My Dear Eve ...,
The Letters of Ernest Rutherford to Arthur Eve
Part III, 1912-1914

by Montague Cohen

In Parts I and II of this article, annotated transcripts were presented of the first 15 of a set of hitherto unknown letters from Ernest Rutherford in Manchester to Arthur Eve in Montreal. These 15 letters were written in the years 1907-11. This part contains a further 13 letters, plus two postcards, written between 1912 and 1914. These letters are interleaved with annotated extracts and summaries of 10 letters from Eve to Rutherford written in the same period; these letters are part of the Cambridge University collection. The period covered by this article saw important developments in the study of radioactivity and the atom, in particular: (i) experimental evidence supporting Rutherford's 1911 nuclear atom, together with the development by Niels Bohr (1913) of a sound theoretical basis for the Rutherford atom; (ii) the discovery of X-ray diffraction by von Laue in 1912 provided a means of measuring X-ray wavelengths and hence of studying the electron configurations of different elements. Much of this work was carried out by Rutherford's team in Manchester and is featured in this article. The scientific aspects of the correspondence are mixed with items of a personal or general nature, including Rutherford's knighthood (1914), Eve's promotion to a Macdonald Professorship at McGill (1913), the tragic death of the wife of Howard Barnes, Director of Physics at McGill (1912) and the loss of the Empress of Ireland in the St. Lawrence River (1914).

Les première et deuxième parties de cet article prèsentaient des exemplaires annotés des 15 premières lettres jusque là inédites qu'Ernest Rutherford à Manchester avait adressées à Arthur Eve à Montréal. Ces 15 lettres ont été écrites entre 1907 et 1911. Cette partie comprend 13 lettres supplémentaires et deux cartes postales écrites entre 1912 et 1914. Elles sont émaillées d'extraits annotés et de résumés des six lettres d'Eve à Rutherford écrites pendant la même période; celles-ci font partie de la collection de l'Université de Cambridge. La période étudiée dans cet article est marquée par deux percées importantes dans l'étude de la radioactivité et de l'atome, en particulier: i) les preuves expérimentales étayant l'hypothèse formulée par Rutherford en 1911 sur l'atome nucléaire ainsi que l'élaboration d'une solide base théorique pour l'atome de Rutherford par Niels Bohr (1913); ii) la découverte de la diffraction des rayons-X par von Laue en 1912 qui a fourni le moyen de mesurer les longueurs d'ondes des rayons-X et donc d'étudier la configuration des électrons de différents éléments. Plusieurs de ces travaux ont été menés par l'équipe de Rutherford à Manchester et sont abordés dans cet article. Les aspect scientifiques de la correspondance se mêlent à des renseignements généraux ou intimes dont l'élévation de Rutherford au titre de chevalier (1914), la nomination d'Eve à une chaire Macdonald à McGill (1913), le décès tragique de l'épouse de Howard Barnes, directeur du département de physique de McGill (1912) et le naufrage de l'Empress of Ireland dans le fleuve St-Laurent (1914).

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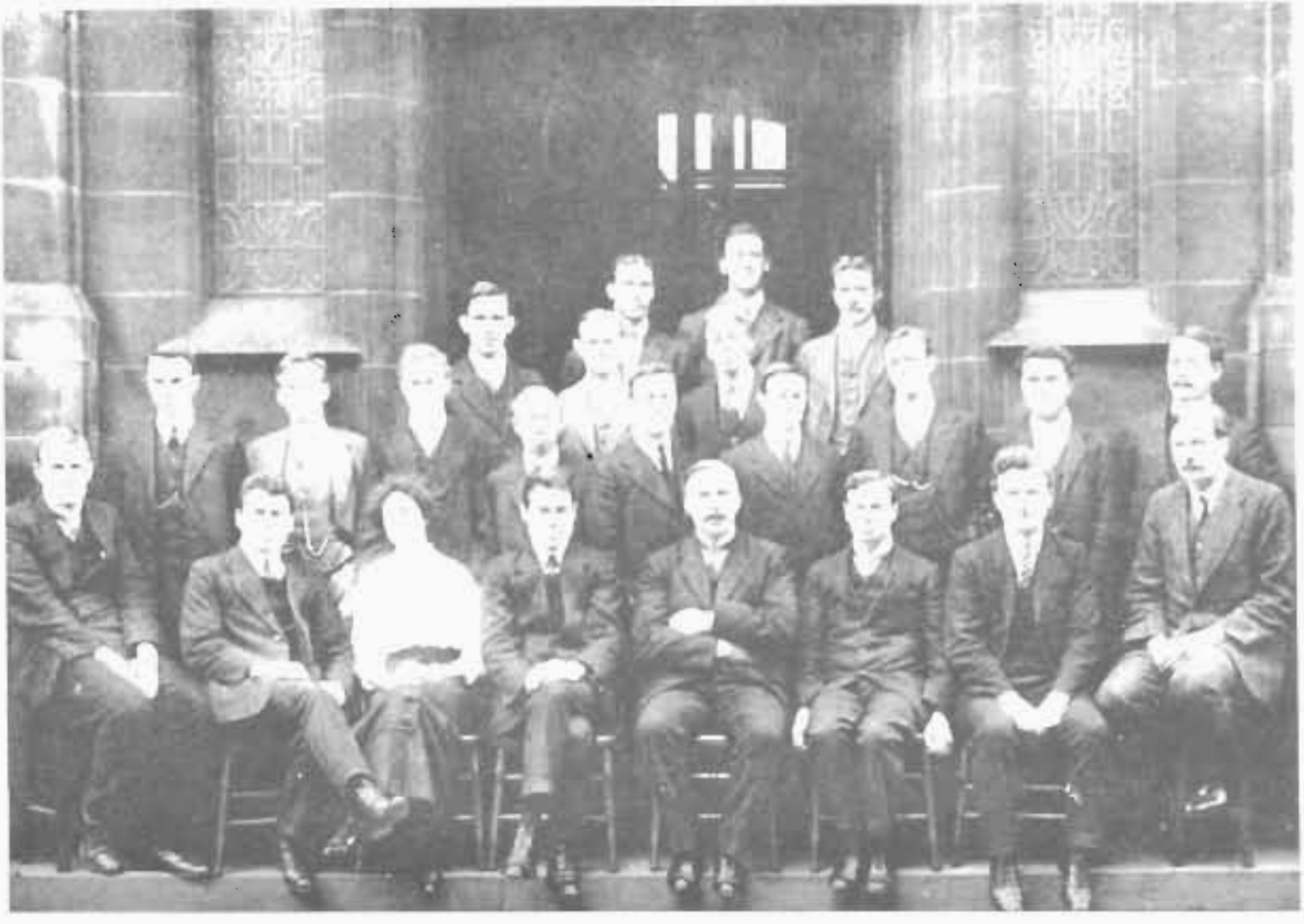


Figure 1. Group photograph of staff and research students of the Physics Department of Manchester University. 1913. (Courtesy Manchester University)

The two previous parts of this article[1] presented the first 15 of 37 hitherto unknown letters from Ernest Rutherford to his friend and former colleague Arthur S. Eve at McGill University. These letters, which are not listed in the *Rutherford Correspondence Catalog*,[2] were recently discovered among other documents and letters at McGill. Part I of the article covered the period 1907-08, i.e. the first 18 months of Rutherford's Manchester period. Part II covered 1909-11, and the present article takes the story to the middle of 1914, just before the outbreak of World War One.

This article includes annotated transcripts of 13 letters, plus two postcards, written by Rutherford between March 1912 and June 1914 (Table I and Figures 3 and 4). As in the previous articles, the letters written *by* Rutherford are interleaved with annotated extracts and summaries of Eve's letters *to* Rutherford in the same period. The latter have long been in the public domain and are part of the Rutherford Collection in the Library of Cambridge University. These letters are therefore not reproduced in full, but the extracts (published by permission of the Syndics of the Cambridge Library) are intended to place the Rutherford letters in the context of a two-way correspondence. It must be admitted, however, that this aim is only partially realized since there are obvious gaps where letters either did not exist or (more probably) have been lost.

The arrangement of letters in this article is indicated in Table 1. There is a gap of over a year between letter R-15 written by Rutherford on 14 June 1911 (see Part II) and R-18 written on 25 June 1912, broken only by two postcards (R-16 and R-17) sent from France in March-April 1912. A further gap of 5 months occurs between R-19 (16 August 1912) and R-20 (10 January 1913). On Eve's side, there are gaps of 4 months between E-21 and E-22 and 5 months between E-23 and E-24. Most significant of all is a gap of 13 months between E-26 (19 January 1913) and E-27 (27 February 1914).

