensive, of letters both to and from Rutherford - indeed, as already noted, the title of the biography specifically refers to Rutherford's letters. However, while there are many indirect references to the letters from Rutherford to Eve, there is only one direct quotation, from a letter written by Rutherford shortly before his death in 1937. The omission was no doubt intentional: thus, although Rutherford's description of the Nobel cermony in his letter to Eve of December 22, 1908 (letter R-6) was far more graphic than the corresponding account written to other friends and colleagues, Eve chose to quote from Rutherford's letter to Hahn rather than transcribe the description in his own possession. It may be that Eve considered it "ungentlemanly" to take advantage of correspondence addressed directly to himself.

Finally, it is worth mentioning that the two men were never on first-name terms. It was always "My dear Eve" or, occasionally, "Dear Eve" and similarly, "Dear Rutherford". The closing signatures are "E. Rutherford" and "A. S. Eve". The letters usually include family greetings to "Mrs. Eve" or "Mrs. Rutherford," and the spouses are invariably referred to as "my wife" or "Mrs. R", never by name. Rutherford's son-in-law, Ralph Fowler (who was later appointed Plummer Professor of Mathematical Physics at Cambridge) is always simply "Fowler". Only Rutherford's daughter, Eileen (1901-1930) is referred to by her first name. Was this a personal idiosyncrasy or merely a reflection of the times? Almost certainly the latter: the use of the surname between close male friends and colleagues was a peculiarly British custom which persists to this day, albeit in much diluted form. Indeed, the use of the surname alone was considered a sign of friendship, in contrast to the more formal use of a title such as "Mr" or "Professor." Mrs. Rutherford, however, did not follow this male convention. There is no surviving example of a letter from Mary Rutherford to Arthur Eve, but several of her letters to Boltwood are included in the Rutherford-Boltwood correspondence[10]. She refers to her husband as "Ern" and signs herself "Mary Rutherford".

Arrangement of Letters in this Article

The McGill collection of correspondence between Rutherford and Eve comprises 34 letters from Rutherford to Eve spanning the period 11 June, 1907 to 11 December, 1915. In addition there are four letters, dated 13 April, 1919, 29 December, 1920, 4 May, 1926 and 6 May, 1933 which have to be considered in isolation. Finally there are two postcards mailed in France in March and April, 1912. The collection is part of the correspondence of Arthur S. Eve (which includes letters to Eve from W. H. Bragg, Frederick Soddy, Otto Hahn and others) found in the Macdonald Physics Building of McGill University when the building was gutted in the 1970's and transformed into a library. The letters are now in the McGill Archives. Only the 1933 letter is listed in the *Rutherford Correspondence Catalog*[12].

Interleaved with the letters from Rutherford to Eve are Eve's letters to Rutherford. The Catalog lists 47 such letters, plus one from Eve to Mrs. Rutherford, dated from 8 July 1907 to 2 June 1930. In the period up to the end of 1915, covered by the set of 34 Rutherford letters mentioned above, there are 35 letters from Eve to Rutherford, pointing to a one-to-one exchange between the two men. The letters from Eve are part of the collection in the Cambridge University Library and quotations from these letters are given here by permission of the Syndics of the Library.

The present article is concerned with only the first seven of the Rutherford letters, covering the period from June 1907 to December, 1908 and designated here as R-1 to R-7 (see Table 2). An appropriate end-point for this sub-set is Rutherford's long letter of 22 December 1908 in which he describes the Nobel ceremony in Stockholm and his subsequent visits to laboratories in Germany and Holland. However, there is a short follow-up letter (27 December 1908) in which Rutherford congratulates the Eves on the birth of their second child. This letter (R-7) is included so that we can bring the story to the end of 1908. These letters are all transcribed in full, with separate explanatory notes.

The interleaving sub-set of seven letters from Eve to Rutherford (designated E-1 to E-7) covers the period 8 July 1907 to 29 November 1908. These letters are not transcribed in full, since they are already in the public domain in the Cambridge collection. However, each letter is summarized with direct quotations as appropriate. The summaries also include comments and explanations corresponding to the notes appended to the Rutherford letters but woven into the texts of the resumés. Thus the sub-set of 14 letters constitutes a reasonable complete and coherent series. It should be noted that the numbers of the Eve letters in this article do not correspond to those in the Cambridge University Library where the first letter from Eve (our E-1) is E-26. (E-1 to E-25 in the Cambridge collection refer to letters from other correspondents with surnames beginning with E.)

Annotated transcripts of the remaining letters from Rutherford to Eve in the McGill collection are being prepared for publication at a later date.

Introduction Notes

1. Eve, A. S. *Rutherford. Being the Life and Letters of the Rt. Hon. Lord Rutherford, O. M.* Cambridge: Cambridge Univ. Press, 1939.

2. Feather, N. *Lord Rutherford.* Rev. ed. London: Priory Press, 1973.

3. Andrade, E. N. da C. *Rutherford and the Nature of the Atom.* New York: Doubleday, 1964.

4. Wilson, D. *Rutherford. Simple Genius.* Cambridge, MA.: MIT Press, 1983.

5. del Regato, Juan A. *Radiological Physicists.* New York: American Institute of Physics, 1985. Chapter 4: "Ernest Rutherford."

6. Hahn, O. "Some Reminiscenses of Professor Ernest Rutherford during his time at McGill University, Montreal." *The Collected Papers of Lord Rutherford of Nelson.* Ed. Sir James Chadwick. London: Allen and Unwin, 1962. I: 164-68.

7. Feather, N. "Rutherford at Manchester: an Epoc in Physics." *The Collected Papers of Lord Rutherford of Nelson.* Ed. Sir James Chadwick. London: Allen and Unwin, 1963. II: 15-33.

8. Shea, W. R. "Introduction: From Rutherford to Hahn," *Otto Hahn and the Rise of Nuclear Physics.* Ed. W. R. Shea. Dordrecht: Reidel Pub. Co., 1983. 1-18.

9. Bunge, M., and Shea, W. R., eds. *Rutherford and Physics at the Turn of the Century.* New York: Dawson and Science History Publications, 1979.

10. Badash, L. ed. *Rutherford and Boltwood. Letters on Radioactivity.* New Haven: Yale University Press, 1969.

11. Morgantaler, G. "McGill alumnae through the decade: Part II. Harriet Brooks-Pitcher." *McGill News*, 64.4 (1984): 20.

12. Badash, L. *Rutherford Correspondence Catalog.* New York: American Institute of Physics, 1974.

TABLE 1

ANALYSIS OF LETTERS IN *RUTHERFORD CORRESPONDENCE CATALOG*

	Letters**		
Period*	Total	From E. R.	% from E. R.
1895-1900	102	72	71
1900-1905	181	38	21
1905-1910	627	180	29
1910-1915	853	183	21
1915-1920	533	152	29
1920-1925	296	127	43
1925-1930	232	89	38
1930-1935	367	130	35
(1935-1937)	(207)	(98)	(47)
Total	3389	1069	31

Rutherford Correspondence Catalog, see Introduction, note 12.

* 1 October - 30 September

** Excluding correspondence between 3rd parties, i. e. neither from nor to Ernest Rutherford.

TABLE 2

The McGill Collection of Rutherford - Eve Correspondence

Section I: 11 June, 1907 - 27 December, 1908

	Rutherford to Eve		Eve to Rutherford
R-1	11 June, 1907		
R-2	4 July, 1907		
		E-1	8 July, 1907
R-3	20 July, 1907		
		E-2	21 July, 1907
R-4	5 September, 1907		
		E-3	24 November, 1907
		E-4	10 December, 1907
R-5	21 December, 1907		
		E-5	29 March, 1908
		E-6	4 November, 1908
		E-7	29 November, 1908
R-6	22 December, 1908		
R-7	27 December, 1908		

R-1

Manchester
June 11, 1907

My dear Eve

I was very glad to get your letter[1] and to hear all was going well with you. The amount of thorium[2] in the air was certainly surprising. It will help to account for the divergence between the amount of emanation[3] & amount of ionization in the air[4]. The curves are good enough to leave no doubt that it is thorium but it is certainly extraordinary how much gets up in the atmosphere[5].

I have been in Manchester since my arrival & have got pretty well settled down in the Lab. I have rigged up the emanation electroscope[6] & my actinium solution and hope to get a reading of all of them this week. I found the lab had no reading microscopes suitable for electroscopes, so got a couple at once from Pye[7] at two days' notice. This is one of the advantages of living in a civilized country. The lab seems pretty good and with the help of a grant of £150 for radioactive apparatus, I think I shall be able to start off in good shape in October. The lab itself has only a small workshop with a few lathes & the janitor does ordinary small work. Just alongside, however, is a regular workshop under the charge of Cook -formerly Dewar's[8] assistant in the Royal Institution, which has a contract with the University for all work at a moderate price. This, I think, will prove invaluable as not only is he skilled in all pressures and big work but has three or four first class mechanics to turn in work in a hurry. He made me an α-ray electroscope which has an extraordinarily small natural leak, so I have hopes to avoid all contamination in his shop - I made a γ -ray electroscope of moderately low leak. Also, by the way, my emanation electroscope when refitted up gave .16 divs natural leak - it was .15 in Montreal, so you see there is a fate about the numbers. We have a first class glassblower round the corner, also a tinsmith alongside, while the Chem Lab keeps a glass shop where almost anything can be got in a few minutes - so I think I am pretty well fixed for getting things together quickly.

I am starting a piece of work with Petavel[9] this week. He is an explosion expert. We are going to explode a bomb with cordite with emanation in it. The max temperature reached will be over 2000° C & pressure over 1000 atmospheres. I don't expect any change but it gives us a maximum at one bang. The weather has been pretty wet so far but one or two really fine sunshiny days. I find the atmosphere good to work in and it appears to agree with me pretty well. Everybody seems jolly & anxious to help and I find a most enjoyable absence of convention. In fact, it is better in that respect even than Montreal - I have been out a good deal. I run down to London next week where my wife is at present located with her mother. Schuster[10] has been away on the continent but returns at end of this week. I haven't heard anything definite about the John Harking Fellowship & your sister-in-law[11] but think it is alright. I will not know till Schuster returns. There are two Germans in the Lab & one Japanese - the latter came to work with me but came before I arrived. The staff of the Lab seems pretty efficient & hardworkers. Stansfield's[12] mother is one of the number. He is working on an Echelon grating.[13]

Give my kind regards to Mrs Eve. Let me hear when you intend to publish your results on the charcoal etc.[14]

Yours ever

E Rutherford

R-1 Notes

1. The letter from Eve referred to by Rutherford is missing from the Cambridge collection and must be presumed lost.

2. Thorium is a naturally-occurring radioactive element whose disintegration results in a 'chain' of elements known as a 'radioactive series.' The disintegration of each member of the series gives rise to the next element in the chain, until finally a stable form (isotope) of lead is obtained. Other naturally-occurring radioactive series are headed by uranium and actinium.

3. 'Emanation' refers to the inert radioactive gas, now called radon, which is produced by the disintegration of radium. Each of the three natural radioactive series (note 2) includes a different isotopic form of radon. Radon-222, in the uranium series, is the most important.

4. The ionization of the air was measured by observing the discharge of a gold-leaf electroscope (see note 6) and was found to be larger than could be explained by the diffusion of radon (emanation) from radium in the earth's crust. The difference was thought to arise from the penetrating radiation (γ Rays) emitted by radioactive impurities in terrestial rocks, but the existence of a third component, cosmic radiation from the sun and stars, was unknown at the time.

5. In the absence of Eve's letter, the precise meaning of the whole paragraph is unclear. Eve published this work in the December 1907 issue of the *Philosophical Magazine* (Eve, A. S.: "On the amount of radium emanation in the atmosphere near the earth's surface," *Phil. Mag.*, Ser. 6, 14 (1907): 724-733), but neither in this nor in earlier papers by Eve on the same subject (*Phil. Mag.*, Ser. 6, 12 (1906): 189-200 and 13 (1907): 248-258), nor in a subsequent paper (*Phil. Mag.*, Ser. 6, 16 (1908): 622-632) is thorium even mentioned. However, in a paper on a related topic (Eve. A. S. and McIntosh, D.: "The amount of radium present in typical rocks in the immediate neighbourhood of Montreal," *Phil. Mag*. Ser. 6, 14 (1907): 231-237), Eve and his co-author discuss the fact that the measured radium content of typical rocks is much more than is required to account for the temperature gradient of the earth. They suggest that "radiothorium must be distributed in the earth, both widely and in considerable quantity, for the active deposits of thorium have been found in the atmosphere in most places where an attempt has been made to discover them. The fact is the more remarkable because the thorium emanation decays so rapidly [half-life 58

seconds] that only a minute proportion of it can escape from the soil into the air." However, in a letter dated July 21, 1907 (E-2 in this series), Eve comments that he has been unable to find thorium in rocks, even "likely rock...it ought to be there and measurable."

6. The gold-leaf electroscope was a standard method of measuring ionizing radiation, utilizing the ability of x-rays and the rays emitted by radioactive materials (α, β and γ) to induce a small electric current in air. The electroscope comprises a strip of gold foil fixed at one end to a rod which is mounted in a box (with a window for observation) and isolated from its surroundings by a block of electrically insulating material. When the rod is given an electric charge, by touching it with a piece of ebonite previously rubbed with fur, the charge is shared between the rod and the gold foil and the free end of the foil moves away from the rod by electrostatic repulsion. In a well-constructed instrument the foil remains in the charged (deflected) position for a long time, except for a small natural 'leak', but radiation causes the leaf to fall back to the rod at a steady rate proportional to the intensity of the radiation. This rate is measured by observing the passage of the foil across a scale by means of a microscope.

7. W. G. Pye and Co., of Cambridge, was (and remains) an important British manufacturer of scientific instruments and later of electronic equipment and appliances. Pye-Unicam is now part of the Philips group.

8. James Dewar (1842-1923) held the posts of Jacksonian Professor of Natural Experimental Philosophy in Cambridge (1875) and Fullerian Professor of Chemistry at the Royal Institution in London (1877). His major work was the investigation of the properties of matter at temperatures approaching absolute zero. He liquified oxygen for the first time in 1878 and invented the double-walled vacuum flask ('Dewar flask') in 1892.