Of these gaps in the present series, it seems that only the last (January 1913–February 1914) can be attributed to the loss of several letters in a row. In the other cases the lack of correspondence can be attributed to the absence of Rutherford from Manchester on business or vacation, although the loss of one or two letters cannot be ruled out. It must be borne in mind (as was pointed out in the previous parts of this article) that the Rutherford–Eve correspondence was essentially of a *personal* rather than a professional nature, i.e. neither side needed or used the correspondence as a means of furthering his research. A gap in the exchange therefore had little or no implication for the work in hand at Manchester or McGill. This is in marked contrast to the Rutherford–Boltwood correspondence[3] which (apart from a great deal of gossip) includes some valuable scientific exchanges between the physicist (Rutherford) and the chemist (Boltwood).

The letters of Rutherford in this period were all typewritten, with occasional corrections and additions by hand. An example is shown in Figure 5. Eve's letters, however, were all written by hand and are often difficult to read; an example is given in Figure 6.

Ernest Rutherford, 1912-14

The period covered by this article was a very important one from the point of view of both Rutherford personally and physical science in general. By 1912 Rutherford had been at Manchester over four years and had built up an impressive team of scientists and graduate students, a team which included Niels Bohr, Hans Geiger, Henry Moseley, Ernest Marsden, Edward da Costa Andrade and others who became famous in their own right. A group photograph of the Manchester team, taken in 1913, is shown in Figure 1. The output of this team is indicated in Table II, which enumerates the papers published by the Manchester group in the years 1907 to 1919. (The figures for 1907 are given in parentheses because Rutherford spent only part of that year in Manchester.) It is seen that the output of papers reached a peak in 1912-14 with an average of 42 per year. (The number of *authors* is considerably higher since the majority of papers had more than one author.) This was for a group which numbered no more than 24

at any time, including both staff and graduate students, down to the most junior graduate. After 1914 the output declined rapidly, as the department was depleted by the war. Most, but not all, of the papers were concerned with radioactivity, radiations (including X rays), the interaction of radiation with matter and the structure of the atom, topics of personal interest to Rutherford. However, it is not true, as has sometimes been alleged, that Rutherford did not permit his colleagues and students to work on problems outside his personal interests. A complete bibliography is given in *Rutherford at Manchester*, ed. J. B. Birks (1962).[4]

Table II indicates that Rutherford's personal output of papers, alone or in co-authorship, actually declined after reaching a peak in 1908-09. Several reasons for this can be suggested. Firstly, as the research activities of the department increased, Rutherford needed to spend more and more time talking to and advising his assistants and students. (It is noteworthy that—at least in his Manchester period—Rutherford did not co-author a paper unless he himself had participated in the experimental work; suggesting and guiding an investigation did not imply authorship.) Secondly, the preparation of the book *Radioactive Substances and their Radiations*,[5] published early in 1913, must have taken up a significant proportion of Rutherford's time in 1911 and 1912. Thirdly—and there is evidence that this was an important factor—the period 1910-14 saw the emergence of two cornerstones of modern science: the nuclear atom (discussed below) and X-ray diffraction (see Note 3 of letter R-20). Rutherford was directly involved in the former and indirectly in the latter since the newly-discovered phenomenon had profound implications for the study of radiation and the structure of matter. At any rate, this was a period in which Rutherford devoted much of his time to thinking in his study rather than experimenting in the laboratory.

An important event in the period under review was Rutherford's knighthood on January 1, 1914. This is covered briefly—almost casually—in the present correspondence. Clearly Rutherford's attitude to the honour was ambivalent: he was pleased and flattered but, at the same time, somewhat uneasy that he had accepted a distinction that went against his democratic outlook.

Arthur Eve, 1912-14

At the beginning of the period covered by this article Arthur Eve was an Associate Professor of Mathematics at McGill, although he worked mainly in the Physics Building. The Director of Physics was Howard Barnes, who had succeeded John Cox in this post in 1910. The correspondence in the present article opens with a letter from Eve in which he reports the tragic and unexpected death of Mrs. Barnes, shortly after giving birth to twin daughters. Thereafter a recurrent theme in the correspondence is Barnes' emotional health and his desire to resign his McGill post and make a fresh start elsewhere. In the event Barnes did *not* leave during the period of this article but eventually (1918) resigned because of a nervous breakdown.

In June 1912 Harold A. Wilson, who had been appointed Macdonald Professor of Physics in 1909 in succession to Rutherford, resigned in order to take up a post in Houston, Texas. An important theme of Eve's letters in 1912-13 was his desire to obtain the appointment while confessing some doubt as to his ability to fill the post adequately: "As to the vacant chair I think the University would like to appoint a Really Great Man. If they cannot, they may appoint me... I could never hope to *fill* a chair occupied previously either by yourself or H. A. Wilson." Rutherford's views on the post were equivocal: while clearly wishing to help his friend if possible, he comes close to saying that he does not consider Eve the right man for the post. Eventually, after a year's delay, Eve *was* appointed.

A photographic portrait of Eve is shown in Figure 2. The precise date of this photograph is unknown, but is believed to be in or near the period of this article.

Highlights of the Correspondence

Among the many topics discussed in the present correspondence attention may be drawn to the following:

Figure 2. Arthur Stewart Eve. (The precise date of this photograph is unknown but is believed to be within or near the period of this article.)

- A meeting of the International Radium Standards Committee in Paris in March 1913 in which radium standards prepared in Paris and Vienna were measured and compared. Eve was a member of the Committee but did not attend. Rutherford played a prominent (but not dominant) role in the proceedings. Mme Curie attended for part of the time.
- The celebrations in July 1912, of the 250th anniversary of the founding of the Royal Society of London.
- Publication in 1913 of Rutherford's book *Radioactive Substances and their Radiations* and its "review" by Eve.
- The variation with altitude of ionization in the atmosphere, work (mainly in Germany) which led to the discovery of cosmic radiation.
- The energy and intensity of the ß-rays emitted by radium and its decay products.
- The relationship between α, ß and γ radiations.
- X-ray diffraction by crystals and the use of the technique to determine the wavelength of X- and γ-rays. This topic led to a discussion of the nature of X-rays.
- Moseley's investigations on the "high frequency" (i.e. X-ray) spectra of the elements.
- Development by Geiger (1913) of a modified version of his particle counter.
- A controversy as to the origin of the formula for "black body" radiation.
- Lectures by Rutherford at the Royal Institution, London (1913), the National Academy of Sciences, Washington (1914) and McGill University Physical Society (1914).
- The sudden death of Mrs. Barnes, wife of the Director of Physics at McGill, after giving birth to twin daughters in January 1912, and the subsequent indecision of Barnes as to his career at McGill.
- The long-delayed promotion of Eve at McGill following the resignation (1912) of the Macdonald Professor of Physics, Harold A. Wilson.
- Local Montreal news included a severe water shortage following the collapse of an inlet pipe in the municipal water plant (December 1913), a spectacular fire in old Montreal (January 1914) and the sinking of the liner Empress of Ireland in the St. Lawrence River with the loss of almost 1,000 lives (May 1914).
- Most important of all, the further development of the nuclear model of the atom. This is discussed below.

The Nuclear Atom, 1904-14

The nuclear atom is pictured as a miniature solar system, with an extremely small but massive nucleus in the centre and a number of electrons revolving in orbits around the nucleus. The nucleus is positively charged and contains nearly all the mass of the atom; the electrons are negatively charged but have only a very small mass compared with that of the nucleus. The number of orbital electrons varies from element to element but always equals the positive charge on the nucleus, so that the atom as a whole is electrically neutral. The model indicates that the atom is mostly empty space and a rapidly moving particle can pass right through the atom without hindrance; occasionally, however, the particle will pass close enough to the nucleus to experience a massive force arising from the electric field of the nucleus and the particle (if electrically charged) will then be deflected (scattered) from its path.