9. Joseph E. Petavel was an engineer/physicist at Manchester who investigated the properties of gases at high temperatures and pressures. He became Professor of Electrical Engineering at Manchester in 1908. At question here is the effect, if any, on the rate of radioactive disintegration of changes in the physical and chemical state of the radioactive material. By this time it was reasonably clear - but not yet completely certain - that such changes have *no* effect on radioactive properties. Rutherford now wished to subject emanation (radon) to extremes of pressure and temperature not previously investigated. The (negative) results of the Rutherford/Petavel experiments were presented at the meeting of the British Association at the end of July, 1907 (see also letter R-3. An abstract of the paper presented by Rutherford and Petavel was given in the *British Association Report* of August 1907, pp. 456-7, and is reproduced in *Rutherford's Collected Papers, Vol. II.* (See Introduction, note 7), but the full paper was apparently never published. The reason for the absence of temperature/pressure effects is, of course, that radioactivity is a *nuclear* phenomenon, but the nuclear atom had not yet been postulated.

10. Arthur Schuster (1851-1934) was Rutherford's predecessor as Professor of Physics at Manchester University, a post he held from 1888 to 1907, when he offered to resign on condition that Rutherford would be his successor. Schuster's wide-ranging interests in physics included terrestial magnetism,

spectroscopy and radioactivity.

11. Eve's sister-in-law was Harriet Brooks, the elder sister of Mrs. Elizabeth Eve and a former research student and co-author of Rutherford. At the time she was working in Paris under Madame Curie and it seems that, later in 1907, she resigned the Harking Fellowship which would have enabled her to work in Manchester under Rutherford. Instead she returned to Montreal and married Frank Pitcher, a former Demonstrator in the Macdonald Physics Building of McGill. Rutherford disapproved of both the resignation and the marriage. Geoffrey Rayner-Canham of Grenfell College, Newfoundland, has informed me that he has seen a copy of Harriet Brooks' marriage certificate which indicates that she and Frank Pitcher were married in London, England, not Montreal.

12. Herbert Stansfield was a Research Fellow (later a Demonstrator and Assistant Professor) at Manchester University. The implication in Rutherford's letter is that Eve also knew Stansfield, presumably because the latter had been a graduate student at McGill, but no proof of this has come to light. (Herbert Stansfield should not be confused with Alfred Stansfield, who was Professor of Metallurgy at McGill from 1901 to 1936. The reference to Stansfield in Rutherford's letter would make good sense if Alfred were meant, since he was known to both Rutherford and Eve, but Alfred Stansfield does not fit the further reference to the echelon grating.)

13. An echelon grating is a device which utilises diffraction to disperse light into its component wavelengths, for spectroscopic purposes. See H. Stansfield, *Phil. Mag.*, Ser. 6, 18 (1909): 371-396.

14. This refers to Eve's experiments in which radon, a radioactive gas (emanation) in the atmosphere, is absorbed in charcoal by drawing air through charcoal-filled tubes. The emanation is subsequently released by heating the tubes (See subsequent correspondence.)

R-2

University
Manchester
July 4 1907

My dear Eve

Just a line to tell you I am forwarding to you as a present one of Phillips' electric chargers for electroscopes to be sent on to you by A. E. Cossor[1] of Farringdon Rd, London. It depends on the electrification of celluloid by flannel[2], but for details see instructions sent with apparatus. Kindly accept the same from me as a radioactive present. It will, I am sure, delight your heart and will result in the immediate banishment of all sealing wax[3]. It works like a charm in Manchester weather anyway.

My wife is in London where I spent a week some days ago. I return to London in a few days and then go off to Cornwall and Devon with an interval for the British Ass[ociation][4].

We are all well and flourishing and I have got some work well in hand.

This is only a note as I am clearing off areas of correspondence. I hope Mrs Eve and yourself are well and I am expecting to hear good news from you directly.

Yours ever

E Rutherford

R-2 Notes

1. The instrument firm of A. E. Cossor later manufactured radio sets and other electronic equipment. Cossor Electronics Ltd is now part of the Raytheon group.

2. The charging of an electroscope (see R-1, note 6) was a difficult procedure since it depended on the production of an electrostatic charge by manual rubbing of one material by another. The apparatus which Rutherford sent to Eve was still hand operated, by turning a handle, but the pieces of celluloid and flannel were mounted on the machine and the charging procedure could therefore be more readily controlled.

3. It is doubtful if the reference to 'sealing wax' means that Eve employed sealing wax for electrostatic charging. It is more likely that Rutherford was using 'sealing wax' as a term for any makeshift or unreliable procedure carried out with equipment held together by string and sealing wax.

4. The annual meeting of the British Association for the Advancement of Science was held in Leicester at the end of July, 1907 (see letter R-3).

<u>E-1 Eve to Rutherford</u>

167 Hutchison Street, Montreal, 8 July, 1907

In this first surviving letter to Rutherford, Eve announces the birth of his first child, Joan, a "first class baby ... she has a good head of hair, cries lustily, weighs 7-3/4 lbs and seems very vigorous." He continues: "We are glad to think that we shall soon see Harriet (see R-1, note 11) and that she will live in Montreal. I am looking forward to making Pitcher's acquaintance." Harriet Brook's fiancé, Frank Pitcher, was a Demonstrator in the Macdonald Physics Building from about 1897 to 1901, corresponding to Miss Brook's own period of Physics research at McGill. However, Pitcher had left McGill before Eve's arrival in 1903, and it seems that the two men had never met. In 1907 Pitcher was employed by the Montreal Water and Power Company. The marriage must have taken place shortly after Harriet's return to Montreal since, in his letter of September 5, 1907 (letter R-3), Rutherford sent his regards to "Mrs. Pitcher".*

Finally, in this short letter, Eve states "I have my Carbon tubes well calibrated now, so I can swear to them. I shall pull air through for a month or two more I expect. I can only get 5 "run" & "rest" per month, at best." The carbon tubes referred to were iron pipes 37 cm long and 4 cm in diameter, each containing 220 grams of finely divided charcoal prepared from the shells of coconuts. Air was drawn through the tubes at a slow rate for 3 - 4 days (the "run" procedure) and the emanation in the air was trapped in the charcoal. Heating the tube released the emanation, the radioactivity of which could then be measured. The tubes were then allowed to "rest" for 3 days. after which they were re-heated; the radioactivity of the gas released after the resting period provided a baseline measurement. The method was described in Eve, A. S.: "On the amount of radium emanation in the atmosphere near the earth's surface, " *Transactions of the Royal Society of Canada*, 4.3 (1907): 19-23; and subsequently in *Phil. Mag.* (see letter R-1, note 5).

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*See, however, "Note added in proof," note 11 of R-1.

R-3

The Victoria
University of Manchester
July 20, 1907

My dear Eve

Congratulations for you both on your accession to the dignity of parentage.[1] You will find a child in the house the most satisfying of all possessions. So speaks one who is old in experience.[2]

I sent your letter on pressure to Nature where it appears this week with one of Schuster.[3] The latter had already been working a year on the subject, so I let him know of your intended publication in time for the letters to appear together. It was only fair under the circumstances. You will see also a letter from Ramsay[4]. He seems quite confident of most of the results but they will certainly want repeating to be sure of them.