The nuclear atom, as just depicted, was born in 1911 when Ernest Rutherford published a paper titled "The scattering of alpha and beta particles by matter and the structure of the atom."[6] However, the birth was preceded by an extended antenatal period. In 1904 a Japanese scientist, H. Nagaoka, proposed a model of the atom comprising a number of electrons of equal mass arranged uniformly in a ring and a positively charged sphere of large mass at the centre of the ring.[7] The model was called *Saturnian* by analogy with the rings of the planet Saturn. Nagaoka's atom aroused very little interest at the time; however, in his 1913 book[8] Rutherford formally acknowledged Nagaoka's work. The first hint of the scattering of α-particles by matter came in 1906, when Rutherford was still at McGill. He noticed that the photographic

image of a fine beam of α-particles was rendered slightly diffuse when the beam passed through air rather than a vacuum, or through a thin sheet of mica[9]. Rutherford did not follow up this observation in Montreal, but later, in Manchester, he suggested to Geiger that a full investigation of the angle of scatter was needed, using different scattering materials. Geiger, and a young graduate student, Ernest Marsden, published three papers on this topic in 1908-10.[10] It was these experiments that demonstrated that a small fraction of the α-particles are reflected back in their direction of origin. The observation—usually referred to as the gold leaf experiment—was the crucial factor that convinced Rutherford that the atom must contain a very small but massive nucleus. The formal birth of the nuclear atom[11] followed in 1911.

Rutherford's 1911 paper aroused surprisingly little interest in the scientific community. Even Rutherford himself, in *Radioactive Substances and their Radiations*, discussed the nuclear atom only briefly, although the scattering of α-particles by a nuclear atom is given fairly full treatment.[12] The general verdict was that the nuclear atom was unrealistic because—according to classical mechanics—orbiting electric charges (electrons) would radiate energy and rapidly spiral into the nucleus. However, by 1914 the situation had changed radically. This change was brought about by two factors. Firstly, in 1913 Niels Bohr published three papers "On the Constitution of Atoms and Molecules,"[13] in which he married Rutherford's atom to Planck's quantum theory, thereby stabilizing the electrons in certain fixed orbits and circumventing the objections of the classical physicists. Secondly, further important evidence in favour of the nuclear atom was provided in Rutherford's laboratory (see below).

Niels Bohr (1885-1962) was a young Danish theoretical physicist who had spent 6 months in Cambridge (1911-12) working under J. J. Thomson and then 4 months with Rutherford in Manchester (March–July 1912). Bohr wrote his "nuclear" paper (in three parts) in Denmark during the latter half of 1912 but sent it to Rutherford for criticism and submission to the *Philosophical Magazine*. For a succinct account of the interaction of Bohr and Rutherford prior to the publication of the latter's papers, see del Regato, *Radiological Physicists*,[14] especially Chapter 7. Subsequently Bohr spent a further two years (1914-16) with Rutherford as lecturer in Manchester University. A good biography of Bohr is that of Ruth Moore.[15] Bohr's own reminiscences of Rutherford were published in 1962 as a chapter in *Rutherford at Manchester*.[16] However, Bohr is nowhere mentioned by name in the correspondence in this article.

The additional experimental evidence on the nuclear atom took the form of investigations on the collision of α-particles with hydrogen and other light atoms. This work was carried out in Rutherford's laboratory by Charles Darwin (grandson of the author of *Origin of Species*) and Ernest Marsden.[17] As a result, in 1914 Rutherford was able to publish his second basic paper on the atom,[18] in which he stated that he would now discuss certain aspects of the "nucleus atom" which he had "deliberately omitted" in his 1911 paper.[19] The modern nuclear atom was now firmly established.

Introduction Notes

1. Montague Cohen, "My Dear Eve..., The Letters of Ernest Rutherford to Arthur Eve, 1907-1908," *Fontanus* 1 (1988), 3-37; and "My Dear Eve..., The Letters of Ernest Rutherford to Arthur Eve, Part II, 1909-1911," *Fontanus* 2 (1989), 111-138.

2. Lawrence Badash, *Rutherford Correspondence Catalog* (New York; American Institute of Physics, 1974).

3. Lawrence Badash, *Rutherford and Boltwood; Letters on Radioactivity* (New Haven: Yale University Press, 1969).

4. J.B. Birks, ed., *Rutherford at Manchester* (London: Heywood and Co, 1962).

5. Ernest Rutherford, *Radioactive Substances and their Radiations* (Cambridge: Cambridge University Press, 1913).

6. Ernest Rutherford, "Scattering of Alpha and Beta Particles by Matter and the Structure of the Atom," *Phil. Mag.*, Ser. 6, 22 (1911), 621-29.

7. H. Nagaoka, "Kinetics of a System of Particles illustrating the Line and the Band Spectra and the Phenonema of Radioactivity," *Phil. Mag.*, Ser. 6, 7 (1904), 445-55. This paper was also published in *Proc. Tokyo Mathematico-Physical Soc.*, Ser. 2, 2 (1904), 92-107.

8. Rutherford, *Radioactive Substances*, 620.

9. Ernest Rutherford, "Some Properties of the Alpha Rays from Radium" (Second Paper), *Phil. Mag.*, Ser. 6, 11 (1906), 166-76; and "Retardation of the Alpha Particle from Radium in passing through Matter," *Phil. Mag.*, Ser. 6, 2 (1906), 134-46.

10. Hans Geiger, "On the Scattering of the Alpha Particles by Matter," *Proc. Roy. Soc.* A81 (1908), 174-77; Hans Geiger and Ernest Marsden, "On a Diffuse Reflection of Alpha Particles," *Proc. Roy. Soc.* A82 (1909), 495-500; and Hans Geiger, "The Scattering of Alpha Particles by Matter," *Proc. Roy. Soc.* A83 (1910), 492-504.

11. See note 6.

12. Rutherford, *Radioactive Substances*, 180-86 and 616-20.

13. Niels Bohr, "On the Constitution of Atoms and Molecules," *Phil. Mag.*, Ser. 6, 26 (1913), 1-25 (Part I), 475-502 (Part II), 857-75 (Part III).

14. J.A. del Regato, *Radiological Physicists* (New York: American Institute of Physics, 1985).

15. Ruth Moore, *Niels Bohr: The Man, His Science, and the World they Changed*. (New York, Alfred A. Knoff, 1966).

16. Niels Bohr, "Reminiscences of the founder of Nuclear Science and of some Developments based on his Work," in *Rutherford at Manchester* (note 5 above), 114-167.

17. Charles G. Darwin, "Collision of α-Particles with Light Atom," *Phil. Mag.* Ser. 6, 27 (1914), 499-506; and Ernest Marsden, "The Passage of α-Particles through Hydrogen," *Phil. Mag.*, Ser. 6, 27 (1914), 824-30.

18. Ernest Rutherford, "The Structure of the Atom," *Phil. Mag.*, Ser. 6, 27 (1914), 488-98.

19. See note 6.

Bibliography

In addition to the bibliographic material listed above, specifically Notes 2-4 and 14-16, the following publications are relevant to this article and have been consulted in the preparation of the explanatory notes:

Andrade, Edward N. da Costa. *Rutherford and the Nature of the Atom*. New York: Doubleday, 1964.

Eve, Arthur S. *Rutherford. Being the Life and Letters of the Rt. Hon. Lord Rutherford, O. M.* Cambridge, Cambridge University Press, 1939.

Feather, Norman. *Some Episodes in the α-Particle Story*, 1903-1977 in *Rutherford and Physics at the Turn of the Century*, ed. Mario Bunge and William R. Shea. New York: Dawson and Science History Publications, 1979 (pp. 79-88).

Webster, Robert L. *Pioneers of Science. Nobel Prize Winners in Physics*, ed. J. M. A. Lenihan. Bristol: The Institute of Physics, 1980.

Wilson, David. *Rutherford, Simple Genius*. Cambridge, Mass.: MIT Press, 1983.

TABLE I

The Rutherford-Eve Correspondence
Part III: 1912-1914

Rutherford to Eve		Eve to Rutherford	
		E-21	28 January 1912
R-16	28 March 1912*		
R-17	5 April 1912*		
		E-22	4 June 1912
R-18	25 June 1912		
		E-23	15 July 1912
R-19	16 August 1912		
		E-24	11 December 1912
		E-25	16 December 1912
R-20	10 January 1913		
		E-26	19 January 1913
R-21	19 February 1913		
R-22	5 March 1913		
R-23	31 March 1913		
R-24	3 June 1913		
R-25	15 December 1913		
R-26	19 January 1914		
R-27	17 February 1914		
		E-27	27 February 1914
		E-28	1 March 1914
R-28	14 March 1914		
		E-29	18 May 1914
		E-30	3 June 1914
R-29	4 June 1914		
R-30	15 June 1914		

* Postcard

E-21 Eve to Rutherford

McGill University, Montreal
The Macdonald Physics Building
28 January 1912

This short letter, written after an interval of almost three months since letter E-20 (1 November 1911), is devoted entirely to the sudden death of Mrs. Barnes, the wife of Eve's colleague Dr. Howard Barnes.[1] "She was recovering well from the birth of her twin daughters three weeks previously, and the doctors thought that danger was over. But she suddenly fainted in bed and never recovered consciousness. Dr. Barnes was with her at the time, and the moment before she had been well and happy. The doctors suppose it was a clot of blood stopped the valves of the heart. The funeral (private) was this morning. It is scarcely possible to conceive of a more deplor-

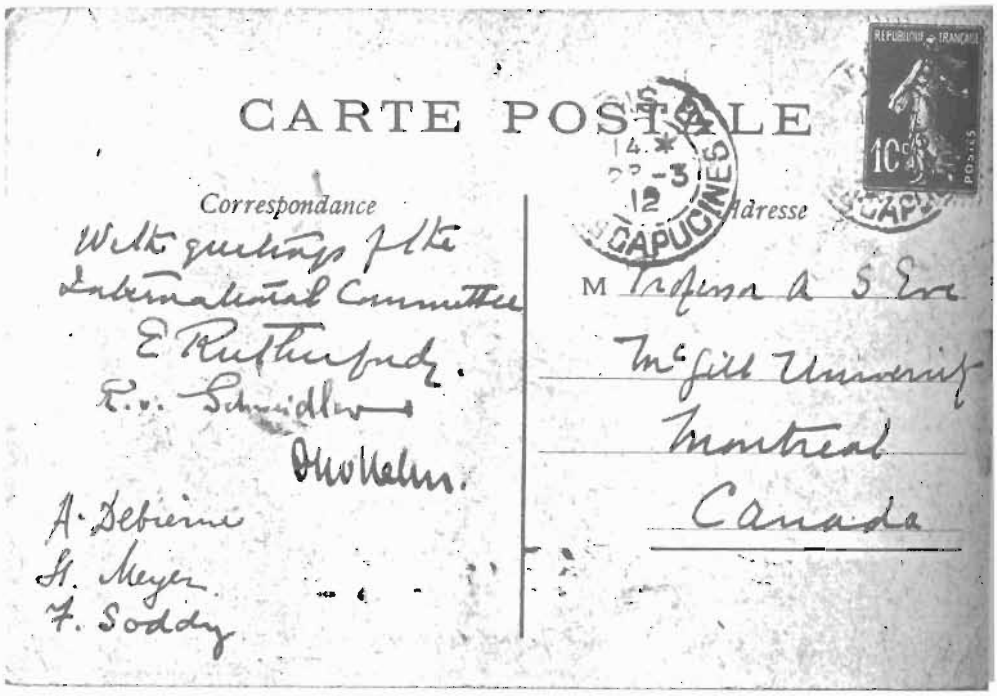


Figure 3. Postcard sent to Eve from Paris (March 1912) and signed by members of the International Radium Standards Committee (see letter R-16).

Figure 4. Postcard from Rutherford to Eve, mailed in the French Pyrenees, April 1912 (see letter R-17).

TABLE II

Papers Published by Rutherford and his Colleagues and Students at Manchester University, 1907-1919*

Year	Rutherford alone	Rutherford with co-author(s)	Other authors	Total
1907	(10)	(0)	(3)	(13)
1908	5	10	16	31
1909	8	8	23	39
1910	5	2	23	30
1911	6	3	30	39
1912	5	3	34	42
1913	3**	9	31	43
1914	3	4	34	41
1915	6	1	18	25
1916	1	1	9	11
1917	1	0	7	8
1918	1	0	3	4
1919	6	1	0	7

* Data derived from the Bibliography in J. B. Birks (ed.), *Rutherford at Manchester* (1962).
** Plus book

able loss, both for poor Barnes, the two boys and those baby twins."

E-21 Notes

1. Howard Turner Barnes (1873-1950) was Macdonald Professor of Physics at McGill and (since 1910) Director of the Physics Laboratories (see Note 8 of letter R-9 in Part II.) According to J. S. Foster, who wrote the obituary of Barnes in *Obituary Notices of Fellows of the Royal Society*, 8 (November 1952), 25-35, the tragic death of his wife, combined with the excessive burden of work resulting from the loss of staff in World War I, led to a serious nervous breakdown in 1917. Norman Shaw makes a similar statement in an obituary of Barnes published in the *Proceedings of the Royal Society of Canada*, 45 (1951), 77-81. There is a 9-year gap in Barnes' publications, from 1917 to 1926, by which time he had recovered sufficiently to resume scientific work as an Emeritus Professor. The evidence of Barnes' letters to Rutherford in 1912 (6 are preserved in the Cambridge collection) is equivocal. On the one hand the letters give little hint of an *imminent* nervous collapse. On the other hand several of these letters indicate a disenchantment with teaching and a desire for a change, which was no doubt only one symptom of the severe stress which eventually led to a breakdown. Thus, on November 25, 1912, Barnes wrote, with reference to his work on icing in the Gulf of St. Lawrence: "I expect to get substantial help from the Government sufficient to make me independent of teaching work. Whether I continue on here will depend on what arrangements I can make with the University." Two weeks later (December 12, 1912) he wrote: "I feel now sadly lacking in authority and power, even my teaching is done badly and unless I can get a better grip on things I feel for the best interests of the University that I must get out."

R-16 Rutherford to Eve (Figure 3)

This postcard, dated March 28, 1912 was mailed in Paris and signed by six members of the International Radium Standards Committee,[1] viz: Ernest Rutherford (U.K.), Egon von Schweidler (Austria), André Debierne (France), Stefan Meyer (Austria), Otto Hahn (Germany) and Frederick Soddy (U.K.). Mme Curie was present for part of the meeting of the Committee but did not sign the card. (The postmark *Capucines* refers to *Boulevard des Capucines* in the heart of Paris.)

R-17 Rutherford to Eve (Figure 4)

The text of this postcard, dated April 5, 1912, reads:

This is on our motor trip to the Pyrenees. Fine weather, motor behaving itself and generally quite contented.[2] You will hear from Meyer standards all lined up O.K.

E. Rutherford

(The photograph on the reverse side of the card is of the mountains near Gavarnie, not far from the Spanish border.)

R-16/17 Notes

1. The International Radium Standards Committee was set up in September 1910 under the joint Chairmanship of Rutherford and Mme Curie (see Note 3 of letter R-11). One of the tasks of the Committee was to arrange for the preparation of one or more radium sources which could be designated as international standards. By 1912 suitable sources, each containing a known mass of radium, had been prepared in Paris (by Mme Curie) and in Vienna (at the Institut für Radiumforschung.) A meeting of the International Committee was therefore called for the purpose of comparing the strengths of the Paris and Vienna sources by measuring the intensity of the γ-rays emitted by each source. (The γ-intensity should be proportional to the mass of radium in the source, after making certain corrections.) The experimental comparison was made by two different methods. The first involved an ionization chamber and a "piezo-electric" electrometer developed originally by Pierre Curie. The other method utilized a technique described by Rutherford and J. Chadwick: "A Balance Method for Comparison of Quantities of Radium and some of its Applications," *Proc. Phys. Soc.*, 24 (1912), 141-51.

In a letter to Bertram Boltwood (the U.S. member of the Committee who was unable to attend the Paris meeting), written prior to the meeting on March 18, Rutherford said: "I have not much doubt but that the two standards will be found in very good agreement, but it will be a devil of a mess if they are not. That is one of the reasons I must be there to act as arbitrator between the two parties." (Badash, *Rutherford and Boltwood*, 264.) In the event, the Paris and Vienna standards agreed within the limits of error of the measurements, about 1 part in 300—hence Rutherford's statement in postcard R-17 "You will hear from Meyer standards all lined up O.K.," Stefan Meyer (Director of the Institut für Radiumforschung in Vienna) being the Secretary of the International Committee.

It was decided to deposit the Paris source in the Bureau International des Poids et Mesures as the primary world standard, while the Vienna source (actually one of three Austrian sources measured at the meeting) was to be held in the Radium Institute in Vienna as a reserve standard.

In a post-meeting letter to Boltwood (22 April 1912), Rutherford commented as follows: "The meeting passed off very pleasantly and without any friction. Debierne [Mme Curie's colleague] had made excellent arrangements for the apparatus for testing, and proved himself a very sensible person. We all had lunch with Mme Curie and her family. She looks rather feeble and ill, but no worse than she did at Brussels two years ago. We held a short meeting in her house and then retired to the Laboratory to make the final arrangements, with which she was quite satisfied. I think we perhaps got through matters very much quicker without Mme Curie, for you know she is inclined to raise difficulties." (*Ibid.*, 270) A full account of the meeting and its results was published in *Nature* by Soddy in an unsigned article: "The International Radium Standard," *Nature*, 89 (April 4, 1912), 115-16.