I want you to do a small job for me. The enclosed P.O.O.[5] arrived for me from Montreal. I don't see how to collect it personally but would be obliged if you would do so. An enclosed paper gives you power of attorney to do so. Please forward me a cheque for the same to the Univ. Manchester. I hope you will be able to manage it for me.

We are at present at Mullion Cove[6] in a cottage all to ourselves. The party includes Mrs. Newton[7], Charlie[8] & my family and another visitor besides. We are having a jolly time with beautiful weather. I find the golf links are two miles off - much too far for an unenergetic man like me to walk in hot weather.

I go to the B. A.[9] at Leicester on July 30 & then return to Mortehoe[10] for another three weeks vacation; then on to Manchester for work. By the way J. J.[11] has a man working on the amount of emanation in the air by the carbon method! You had better send him a copy of the R. S.[12] paper as a cocktail!! With kind regards to Mrs. Eve.

Yours ever

E. Rutherford.

R-3 Notes

1. Eve had just sent the news of the birth of his first child, Joan (see letter E-1)

2. Rutherford's only child, Eileen, was born in March 1901 and was now six years of age.

3. "The effect of pressure on the radiation from radium," separate letters (under the same title) by Arthur Schuster (see R-1, note 10) and by A. S. Eve and Frank D. Adams. (*Nature* 18 July 1907: 269.) The letters concluded that a pressure of up to 2000 atmospheres (Schuster) or 3.2 x 10^5 lb/sq. inch (Eve and Adams) had *no* observable effect on the rate of disintegration of radium and its products.

4. Sir William Ramsay (1852-1916), a Professor of Chemistry at University College, London, was the discoverer of the rare noble gases in the atmosphere. He was awarded the Nobel Prize for Chemistry in 1904. A letter from Ramsay, headed "Radium emanation," appeared on the same page of *Nature* as the letters from Schuster and Eve (see note 3 above). In this letter Ramsay claimed that radium emanation, already known to produce helium (the α - particle is the nucleus of the helium atom) could, under some circumstances (e.g. if the emanation is dissolved in water or in a solution of copper sulphate), produce various other elements, including argon and neon, by a "decomposition" process. However, Rutherford and his associates were highly skeptical of Ramsay's work in the field of radioactivity and the subsequent development of the subject showed that their skepticism was justified.

5. Post Office Order. Presumably a Canadian postal order was not negotiable in England; it was not equivalent to a modern International Money Order.

6. Mullion Cove is on the south coast of Cornwall, near the southernmost point (Lizard Point) of England.

7. Rutherford's mother-in-law.

8. Charles Newton, brother of Mrs. Rutherford; a medical student at Edinburgh.

9. British Association for the Advancement of Science.

10. Mortehoe is a village near Ilfracombe on the north coast of Devon. Although Rutherford writes that he will "return" to Mortehoe, this is in fact a different place, in a different region, from his previous holiday location at Mullion Cove.

11. Sir J. J. Thomson, Director of the Cavendish Laboratory at Cambridge. (See R-6, note 2)

12. The initials "R. S." in Rutherford's letters usually stand for the Royal Society (of London). Here, however, Rutherford means the Royal Society of Canada, specifically the paper published in the *Transactions* of the Society in June, 1907 (see letter E-1). These transactions were probably not readily available in Cambridge, and the subsequent paper on the same subject was published by Eve only in the December, 1907 issue of the *Phil. Mag.* (see R-1, note 5). The (up to now) unnamed researcher in the Cavendish Laboratory published his results a year later and revealed that he had not simply copied Eve's technique of absorbing the emanation in charcoal, but had also condensed the gas by means of liquid air. (John Satterley: "The amount of radium emanation in the atmosphere." *Phil. Mag.* Ser. 6, 26 (1908): 584-615.)

E-2 Eve to Rutherford

167 Hutchison Street, Montreal, 21 July 1907

Eve begins by stating that the charger sent by Rutherford (see R-2) has arrived and "works admirably. I am delighted with it. I am going to try & make something of the same sort or a larger scale for charging my wires. The Whimshurst won't work in the summer and the dry piles have not yet come. I thought a water motor and wheel and piston might do well. I am surprised at the amount of charge the little charger can put up."

The phrase "charging my wires" refers to Eve's investigations "On the radioactive matter present in the atmosphere," *Phil. Mag.* Ser. 6, 10 (1905): 98-112. (For references to subsequent papers by Eve on this topic, see R-1, note 5.) Eve collected the emanation from the air of a closed vessel by means of an insulated, negatively-charged wire located in the middle of the vessel. The potential of the wire was about -10,000 volts, obtained by means of a Whimshurst machine driven by an electric motor. The vessels used included an iron tank in the Engineering Building at McGill University and a zinc cylinder placed out-of-doors on the McGill Campus, away from any building. A Whimshurst machine is a device for producing an electric charge by friction and accumulating the charge, so as to build up a high potential, by induction. The machine does not function well in the humid atmosphere of a Montreal summer. "Dry piles" are now called "dry batteries" or simply "batteries," as distinct from the wet batteries (lead-acid rechargeable cells) commonly used in laboratories at the time.

Eve's letter continues: "I am getting such big catches of emanation now. I am bubbling thro' very slowly for 3 days to make dead sure it is not impurity. I am getting more than the big gun on the campus gave. I do not know why there should be more, unless some thunder rains bring up the emanation." (The "big gun" presumably refers to the zinc cylinder discussed above.)

The letter concludes with a discussion of Eve's plans to measure the radioactivity of local rock: "Adams and I are trying to coax McIntosh into testing 20 Laurentian rocks. I am ready to do the electroscope work but the chemical work is rather tedious." (Frank D. Adams was the Logan Professor of Geology and Palaeontology at McGill; A. Douglas McIntosh was the Senior Demonstrator in Chemistry.) This paragraph also contains Eve's complaint that he has been unable find thorium in rocks (see R-1, note 5.)

R-4

17 Wilmslow Rd
Withington
Manchester
Sept 5, 1907

My dear Eve,

The above is our home address where we are now comfortably installed for six months at any rate.[1] We came back from Mortehoe about a week ago after a very lazy time interspersed with some golf on a nine hole course at Woolacombe[2] - equivalent in hard work to 18 ordinary holes. We have a lawn at the back of the house in which I have installed a hole for practice at approach and putting, so I expect to get mild exercise on the cheap. Work does not begin till October but I am getting things into shape. The electroscope I brought over suddenly went wrong and had to be taken to pieces. The trouble was the leaf got a half turn on itself. It was very annoying as I had already calibrated it and used it for my growing radium solutions.[3] I am hoping before the year is out to get about half a gram of radium to play with. I hope then to form my own conclusions on Ramsay's experiments.[4]

I saw your paper on spraying in the Phil Mag,[5] which reads very well. I ought to write up several papers but dislike the work. Have you sent off your emanation-in-atmosphere paper yet?[6] I hope to have a couple of chemists helping me next year working up the residues I got from the Roy[al] Soc[iety].[7] We had Walker[8] along yesterday on his way home and looking well and happy. He will be able to give you a first hand account of our surroundings.