2. In his letter to Boltwood prior to the meeting, Rutherford wrote: "I leave Paris on the

following Thursday morning [March 28] and go to Havre, where I am to meet my wife, the chauffeur and the motor, and also Professor [W.H.] Bragg, who is coming with us. We then intend to make a beeline for the South of France, skirt along the Pyrenees and return homewards, a distance in all of 1,800 miles in a little over three weeks... I am pretty well tired out and want a holiday with no cares or worries, although I anticipate plenty of a mechanical kind." (Badash, *Rutherford and Boltwood*, 264). Evidently the "mechanical worries" did not materialize since Rutherford's letter to Boltwood after returning home (22 April 1912) speaks of a "thoroughly pleasant time, with three weeks' sunshine marred occasionally by cold wind" but makes no mention of any automobile breakdown (*ibid.*, 269.)

E-22 Eve to Rutherford

McGill University, Montreal
The Macdonald Physics Building
4 June 1912

The main pupose of this letter is to send Rutherford the half-yearly interest ($62.50) due on June 1st, in respect of the mortgage taken by Eve a year earlier when he purchased from Rutherford some land near Montreal.[1]

Eve mentions that he and his family will be spending July and August at Porter's place at Guysborough in Nova Scotia.[2] He goes on to state that H. A. Wilson will marry Miss Paterson Smythe in July and will move to the new University at Houston, Texas in September.[3] "It is a great loss to us, as he is a very sound and learned physicist, and I like him. Whether or not he is wise to make the change is an open question, on which opinions differ."

Eve notes that "I am fooling with X-rays and finding some interesting points, but nothing of the first magnitude."[4]

Eve expresses the hope that "your motor journey through France to the Pyrenees was a golden holiday for you and Mrs. Rutherford;"[5] also "I hear that Barnes and Cunliffe[6] were with you at the same time."

E-22 Notes

1. The land in question had been acquired by Rutherford in 1906 for the purpose of building a house, but Rutherford left Montreal before the plan could be carried out. The purchase arrangements included a 20-year mortgage for $2,500 at 5%, granted by Rutherford to Eve. See also Note 4 of letter E-16 in Part II of this article.

2. J. Bonsall Porter was Macdonald Professor of Mining Engineering at McGill University. Guysborough is on the coast of Nova Scotia, about 200 km east of Halifax.

3. Harold A. Wilson was Macdonald Professor of Physics at McGill from 1909 to 1912, when he was appointed Professor of Physics at the Rice Institute in Houston, Texas. See Note 8 of letter R-9 in Part II.

4. Eve's "fooling with X-rays" led to the publication of two papers in 1912: A. S. Eve and F. H. Day, "On the Absorption of Röntgen Rays in Air," *Phil. Mag.* Ser. 6, 23 (April 1912), 683-688; and A. S. Eve, "A Comparison of the Ionization within Closed Vessels due to Röntgen and Gamma Rays," *Phil. Mag.* Ser. 6, 24 (September 1912), 432-36.

5. See letter (postcard) R-17 and Figure 2. This card was written two months earlier and had almost certainly been received by Eve, together with the postcard from Paris written on March 28, before he composed his letter on June 2. It is strange, therefore, that Eve did not acknowledge receipt of either message. Furthermore, Rutherford's trip to the Pyrenees followed the meeting in Paris of the International Radium Commission which Eve was unable to attend (see Note 2 of R-17), yet he does not mention the meeting in this letter. The most likely explanation is that a letter (or letters) from Eve to Rutherford written in the period February-May 1912 has been lost.

6. Barnes: see Note 8 of letter R-9 in Part II and Note 1 of letter E-21. Cunliffe: John Williams Cunliffe had been a Lecturer/Associate Professor at McGill from 1899 to 1907, when he moved to Columbia University. (Barnes' wife was Annie Kershaw Cunliffe, but I have been unable to determine the relationship, if any, between Annie and John Cunliffe.)

R-18 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
June 25, 1912

My Dear Eve,

I beg to acknowledge the receipt of a draft from the Bank of Montreal for £12. 16. 9. in payment of half yearly interest on your mortgage due on June 1st, 1912.

I was interested to hear from H. A. Wilson of his decision to go to Texas, and also to get married. Of course I quite understood the last few years that for a number of reasons Barnes and he have not pulled together very well. I understand that Wilson's post is a good one, but I would not like personally to go to such a hot place. I was not able to see Barnes before he left or I would have discussed the matter with him. I presume that you personally would have no objection to be a candidate, but I have no idea what the University proposes to do in the matter. I hope to see Peterson at the Universities Congress[1] and to enquire about the matter.

We have just finished our Examinations, and finish up with Degree Day at the end of the week. The summer is filled with Congresses of various kinds, including the Universities Congress next week, then the Royal Society Celebration[2] followed by the Mathematical Congress at Cambridge[3] and the B. A. meeting[4] not to mention the Eugenics Congress[5] thrown in.

I have got a lot of work in progress and hope to get some of it done. As you know Geiger is leaving us at the end of the summer to go to the Reichsenstalt.[6] We shall miss him very much. I am fortunate, however, in having a number of good men at this stage, and hope to do something definite with them.

I think my general idea of the atom, which I published a year ago, is being rapidly verified.[7] I have now not the least doubt that most of the mass of the atom is concentrated throughout an exceedingly small volume.

I have now got on to the last chapter of my book and shall be very thankful when it is through.[8] We are all a little bit under the weather at present, which has been fairly hot and close, and Eileen is in bed with a bilious attack, but otherwise there is not much to complain of.

I shall be glad to hear how things are progressing with you, and hope you are all in good health.

With kind regards,

Yours very sincerely,
E. Rutherford

R-18 Notes

1. The Congress of the Universities of the Empire took place in London, July 2-5, 1912, with the participation of more than 50 universities. McGill was represented by the Chancellor, Lord Strathcona, and the Principal, Dr. Peterson, both of whom appear to have played prominent roles in the proceedings. However, the extensive reports of the Congress in the London *Times* make no mention of Rutherford's participation; nor does Rutherford refer to the Congress in subsequent letters such as those of August 15 to Boltwood (Badash, *Rutherford and Boltwood*, 275) and August 16 to Eve (R-19 in this article.) Nevertheless, in the present letter Rutherford indicates his intention of attending the Congress and, in his next letter to Eve (R-19) confirms that he has seen Peterson "when he was in England."

2. To celebrate the 250th anniversary of its foundation, the Royal Society of London organized a number of events, including a reception in the Society's rooms in Burlington House, London (July 15, 1912), a service at Westminster Abbey (July 16) and a banquet in the Guildhall (July 16). The celebrations were attended by about 300 delegates from Britain, the Dominions and other countries. Canada was represented by Dr. Peterson, Principal of McGill University. However, the *Times* did not include Rutherford in the list of guests, which is strange in view of the fact that Rutherford was not only a Fellow of the Society but a recipient of the Society's Rumford Medal in 1904 and a Nobel Laureate (1908).

3. The International Congress of Mathematicians was held in Cambridge,

August 22-27, 1912 but there is no indication that Rutherford attended even a part of the meeting.

4. The annual meeting of the British Association for the Advancement of Science took place in Dundee, Scotland, commencing September 5, 1912. The Presidential address in Section A (Physical Science) was given by Prof. H. L. Callendar (Rutherford's predecessor at McGill) on the nature of heat. Rutherford and an assistant, Mr. H. Robinson, gave a paper on the heating effect of emanation and its products.

5. The International Eugenics Conference was held at London University, July 24-30, 1912, but there is no indication that Rutherford participated in any way.

6. *Reichsenstalt* refers to the Physikalisch-Technische Reichsanstalt in Berlin (the spelling error is Rutherford's.) Hans Geiger was appointed Director of the Laboratory for Radium Research (see Note 5 of letter R-9 in Part II for further details.)

7. Rutherford published his new theory of the structure of the atom—the now-familiar nuclear atom—in the May 1911 issue of *Phil. Mag.* (see Note 6 of letter R-13 in Part II and "The Nuclear Atom, 1904-14" in the Introduction to this article.). The "verification" to which Rutherford refers rested mainly on careful experimental work on the scattering of α-particles by matter through large angles. These measurements were made by Geiger and Marsden and published in April 1913: H. Geiger and E. Marsden, "The Laws of Deflexion of Particles Through Large Angles," *Phil. Mag.* Ser. 6, 25 (1913), 604-23. This was followed, in July 1913, by the paper of Neils Bohr (at that time working with Rutherford in Manchester) which gave the "Rutherford" atom a sound theoretical basis in quantum physics and thereby firmly established the "Rutherford-Bohr" nuclear atom: N. Bohr, "The Constitution of Atoms and Molecules," *Phil. Mag.* Ser. 6, 26 (1913), 1-25.