I suppose you now get exercise without golf - I allude to midnight perambulations with the baby. I only did it once but then I am not the model that you are. Give my kind regards to McIntosh[9] and tell him I don't think it is worth while publishing the helium paper after all. I have started to write it up three times but gave it up each time. Give my best regards to Mrs. Eve - and the baby - also to Mrs. Pitcher.[10]

Yours ever

E. Rutherford

P. S. I got the draft alright - many thanks.

R-4 Notes

1. In fact, the Rutherfords remained at this address until they moved to Cambridge in 1919. The house at 17 Wilmslow Road no longer exists.

2. Woolacombe is close to Mortehoe (see R-3, note 10), certainly closer than the two miles from Mullion Cove to the golf links, which Rutherford complained of in letter R-3.

3. Radium is produced in all three of the radioactive series. In particular, radium could be 'grown' (i.e. the amount of radium increased) by the decay of solutions of actinium or thorium salts. Actinium produces radium-223 (half-life 11.7 days) and thorium gives radium-228 (half-life 6.7 years), but chemically they are identical with radium-226 (half-life 1600 years), which is the common form of radium derived from uranium. However, the concept of 'isotopes' was not developed until 1913.

4. See R-3, note 4.

5. Eve, A. S.: "Ionization by spraying," *Phil. Mag.*, Ser. 6, 14 (1907): 382-395. A fine mist can be produced by causing air to flow over a small opening or nozzle in a vessel containing a liquid, an effect less familiar at that time than today. Eve showed that the resulting mist is highly ionized, with both the number of ions and the ratio of positive to negative ions depending on the nature of the liquid.

6. The paper was published in the December 1907 issue of *Phil. Mag.* (See letter E-1, and R-1, note 5.).

7. The Royal Society (of London) had received about a ton of residues from the Joachimsthall mines in Bohemia, at that time in Austro-Hungary and one of the two main sources of the world's radium. The residues were distributed by the Royal Society among scientists working in the field of radioactivity. Rutherford received residues of polonium and actinium, the latter in the form of 40 kilograms of hydroxide. In a letter to Dr. Bertram Boltwood dated 28 July, 1907, Rutherford asked Boltwood's advice as to the best method of rapidly concentrating the actinium. Boltwood, who was a chemist, replied in detail on 23 September. (See Introduction, Note 12.)

8. H. Walker was a Professor of Chemistry at McGill University.

9. McIntosh: see letter E-2.

10. Mrs. Pitcher: see R-1, note 11 and letter E-1.

E-3 Eve to Rutherford

167 Hutchison Street, Montreal, 24 November, 1907

The letter begins: "You should have been here a few weeks ago when the [McGill] Chemical Society glorified Ramsay's work, Walker and McIntosh taking a paper each, and lauding them sky high, particularly McIntosh. It was the lion and the lamb lying down together at last, and the lion chewing straw with the ox." (Ramsay: see R-3, n. 4; Walker: see R-4, n. 8; McIntosh: see E-2.)

After complaining that his "beloved and faithful electroscope" had sprung a leak and had to be dismantled, cleaned and re-calibrated, Eve notes that he has not found any difference in radium emanation in water and in a solution of copper sulphate. This is a reference to Ramsay's letter in *Nature* July 18, 1907: see R-3, note 4. Eve continues: "I have done a month's work at Secondary radiation and detected Tertiary and Quaternary radiation from lead. Now I find that Allen was ahead of me in a paper in the Phys. Review August 1906, which I missed. Do you know the paper? My results agree with his." The paper referred to was: Allen, S. J.: "The velocity and ratio *e/m* for the primary and secondary rays of radium," *Physical Review*, 23 (1906): 65-94. This paper, and Eve's own work in the same area (*Phil. Mag.*, Ser. 6, 15 (1908): 720-737), were concerned with the release of secondary electrons from an absorbing material irradiated by *beta*-particles from a radioactive source (β-rays are streams of fast-moving electrons). In earlier work, published in 1904, Eve had also investigated the secondary radiations generated by the *gamma*-rays emitted by radium. He continued to study the properties of the gamma emission and published a further paper in this area soon after his β-ray paper cited above. (Eve, A. S. "The secondary γ-rays due to the γ-rays of radium C." *Phil. Mag.* Ser. 6, 16 (1908): 224-234.)

Eve then refers to the theory of the nature of γ-rays put forward by W. H. Bragg, Professor of Physics at the University of Adelaide in South Australia. In a paper published in the October, 1907 issue of *Phil. Mag.* (Ser. 6, 14: 429-449), Bragg had suggested that γ-rays consisted of "neutral pairs," i.e. a β-particle associated with an α-particle in such a way that "the tubes of induction pass from one particle to the other, and the electric field is greatly contracted." Bragg postulated that, since the electric field of the α-particle was the main cause of its loss of energy when passing through matter, the "neutral pair" would have great penetrating power since "the chief cause of the stopping of the α-particle has been removed." Eve's comment takes the form of a rhetorical question: "Do you believe that an α-particle and a β-particle can join company and fly through a kilometre of air or more? Bragg's latest!" (See also Bragg, W. H., *Nature*, 77 (1908): 270-1.)

The letter now moves away from science to university and personal topics. Eve states that "The U. States financial and commercial outlook is very blue and this will react to some extent on Canada. Our outlook at McGill is not too bright as no new money is coming in and the College has very heavy expenses to face for a building. Some blame the Principal, but I don't see why... I am hoping to be made Assoc. Prof., but they are on the "save", and won't do it before Sept. 1908, if then. The poor beggars have not the money, if they have the will." (Eve was right - he did not receive the promotion until 1909.)

Eve gives the news that Tory (H. M. Tory, a Professor of Mathematics) is leaving McGill to become Principal of the new Alberta University at Edmonton - "A good man for a good place" - and the letter ends on a pleasant note: "The new Eve is very bright and lively and adds greatly to the pleasure of life." There is, however, a postscript in which Eve returns to the problem of secondary radiations: "In my secondary radiation paper I was wrong in saying secondary rays were homogeneous. I did not investigate a sufficient range." He adds a sketch showing the absorption curves in aluminum of secondary radiations from brick and lead.

E-4 Eve to Rutherford

167 Hutchison Street, Montreal, 10 December, 1907

This letter is mainly concerned with the growth of radium in a solution of thorium nitrate: see R-4, note 3. Eve reminds Rutherford of the 500 grams of thorium nitrate, free from radium, he had left behind in Montreal. "I could not boil it properly in the vessel so I decanted it October 10th and tested it a week ago. It gave me a max 4.5 Div. a min...." Eve then provides some calculations to show that 100 grams of Rutherford's thorium nitrate now contained 1.15 x 10^{-9} grams of radium. However, "there is a little to add to this because there was a thin white deposit on the bottom of the original flask. I have got this off and will test it later; I do not expect it will largely add to the result."

Eve continues by comparing his results with those of Hahn on thorium nitrate solutions prepared (i.e. free of radium) in 1900, 1902 and 1906. (Hahn, O.: "Die Muttersubstanz des Radiums," *Chemische Berichte*, 40 (1907): 4415. See also R-5, note 5.) Eve concludes: "Your stuff fits in pretty well, assuming it is about 2 years old. How old is it? I will test the decanted fluid in April 1908 and Nov. 1908, if all is well. I thought this would interest you."