8. "My book" refers to the third edition of *Radioactivity*, first published in 1904. However, the book eventually appeared under a new title *Radioactive Substances and their Radiations* and was essentially a new work. See subsequent correspondence in this article, especially letter E-25, also Note 7 of letters E-18/19/20 in Part II.

E-23 Eve to Rutherford

Long Beach Lodge
Guysborough, Nova Scotia
15 July 1912

Eve thanks Rutherford for his letter (R-18) which "has followed me here." He praises "Porter's charming place" and comments "It is my first experience of Nova Scotia and it is a beautiful country—in summer."

Eve expects that the new edition of Rutherford's book "will be a great help to all. Mme Curie's book[1] is useful but the fatal omission of an index spoils it."

The main topic of the letter is the vacant Chair of Physics at McGill University:[2] "As to the vacant chair I think that the University would like to catch a Really Great Man. If they cannot, they may appoint me. I quite concur with this view. I would not like to see them appoint a man who was just about my equal. However, I am conscious that both physically[3] and intellectually I could never hope to *fill* a chair occupied previously either by yourself or H. A. Wilson.[4] I think that the Governors will be guided much by your view, and you need not worry about me, as I shall be perfectly happy whether I do or do not get the post. My present billet[5] is a very satisfactory one, and the honour of promotion to your chair would give me the greatest pleasure."

Eve concluded the letter with a comment on his vacation activities: "My wife walked about 8 miles and fished most of yesterday with me. Last week I lost a 10 lb salmon, after an hour's acquaintance, for want of a gaff.[6] I had light trout tackle and a small net."

E-23 Notes

1. Marie Curie, *Traité de radioactivité* (Paris: Gauthier-Villars, 1910, 2 v.) See also letter R-13, especially Note 8, in Part II.

2. The vacant chair was the Macdonald Professorship in Physics occupied by Rutherford from 1898 to 1907 and subse-

quently by H. A. Wilson, who was due to take up a new appointment in Texas in September 1912 (see letter E-22). At this time Eve's official position was that of Associate Professor of *Mathematics*, even though his work was entirely within the field of physics. It should also be stressed that there were *two* Macdonald Professors of Physics, one of whom (H. T. Barnes) was also Director of the Physics Building. (Physics was not yet dignified with the status of "department.") Eve was therefore seeking promotion but at this stage did not aspire to direct the physics program.

3. The significance of Eve's use of the work "physically" is not clear. It could perhaps refer to the fact that Eve was older than both Rutherford and Wilson.

4. See Note 2 above.

5. *Billet* is used here to mean "appointment" or "situation."

6. *Gaff*: a barbed fishing-spear or stick with an iron hook for landing large fish.

R-19 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
August 16, 1912

My dear Eve,

I received your letter some time ago re Montreal matters. I quite understand your position, which I think is very reasonable and sensible. I saw Peterson when he was in England, and I gathered from him that no definite move will be made in the question of a successor for some little time.[1] We naturally spoke of your claims, and Peterson obviously is quite sound on that point. I am not sure, however, whether ultimately it might not be better for you in any case to retain your present position,[2] which I presume will ultimately be as good as a Professorship of Physics. I do not know of anyone at the moment who I think is big enough to fill the post. It seems to me from the point of view of McGill's best interest that it may be worth their while to catch a young fellow of promise and appoint him on a much lower salary than Wilson, and look after him if he develops. I may be prejudiced on this point of view, but I certainly derived great benefit from such a course, and I trust the University did likewise.

I had a visit to-day from W. Heap Holland of Fairmount, British Columbia, who has a ranch in British Columbia, and has on it some hot springs which he thinks may turn out to be of commercial value. As a preliminary, he wants the activity of the waters examined,[3] and I referred him to you as the man nearer the spot. His people live near here, and he informs me that he is a nephew of Lord Rotherham. Notwithstanding that he seems a thoroughly good fellow and has commercial interests in Manchester as well as in Canada. He tells me he knows Adami, who lives in his neighbourhood.[4] I referred him to you as I thought you might possibly think it worth while to keep in touch with radio-active examination of waters etc. in Canada.

We are going on a holiday tomorrow and I am just trying to push work through.

Yours ever,
E. Rutherford

R-19 Notes

1. Rutherford is replying to Eve's letter of 15 July 1912 (E-23). The matter in question is the Macdonald Professorship of Physics vacated by H. A. Wilson (see Note 2 of E-23) and earlier held by Rutherford himself. Rutherford's information was correct: the post remained unfilled through the 1912-13 academic year. Eventually Eve was appointed: see Note 5 of letter E-24 below.

2. As stated in Note 2 of letter E-23, at the time Eve's official position at McGill was that of an Associate Professor of *mathematics*, although most of his work was in the domain of physics. Rutherford's statement that "I do not know anyone ... who ... is big enough to fill the post" is a tactful way of saying "I do not think that *you* are big enough for the post."

3. At the time, and indeed well into the 1960s, radioactivity was considered a desirable feature of the spring water found in many health spas. At the time also, scientists in many countries, including Canada, were busy measuring the low levels of radioactivity found

in ocean and lake waters as well as in rocks and other naturally occuring substances. Eve was well placed to help Rutherford's visitor in his quest.

4. John George Adami was Professor of Pathology and Bacteriology at McGill. He had held this post since 1892, i.e., throughout Rutherford's tenure at McGill, and the two men clearly knew each other. (A letter from Adami to Rutherford, dated 11 January 1912, is preserved in the Cambridge collection.) However, the statement that Adami "lives in his neighbourhood" is a puzzle. Presumably the "neighbourhood" refers to Fairmount, British Columbia, but there is no evidence that Adami either lived in B.C. or had an association with that province. A posthumous tribute to Adami, with contributions from his widow, friends and colleagues (Marie Adami, "J. George Adami: a Memoir," London: Constable, 1930) gives no hint of a link with British Columbia. It is probable, therefore, that Rutherford misunderstood his visitor and that the association was in England rather than Canada. Adami hailed from Liverpool (and eventually retired there) and it is possible that Adami's family in Northwest England, between Manchester and Liverpool, was known to Holland's family in the same area.

E-24 Eve to Rutherford

McGill University, Montreal
The Macdonald Physics Building
11 Dec 1912

Eve begins by thanking Rutherford "for the goodly pile of papers bearing witness to the tireless energy of yourself and your Laboratory." He then comments on the work of two German scientists: "Laue's work is very interesting and suggests an electromagnetic explanation of X-rays.[1] How do they ionize?"[2] and "The extra radiation which Hess[3] got, strongly marked, at 4000 meters is a puzzler. If real, it more than accounts for the discrepancy with altitude."[4]

Eve then refers to his own position at McGill: "I am sending a letter to Peterson[5] asking him to define my position, if possible, before 1st February. If they do not promote me now, they never will, and I have no intention of vegetating, and I have enough means to risk throwing myself on the wide wide world, if they turn me down. Naturally I would rather not."

With regards to his on-going research, Eve writes that he is trying to settle up a few points on penetrating radiation, and "the evidence is pretty good already."[6] In general "Everything is going quietly and well in the Physics Building." However, Eve hastens to add that "Men are overburdened with teaching, coaching and demonstrating and it decreases the output of research work. I think the above have more than doubled since you left us."[7]

E-24 Notes

1. Max von Laue (1879-1960) was the discoverer of X-ray diffraction, i.e., the "reflection" of X-rays by the atoms in a regular crystal structure, analogous to the diffraction of light by a grating. In 1909 von Laue became a *Privatdozent* at the Institute for Theoretical Physics of the University of Munich. In the spring of 1912 he conceived the idea of sending a narrow beam of x-rays through a crystal of zinc sulphide; the result was an array of dark points on a photographic plate behind the crystal, each point corresponding to the diffraction of the rays by regularly spaced atoms in the crystal. In May 1912 von Laue, together with assistants Walter Friedrich and Paul Knipping, announced their success in a letter to the Bavarian Academy of Sciences. Von Laue was awarded the Nobel Prize in Physics in 1914. The discovery of X-ray diffraction was important in two ways: firstly, it confirmed the wave nature of X-rays, i.e., X-rays are electromagnetic radiation similar to light but of a shorter wavelength, an unproven (and controversial) assumption before 1912; secondly, it proved that crystals are regular arrays of atoms and opened up a powerful new technique for the study of these structures.