Rutherford replied in detail to this part of Eve's letter (see R-5), but it is very difficult to check the figures 80 years later, because there are too many uncertainties as to the assumptions made in the original calculations, such as the atomic weight of radium. Even Rutherford has to ask Eve (letter R-5) whether Hahn's numbers were for 100 grams of thorium or thorium nitrate.

Eve ends the letter with the news that "Joan Eve has a tooth" and "Dr. Harrington died on Friday and practically the whole University is going to his funeral tomorrow." (Bernard J. Harrington was Macdonald Professor of Chemistry and Mineralogy at McGill. He was 59 when he died on November 29, 1907.)

R-5

17 Wilmslow Rd
Withington
Manchester
Dec 21, 1907

My Dear Eve,

Just a note before I leave for London to attend Kelvin's funeral in the Abbey tomorrow.[1] I rec[d] your letter [E-4] re the amount of Ra in the Th solution[2]

500 grs of Th Nit (* of this) were taken which initially contained (bubbling method) 2 x 10^{-8} gr $RaBr_2$ (old standard),[3] Barium was pp[d] as sulphate in the solution and am[t] reduced to (mean of several observations) 8 x 10^{-10} gr $RaBr_2$.[4]

I did not detect any certain growth over interval of three months. You say 500 gr gives now 5.76 x 10^{-9} gr Ra. Increase is therefore 5.76 x 10^{-9}- .45 x 10^{-9} or 5.3 x 10^{-9} gr Ra. The age of solution is from April 1904 to Oct 1907 = 3.6 years about

... growth per year = 1.47 gr Ra [x 10^{-9}]

This is less than Hahn[5] but on the other hand, I should not be surprised if the deposit (which probably contains some Ba and Ra with *) contained a good deal.[6] Get it into solution and test it some time. There is of course a little uncertainty relative to amount det[d] originally by the bubbling method. By the way are Hahn's numbers for 100 grs Th or Th Nit?

I was interested to hear you were working on secondary and tertiary rays. As you say, they appear very popular at present.

You may be interested to hear that I think I have got a method (electrical) for directly counting the α particles.[7] I am not quite sure yet until I compare the experimental and theoretical numbers.

I cannot do much for a year or more with the Ra as Ramsay has it first. He provides me with emanation occasionally.[8]

Give my kind regards to Mrs Eve. Apart from a bad cold, my wife is well. Eileen and myself are flourishing. I go to the seaside at St. Anne's[9] for a week for fresh air and golf in a few days.

Yours very sincerely

E. Rutherford.

* Illegible word

R-5 Notes

1. Lord Kelvin (Sir William Thomson, 1824-1907) was Professor of Natural Philosophy at Glasgow University from 1846 to 1898, and President of the Royal Society, 1890-95. He was jointly responsible with Faraday for initiating the theory of the electromagnetic field and he also made major contributions to thermodynamics and hydrodynamics. During his lifetime, Kelvin was the acknowledged leader of the physical sciences in Britain. He was buried in Westminster Abbey.

2. A solution of thorium nitrate, $Th(N0_3)_4$

3. The amount of radium in a thorium compound was estimated by measuring the activity of the emanation (radon) produced when the radium disintegrated. The mass of radium was usually expressed in terms of the equivalent mass of radium bromide, $RaBr_2$, where 1 mg of Ra was assumed equivalent to 1.72 mg of $RaBr_2$ (Rutherford and Boltwood, *Phil. Mag.*, Ser. 6, 9 (1905): 599.) The "bubbling method" referred to by Rutherford, involved bubbling dust-free air through a thorium solution in order to sweep up the emanation (radon) produced in the solution by the decay of radium, itself a product of the decay of preceding elements in the series. The air loaded with emanation was then passed into an electroscope or ionization chamber for measurement purposes and the mass of radium in the solution was deduced from the activity of the emanation. Unfortunately, while this method is indirectly referred to in several early papers, no explicit details were published by either Rutherford or Eve. In a letter to Boltwood (see Introduction, note 12), dated November 10, 1906, Rutherford discusses the measurement of radium in a solution of actinium dissolved in nitric acid "by the method of bubbling - about 3 litres of air passed into a big electroscope." In addition, Chapter 7, of the 2nd edition of Rutherford's book, *Radio-Activity* (Cambridge, University Press, 1905) contains a description, with diagram, of the extraction of emanation from a solid thorium compound by passing dust-free air, previously bubbled through sulphuric acid, over the compound in a glass tube. The air current picks up the emanation produced by the thorium and carries it along to a large ionization chamber connected to an electroscope. This method works for thorium and actinium compounds because these radioactive series include isotopes of radium, ^{224}Ra and ^{223}Ra respectively, with short half-lives, 3.6 d and 11.7 d respectively, and radon is constantly produced in measurable amounts. Uranium compounds, on the other hand, produce ^{226}Ra (the most common isotope of radium), whose half-life of 1600 years does not lend itself to this method. A solution containing ^{226}Ra has to be boiled to release its radon.

4. Radium and barium are chemically similar, so the precipitation of barium in a solution also serves to precipitate radium. Rutherford's figures indicated that about 96 percent of the radium was removed from the thorium nitrate solution in this way. The purpose of the exercise was to measure the regrowth of radium in the thorium solution as a result of the decay of thorium and its daughter products.

5. See letter E-4, in which Eve compares the radium contents of Rutherford's and Hahn's thorium solutions. Otto Hahn (1879-1968) was a German radiochemist. Hahn spent a year working with Rutherford in Montreal, 1905-6, and the two men remained life-long friends. (For Hahn's reminiscences of Rutherford at McGill, see Introduction, note 6.) Hahn was mainly responsible for elucidating the decay scheme of the thorium series. He received the Nobel Prize in chemistry in 1944 for his discovery of nuclear fission. In 1907 he was appointed a 'Privatdozent' (lecturer) in Fischer's Institute in Berlin (see R-6, Note 12.)

6. See letter E-4, in which Eve refers to a white deposit on the bottom of the flask.

7. This note in a letter to Eve in December 1907 appears to be Rutherford's first reference to the device subsequently called a "Geiger counter." About a month later (January 31, 1908) Rutherford gave a brief summary of the principles involved in the counter, at the end of a discourse to the Royal Institution on "Recent advances in radioactivity." This lecture was published in *Nature* March 5, 1908: 422-6. A few days after the Royal Institution discourse, Rutherford and Geiger lectured to the Manchester Literary and Philosophical Society on "A method of counting α particles" and this was reported briefly in *Nature* on April 23, 1908. However, the definitive paper on the Geiger counter was presented to the Royal Society on June 18, 1908 and published in July 1908: Rutherford, E. and Geiger, H.: "An electrical method of counting the number of α particles from radioactive substances," *Proc. Roy. Soc.* A, 81 (1908): 141-161.

8. The Austrian Academy in Vienna had loaned about 300 mg of radium bromide jointly to Ramsay and Rutherford. However, the whole consignment was sent to Ramsay in London, and Ramsay refused to divide it, since "it is so infinitely more valuable as a whole." Ramsay proposed to keep the radium for a year, or a year and a half, before passing it to Rutherford and meanwhile offered to provide Rutherford with a regular supply of emanation. Rutherford was very unhappy with this arrangement and in January, 1908 persuaded the Austrian Academy to provide a separate consignment of 500 mg for his own use. Detailed accounts of this episode are given in the biographies of Rutherford by Eve and by Wilson. (See Introduction, notes 1 and 4.)