2. *How do they ionize?* Eve's question was pertinent. Ionization is the process whereby neutral atoms of matter are converted into pairs of positively and negatively charged particles (ions). It was assumed at the time that ionization was brought about by direct collisions between moving particles and atoms, such that the more massive the particle the

greater the effect. On this basis an electromagnetic wave, which has no mass at all, ought not to ionize. However, in 1900 Planck had postulated the discrete (quantum) nature of radiation and in 1905 Einstein had used Planck's theory to explain the emission of electrons from a metal surface by light (the photoelectric effect.) It remained to apply quantum theory to the interaction of X-rays with matter and to show that most of the ionization observed with X- and γ-rays is *indirect*, i.e., the initial interaction processes result in relatively few moving particles, each of which, however, has sufficient energy to generate a large number of ions.

3. In 1910 Victor Franz Hess (1883-1964) became an assistant to Stefan Meyer at the newly founded Institute for Radium Research in Vienna. In the period 1919-38 he was professor of physics at the Universities of Vienna, Graz and Innsbruck. He left Austria following the Nazi occupation in 1938 and was appointed professor of physics at Fordham University in New York. Hess received the Nobel Prize in physics in 1936 for his discovery of cosmic radiation (see Note 4 below).

4. In 1910 Theodor Wulf found (in measurements at the Eiffel Tower) that the ionization of the atmosphere at 300 m above a γ-ray source is greater than at 300 horizontal meters. He suggested that extraterrestrial sources were responsible for this effect. In 1911 Hess took up the problem and (with the aid of the Austrian Aeroclub) made ten daring balloon ascents to collect data, reaching a height of 5350 m. Hess found that the ionization of air decreased up to about 150 m, but increased at greater heights, such that the radiation at 5,000 meters was several times that at sea level. Furthermore, at all levels the radiation was the same night or day and the altitude effect could therefore not be due to direct radiation from the sun. The name "cosmic radiation" was suggested by R. A. Millikan in 1925.

5. Williams Peterson was Principal (also Professor of Classics) of McGill University (see Note 7 of letter R-9). In the event, Eve did not carry out his threat to throw himself "on the wide wide world" since he was appointed Macdonald Professor of Physics in 1913, although the effective date of the appointment is not stated in the McGill Annual Report for 1912-13. (See also Note 2 of E-23 above.)

6. *Penetrating radiation* means X- and γ-rays. However, apart from the two papers already published in 1912 before this letter was written (see Note 4 of E-22 above), Eve did not publish this work.

7. It is difficult to substantiate Eve's statement from the statistics given in the McGill annual reports for the period. According to these data, the total enrolment of undergraduate students in the downtown campus increased from 969 in 1906-7 to 1104 in 1911-12, a gain of 14 percent. In the Faculties of Applied Science and Arts the gains were somewhat larger, 21% (374 → 453), and 24% (257 → 319) respectively. However, the enrolment in Medicine remained stationary: 338 → 332. On the other hand, it is possible that the teaching load per member of the staff was not directly linked to the student enrolment.

E-25 Eve to Rutherford

McGill University, Montreal
The Macdonald Physics Building
16 Dec 1912

This letter is concerned entirely with Rutherford's new book *Radioactive Substances and their Radiations*,[1] an advance copy of which Eve has just received. Eve begins by thanking Rutherford for "your much appreciated gift... All my spare time yesterday I was reading, and dipping into it eagerly."

Eve's general appraisal of the book is as follows: "It is awfully well done and I congratulate you on it. You have been quite liberal to the old pioneers, and not allowed their often difficult labours to be obliterated by the latest determination. This adds to the charm of the book, as you can see the flower opening all the way from the bud. It seems to me remarkably free from all misprints and errors, although by the way *coconut* has nothing to do with *cocoa* beans (see Murray's Dict[y]). But perhaps cocoanut is almost permitted by usage.[2] Your references to my work are so frequent that I have a feeling that your heart was working with your brain. It is astonishing that so young a subject is so rapidly approaching a more or less

final form, by which I mean that the next steps forward are likely to be either speculative or attained with extreme toil.[3] I wish we could get some hint as to how the energy got into the uranium atom, and how it is tipped out."[4]

Eve concludes with a paean of praise for Rutherford, comprising an astonishing mixture of metaphors: "This book is a monument to your work; for the work of your pupils is so largely yours, and we know it. Unless you had been at the helm or in the crow's nest, the whole ship would have littered the seas in chaos. I should like to know what sort of comic opera of a subject, and what wild notations, we should have had without you."

E-25 Notes

1. E. Rutherford, *Radioactive Substances and their Radiations* (Cambridge University Press, 1913), 699. This book was actually the 3rd edition of Rutherford's 1904 book *Radioactivity* but (as stated in E-18/19/20 Note 7) a change in title was decided upon in order to avoid difficulties relating to translation rights.

2. The reference to *coconut* refers to section 138 (pp. 378-80) of the book, in which Rutherford notes that "charcoal and notably cocoa-nut charcoal is a strong absorbent of the emanations of radium and thorium." The section discusses the mechanism and applications of the phenomenon, for example to determine the amount of radium emanation in the atmosphere, a topic of particular interest to Eve: A. S. Eve, "On the amount of radium emanation in the atmosphere near the earth's surface," *Phil. Mag.* Ser. 6, 16 (1908), 622-32. Eve's implied criticism of Rutherford's spelling of *cocoa-nut* is only partly justified. *Murray's Dict*[y] refers to *A New English Dictionary on Historical Principles* (in 10 volumes) edited by James A. H. Murray (Oxford: Clarendon Press, 1888-1933), subsequently known as the *Oxford English Dictionary*. Volume II, published in 1893, gives *coco* as the preferred spelling of the Indian nut, with *cocoa* as a corruption of *cacao*, the seed of *Theobroma Cacao*, a tropical American tree. The dictionary notes: "The word [cocoa] was originally of 3 syllables, *ca-ca-o, co-co-a*, but the error of spelling *coco* as *cocoa* has led to the further corruption of pronouncing *cocoa* as *coco*." It is safe to assume that Rutherford understood the difference between the coco- (or cocoa-) *nut* and the cacao *bean*.

3. Eve's statement that the subject of radioactivity is "so rapidly approaching a more or less final form" might be considered as optimistic in view of the fact that the neutron and the neutrino had not yet been discovered, the concepts of atomic number and isotopes not yet developed and artificial (induced) radioactivity not yet demonstrated. However, the validity of Eve's statement turns on the meaning of "the subject of radioactivity." Badash has argued that, in terms of the chemical identification of the elements in the natural decay series, and the nature of the transitions between them, the problem was indeed solved by the early 1920s. Badash speaks of the "suicidal success of radiochemistry" in the years before 1920. As a result the subject virtually did not exist in the 1920s but was resurrected in the mid-1930s (following the discovery of artificial radioactivity) as nuclear chemistry, while radio-physics became nuclear physics. See: Lawrence Badash, "The Suicidal Success of Radiochemistry," *Brit. J. Hist. of Science*, 12 (1979), 245-56. The concept of a given chemical element occurring in different forms with different atomic weights was put forward virtually simultaneously by Kasimir Fajans and Federick Soddy: K. Fajans, "Die Stellung der Radioelemente in Periodischen System," *Physikalische Zeitschrift*, 14 (1913), 136-42; F. Soddy, "The radio-elements and the periodic law, *Chemical News*, 107 (28 Feb. 1913), 97-9. The name *isotopes* for this phenomenon was suggested by Soddy in December, 1913: F. Soddy, "Intra-atomic charge," *Nature* (4 Dec. 1913), 400. For a discussion of the contributions of Fajans, Soddy and others to the concept of isotopes, see the paper by Badash cited above.

4. Although the equivalence of mass and energy had been enunciated by Einstein as far back as 1905 (the famous equation $E = mc^2$) the principle had not so far been applied to radioactivity. It was not yet realized that a radioactive transformation involves a small loss in mass (i.e. the total mass of the daughter atom and the ejected particle is less than that of the parent atom) and it is this "missing"

mass which provides the energy needed to eject the particle. In his 1913 book (written in 1911-12) Rutherford refers (p. 618) only to J. J. Thomson's theory that "an atom consisting of a large number of revolving electrons may radiate energy extremely slowly, and yet, finally, this minute but continuous drain of energy from the atom must result either in a rearrangement of its component parts into a new system, or in an expulsion of electrons ... from the atom."

R-20 Rutherford to Eve

Private and Confidential*
17 Wilmslow Road
Withington, Manchester
Jan. 10th, 1913

My Dear Eve

I enclose herewith a formal receipt for the draft you sent me from Montreal, which I ought to have sent earlier.

Please give our thanks to Mrs. Eve for sending the fine photograph of your girl. It is a very excellent picture.