9. St. Anne's is a resort near Blackpool on the Lancashire coast.

E-5 Eve to Rutherford

167, Hutchison Street, Montreal, 29 March, 1908

Eve begins by stating that he has read Rutherford's (Royal Institution) lecture in *Nature* (see R-5, note 7) "and I am delighted with the splendid method of counting α- particles. It is a great achievement."

After a brief reference to his own lectures on radioactivity - "given to a small but choice audience" - Eve remarks that he has almost completed a year's experiments on emanation in the air" and my results for summer and winter are almost exact."

Eve offers Rutherford his congratulations "on your Turin prize," i.e. the Bressa prize awarded every two or three years by the Turin Academy of Sciences. The award to Rutherford was announced on March 10, 1908: for further details see Eve's biography of Rutherford (Introduction, note 1). Eve then gives the news that Harkness (James Harkness, Professor of Mathematics at McGill) will be married "early in May, then to Italy."

The remainder of this short letter is concerned with the radioactivity of sea water. Eve states that "Joly's results on sea water surprise me." John Joly, Professor of Geology and Mineralogy at Dublin, had carried out extensive measurements on samples of coastal sea water and had obtained a mean value of 2.55 x 10^{-14} grams of radium per cubic cm of water. This was many times higher than Eve's value for a single sample of mid-Atlantic sea water, 8.6 x 10^{-16}. Eve comments that "luckily I kept my Atlantic sea water" and he proposed to test it again: "If my results are confirmed I will collect sea water in August on my way back to Canada and try again. However I do not see how Joly can be wrong and I do not set my one experiment against his numerous ones. Have you a student who would try his hand at it?" However, in his paper on this subject (*Phil. Mag.*, Ser. 6, 15 (1908): 385-393), Joly suggests that there is a genuine difference between his own coastal samples and Eve's mid-ocean sample, and that the dynamics of emanation release and travel in an extended fluid medium would "help to explain Eve's difficulty in accounting for the amount of ionization observed over the ocean."

Eve concludes by noting that "we are looking forward to our English holiday" - a holiday which was to include a visit to the Rutherfords in Manchester, although Eve does not say so in this letter.

E-6 Eve to Rutherford

McGill University, Montreal, 4 November, 1908

This letter was written over seven months after the previous one (E-5), and there is no indication of any correspondence in either direction during this period. However, Eve and his family spent the summer months in England, and Manchester was included in their itinerary: "We often think of our very pleasant visit to you and Mrs. Rutherford in May."

The letter opens with thanks to Rutherford "for the galaxy of papers which you sent me. They are a fine group and I congratulate you on them." If Rutherford enclosed a letter with the package, it has not survived. Eve then reports that he has given the (McGill) Physical Society a summary of all the work done in radioactivity since Rutherford's own summary of spring, 1907. "It was quite a task getting everything up to date" - a statement amply confirmed by the scientific journals of the period. Eve mentions specifically the problem of the radioactivity of ocean water, and the work of Hahn (see R-5, note 5) and Strutt. Robert J. Strutt (1875-1947) was the son of Lord Rayleigh. His early research was in radioactivity; he estimated the age of minerals by measuring their helium content. However, he is remembered mainly for his work in atmospheric physics. Strutt was Professor of Physics at Imperial College, London, from 1908 to 1919, when he became the 4th Baron Rayleigh on the death of his father.

The letter continues: "It seems queer to think Cox is leaving us in April. There are so many and swift changes that I do not know where I am!" John Cox (1851-1923) was the first Macdonald Professor of Physics at McGill (1890) and Director of Physics from 1901 until his retirement in 1909. It was Cox who had recruited Rutherford for McGill in 1898.

Finally, a personal note: "Our young woman runs and talks and is great company. Another Evelet is expected to visit Montreal in December. My work and life generally go along about as happily as they possibly can."

E-7 Eve to Rutherford

167 Hutchison Street, Montreal, 29 November, 1908

This letter opens with a reference to Rutherford's Nobel Prize, announced about two weeks earlier: "In addition to our general cablegram I want to write and express to you our hearty congratulations on this splendid prize which the gods have shaken into your most deserving lap. You have certainly been sailing with a full sail and a brimming tide."

Eve continues on a more usual note: "I am glad that you have laid the last of Ramsay's spooks, and I see that Dewar has come as light cavalry to complete the rout." This remark almost certainly refers to a report in *Nature* November 5, 1908: 23 of the meeting of the Mathematical and Physical Science Section of the British Association (Dublin, September 3, 1908). Ramsay read a paper titled "Do the radioactive gases (emanations) belong to the argon series?" (see R-3, note 4). There was an "exchange of views" between Ramsay and Rutherford, since "Professor Rutherford is not convinced of the production of neon in radioactive changes." The debate was renewed the following day (September 4) at the meeting of the Chemistry Section, reported in *Nature* October 8, 1908: 589. Rutherford reported experimental work showing that the amount of neon in 1/15 c.c. of air readily gives the neon spectrum, and he attributed Ramsay's assumed formation of neon to a slight leakage of air during the experiments. Ramsay, in reply, upheld his experiments but agreed that the formation of lithium from copper was less certain that the other transmutations he had observed. Eve's reference to Dewar (see R-1, note 8) was problably a response to the *Nature* report of the September 3 meeting (see above), in which Ramsay's paper was followed by that of Dewar on the rate of production of helium from radium. Dewar reported that, in measurements involving "extreme precautions," he found the rate of production to be about 0.37 cubic mm per gram of radium per day, a number of the same order of magnitude as Rutherford's theory requires.

Next, Eve discusses briefly the still unsolved problem of the amount of "penetrating radiation" giving rise to ionization in the air over areas of sea. "McLennan...finds a great deal over Lake Ontario." (J. C. McLennan was Professor of Physics at Toronto.) Eve states that he has calculated that the γ-rays in earth, air and sea should produce ionization in the ratio 15: 1: 0.2 respectively, but the measured ionization does not fit this prediction. "This then is a dilemma. So I am getting Bates to check McLennan, and I am checking Joly on sea water." (F. W. Bates was a Demonstrator in Physics at McGill.)

The letter concludes as it began: "But these are side issues. I really want to repeat my most sincere congratulations, and to wish you all success and happiness in the future." Rutherford sent his thanks on December 22, 1908, after returning from the Nobel ceremony in Stockholm. (See letter R-6.)

<u>R-6</u>

17 Wilmslow Road
Manchester
Dec 22, 1908

My dear Eve,

My wife & I have just returned from Stockholm after having a great time of it. We left here over a fortnight ago & attended the Cavendish[1] Dinner in celebration of "Sir Joseph" or otherwise J. J.[2] It was a festive occasion & a special song on the α-rays[3] was prepared in my honour. To my prejudiced judgement, it went uncommonly well. We then left for Harwich, Hook,[4] Hamburg, Copenhagen and Stockholm arriving Wed. morning - the day before the beginning of the official celebrations.[5] We were met by Arrhenius[6] & others and put up at the Grand Hotel where all the prize winners were staying. On Thursday the celebrations opened with evening dress at 4 in the Academy of Music with speeches & music interspersed. The names of the prize winners were declaimed & the medals and diplomas presented by the King. We then immediately went to the hotel dinner & had our seats among the royalties. My wife had two princes one on either side[7] & the Crown Princess (England)[8] opposite. My health was proposed & I gave a speech which they apparently enjoyed. I joked about my sudden transformation into a chemist. The celebrations were kept up by some till past one o'clock with copious libations of Swedish Punch. We got away at 11 to take some rest after our labours. Next afternoon, I gave a lecture on the nature of the α-particle before the Swedish Academy & in the evening dined with the king and queen at the palace. We got away at 10:30 & a number of us celebrated till 1 pm in a restaurant. Besides this there were a number of dinners & lunches. We stayed 6 days - long enough to see something of the beauties of Stockholm & had a really great time. We then travelled to Berlin where we spent two days. I saw Regener[9] & Marckwald[10] & most of the physicists there & also Nernst[11] and Emil Fischer[12]. Hahn[13] took charge of us & arranged everything for us. I saw the Reichanstalt[14] and Warburg[15]. Professor Rubens[16] gave us a farewell supper at which practically all the physicists of Berlin were present. We caught our train by a minute to spare & went by night to Amsterdam and then on to Leyden to see Professor Lorentz[17]. We saw something of the University & the apparatus for liquefaction of helium. Onnes[18] was not well enough to be on hand. We sailed the same evening for Harwich & then <u>slowly</u> home on Sunday. We arrived well but needing to rest a little after our labours. Altogether we had the time of our lives. Everybody went out of their way to make our stay pleasant. I saw a good deal of Arrhenius who wished to be remembered to Cox[19] - so transfer this wish to him.

"Dr" Newton[20] (he is just through) is now staying with us & sends his kind regards.

Thanks very much for your kind congratulations. I hope my McGill friends are not too surprised at my sudden transformation into a chemist. I must confess to considerable surprise myself. I am glad to hear of your work & hope you will manage to clear up the outstanding difficulties of the ionization and radioactivity of the atmosphere.

We are going to rest here over Xmas. With best wishes to yourself and Mrs. Eve from my wife and I for a happy & successful New Year.

Yours ever

E. Rutherford

R-6 Notes

1. The Cavendish Laboratory in Cambridge University, (founded in 1891). Rutherford was a graduate student in the Cavendish from 1895 to 1898 and returned as Director in 1919.

2. Sir Joseph John Thomson (1856-1940), English physicist. Director of the Cavendish Lab from 1894 to 1919. He measured the ratio of charge to mass of the 'cathode rays' produced in a discharge tube and identified these rays with the hypothetical unit of negative electric charge, for which the name *electron* had earlier been suggested by G. J. Stoney. Thomson received a Nobel Prize in physics (1906) for his investigations of the conduction of electricity through gases. Thomson introduced Rutherford to the study of α-rays in 1896 and radioactivity in 1897, and recommended him for the post at McGill which Rutherford took up in 1898. Thomson was affectionately called 'J. J.' by his colleagues and students.

3. Most of Rutherford's early work on radioactivity involved the study of α-rays, which consist of streams of heavy, positively-charged particles, known by this time to be charged atoms of helium. The "special song," written by Alfred A. Robb, is reproduced in the Rutherford/Boltwood correspondence (Introduction, note 12), pp. 206-207.

4. Harwich, on the east coast of England, and Hook of Holland in the Netherlands, were (and remain) the terminals for one of the main ferry-boat services between England and the Continent, especially for travel to Holland, Germany and Scandinavia.

5. Thursday, December 10, 1908.

6. Svante Arrhenius (1859-1927), Swedish chemist and physicist. In 1903 Arrhenius received the Nobel Prize in chemistry for his work on the dissociation of solute molecules in electrolytic solutions, and in 1905 was appointed Director of the Physical Chemistry Department of the Nobel Institute in Stockholm.

7. The official record gives the names of four princes present at the Nobel ceremony but does not identify them further. I am unable to identify the 'two princes' referred to by Rutherford.

8. Princess Mary, wife of the future King George V. (The term 'Crown Princess' is applied in Europe to the wife of the Heir to the Throne, but is not usually used in Britain. No doubt Rutherford borrowed the term used by his Swedish hosts.)

9. Erich Regener (1881-1955), German physicist. He developed the scintillation method of studying particles (first used by Rutherford and Geiger) into a practical and accurate research technique, and made (1909) the first accurate determination of the charge on the electron.

10. Willy Marckwald, Professor of Chemistry in Berlin at Fischer's Institute. Marckwald worked extensively in the field of radioactivity.

11. Hermann Nernst (1864-1941), German physical chemist. Appointed Professor of Chemistry in Berlin in 1905 and developed the Nernst Heat Theorem, also known as the "3rd Law of Thermodynamics," in 1906. Received the Nobel Prize in chemistry in 1920 for his work in chemical thermodynamics.

12. Emil Fischer (1852-1919), German chemist. Appointed Professor of Chemistry at Berlin in 1892 and received the Nobel Prize in chemistry in 1902 for his work on the synthesis of sugars and purines. He laid the chemical foundations of biochemistry.

13. Otto Hahn: see R-5, note 5.

14. "Reichanstalt" is a mis-spelling for Reichsanstalt, specifically the Physikalisch-Technische Reichsanstalt (State Institute for Physical and Technical Research), in Berlin-Charlottenburg, one of several state research institutes in Germany.

15. Emil Warburg (1846-1931), German physicist. Professor of Experimental Physics in Berlin, 1895-1905 and President of the Physikalisch-Technische Reichsanstalt from 1905. His main work was on the kinetic theory of gases.

16. Heinrich Rubens (1865-1922), German physicist. In 1906 he was appointed Professor of Experimental Physics in Berlin and Director of the Konigliche Physikalische Institut (Royal Institute of Physics). His main work was in the exploration of the far infra-red region of the electromagnetic spectrum.

17. Hendrik Lorentz (1853-1928), Dutch physicist. Professor of Physics at Leiden, 1877-1912. He made major contributions to theoretical physics and shared the Nobel Prize in physics in 1902 for investigations on the influence of magnetism on radiation phenomena.

18. Heike Kamerlingh Onnes (1853-1926), Dutch physicist. As Professor of Physics and Director of the Laboratory at Leiden, 1882-1924, he made Leiden the world centre for low-temperature physics. He succeeded in liquefying helium in 1908 and was awarded a Nobel Prize in physics in 1913 for his investigations of the properties of matter at low temperatures.

19. John Cox: See E-6.

20. Charles Newton, Rutherford's brother-in-law (see R-3, note 8.)

R-7

17 Wilmslow Road
Withington
Manchester
Dec 27, 1908

Dear Eve

Congratulations to you both on your α-particle (He).[1] You keep up with the times. May he turn into a Nobel man in the days to come.

We are having a quiet Xmas. With best wishes to you both from my wife and myself.

Yours ever

E Rutherford

Note added at top of page

I was so tired of writing I addressed this to Montreal, Manchester!! ER

R-7 Note

1. The reference is to the birth of a son, Richard, to Professor and Mrs. Eve - their second child but first son. Rutherford referred to the sex of the child by punning on the chemical symbol for helium, He, since the α-particle (which was a focus of Rutherford's investigations) had been shown to be identical with the helium atom.

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