I have just returned from a holiday on the Riviera, where we had a very pleasant and quiet time with plenty of sunshine. I received while there your letter about my book. I am glad you have a good opinion about it, and value very much your kind remarks. It was a heavy task getting it through and I am very glad to have it off my hands. I have now got rid of a good many meetings etc., like the Royal Society and the University Council, and will have more leisure for my own work this year.

You will see by a letter in "Nature" of Chadwick and Russell[1] that we are pushing on with the production of γ rays by α rays. I think I told you that I am analysing the radiation from radioactive substances, and think I shall be able to put the matter into good shape, and show the connection with β rays. It will take, however, a good deal of experimental work before I am in a position to say very much.[2] The question of the crystal photographs of the X-rays is very interesting, and there seems to be no doubt that young Bragg's explanation that the spots are obtained by reflection from crystal layers, is satisfactory.[3] As you say, the important question is whether the rays ionise. C. T. R. Wilson has tried it by his method and says they do not.[4] One of my men, Moseley, is examining the question by a very delicate method, and should soon be in a position to settle definitely the problem.[5]

I have heard nothing very definite about what is to be done about the Physical Department in Montreal. Barnes occasionally writes to me and is apparently not very certain of his own plans. I can well appreciate the conditions of the Department have changed a good deal since my departure. The number of students has increased so much that obviously a large amount of the energy of the teachers has to go in lectures and demonstrating. I was interested to hear that you have asked Peterson to regularise your position. From what you told me some time ago, I presume that you are content either to go on with the more Mathematical side or to switch over entirely to the Physical side. I do not know what are Peterson's views on the question; but between ourselves I think he appreciates that it is rather difficult to fit in people with Barnes. He was certainly very annoyed at the departure of H. A. Wilson, and was inclined to blame Barnes a good deal for it. On the other hand, I gathered from Barnes' letters to me that he is rather wavering whether to go with the professorial work or to take up work with the Government.[6] If he were to decide to give up his professorial work it would, of course, greatly simplify the situation. It would then be possible to consider the whole matter afresh and decide upon the best course of action to pursue independent of personal considerations. In such a case, it would seem to me desirable to appoint a somewhat senior man as Director, and as a second man some young fellow of promise whose position could be improved as he showed his worth. As far as I can see, it is no very light task running the show at present, and there will want to be a great deal of teaching power if there is to be much leisure for individuals in research. From my conversation with Peterson I am quite sure that he understands your position and will take your claims into his consideration.

I shall be glad to hear from you how things develop. I do not like writing to Peterson about the matter until he writes definitely to me, and I do not know whether he will do so.

I am glad to hear that your family is progressing well. Give my kind regards to Mrs. Eve, and I wish you all a happy New Year.

Yours very sincerely,
E. Rutherford

PS How is Gray[7] doing? He writes to me occasionally.

[*] Added by hand.

R-20 Notes

1. J. Chadwick and A. S. Russell, "Excitation of γ Rays by α Rays," *Nature*, 90 (Dec. 26, 1912), 463. Also: J. Chadwick, "Excitation of γ Rays by α Rays," *Phil. Mag.* Ser. 6, 25 (Jan. 1913), 193-97.

2. The "good deal of experimental work" was accomplished in a remarkably short time. In 1913 Rutherford (with his research students H. Richardson and H. Robinson) published three papers on the γ rays from different radioactive elements, viz: radium B, C, D, and E, thorium products and actinium products (*Phil. Mag.*, Ser. 6, 25 (1913), 722-34 and 324-32; 26 (1913), 937-48.) Further papers on the same topic appeared in 1914, viz: the soft γ rays from radium B, and the penetrating γ rays from radium B and C (both with E. N. da C. Andrade) (*ibid.* 27 (1914), 854-68 and 28 (1914), 263-73); the ß rays excited by γ rays (with H. Robinson and W. F. Rawlinson) (*ibid.*, 28 (1914), 281-86); the connexion between the ß and γ ray spectrum (*ibid.*, 28 (1914), 305-19).

3. "Young Bragg" refers to William Lawrence Bragg (1890-1971), the son of William Henry Bragg (1861-1942) who was Professor of Physics at Leeds University from 1909 to 1915. At the time of this letter the younger Bragg was a research student at the Cavendish Laboratory. A few months earlier, in May 1912, von Laue and his colleagues in Munich had announced the remarkable result of passing a narrow pencil of X-rays through a crystal of zinc blende (a form of zinc sulphide) which has a cubic structure. This gave rise to a regular pattern of dark dots on a photographic plate behind the crystal (see Note 1 of E-24). Laue's discovery was soon confirmed by other scientists and in October 1912 Bragg Senior, in a letter to *Nature*, stated that the positions of the spots in the pattern conformed to a simple numerical rule: W. H. Bragg, "X-rays and Crystals," *Nature*, 90 (Oct. 24, 1912), 219. Meanwhile at Cambridge Lawrence Bragg was undertaking his own research into the phenomenon, which resulted in a paper read at a meeting of the Cambridge Philosophical Society on November 11, 1912 and published three months later: W. L. Bragg, "The Diffraction of Short Electromagnetic Waves by a Crystal," *Proc. Camb. Phil. Soc.*, 17 (Feb. 1913), 43-57. In this paper Bragg advanced a theory to account for the pattern of spots and to explain his father's numerical rule. The theory included an equation (subsequently known as "Bragg's Law") relating the angle of reflection with the wavelength of the X-rays and the distance between successive planes of atoms in the crystal. Bragg's law is now a cornerstone of the science of X-ray crystallography. The elder Bragg acknowledged his son's theory in a second letter to *Nature*: W. H. Bragg, "X-rays and Crystals," *Nature*, 90 (Nov. 28, 1912), 360-61. In this letter Henry Bragg admitted that the new phenomenon pointed to a wave nature of X-rays and that his own "neutral pair" theory (see Note 2 of letter R-14) was inadequate to explain all the facts of radiation. "On the other hand," Bragg wrote, "the properties of X-rays point clearly to a quasi-corpuscular theory, and certain properties of light can be similarly interpreted. The problem then becomes ... not to decide between two theories of X-rays, but to find ... one theory which possesses the capacities of both."

There is a minor problem as to how Rutherford came to know about "young Bragg's explanation" in January 1913, since the relevant paper was not published until a month later. However, news of Lawrence Bragg's Cambridge paper in November was no doubt quickly disseminated in the relatively small British physics community, especially in view of Bragg Senior's November 28 letter in

Nature and the fact that Manchester and Leeds are almost neighbours.

The two Braggs subsequently undertook a study of crystal structure by X-ray diffraction which resulted in a joint book, *X-rays and Crystal Structure* (London: G. Bell and Sons, 1915) and a joint Nobel Prize (1915). W. L. Bragg was Rutherford's successor as Langworthy Professor of Physics at Manchester in 1919 and, again, as Cavendish Professor of Physics at Cambridge in 1938.

4. Charles T. R. Wilson (1869-1959) was the inventor of the "Wilson cloud chamber," whereby the paths of charged particles are rendered visible by the condensation of water vapour (in dust-free air) around nuclei formed by positive or negative ions (see Note 3 of letter E-18/19/20). The passage of an X- or γ-ray is not readily discernable by this method since the ions produced (mainly by an indirect process) are relatively few in number and widely spaced. Hence Wilson's initial conclusion that these rays do not ionize.

5. Henry G. J. Moseley (1887-1915) was the research student at Manchester whom Rutherford regarded as "in some respects the most promising of all [young British scientists]" (letter R-29 below). He is best known for "Moseley's law" relating the frequency of characteristic X-rays with the atomic number (i.e. nuclear charge) of the emitting element. This work was published in 1913 and 1914: H. G. J. Moseley, "The High Frequency Spectra of the Elements," *Phil. Mag.* Ser. 6, 26 (1913), 1024-34 and 27 (1914), 703-13. Moseley was killed on active service in 1915, a loss universally regarded as a tragedy for science. (For an appreciation of Moseley and his work, see Sir Charles Darwin, "Moseley and the Atomic Numbers of the Elements," in Birks: *Rutherford at Manchester.*) Rutherford's reference to Moseley in this letter is, however, puzzling since none of Moseley's published papers refers specifically to the question of whether or not X-rays ionize. On the other hand, another student of Rutherford, Florance, was working on this problem and had published a paper just before Rutherford wrote this letter: D. C. H. Florance, "A Study of the Ionization Produced by ß and γ Rays at High Pressures," *Phil Mag.* Ser. 6, 25 (Jan. 1913), 172-83. Florance found that when the plates of his ionization chamber were 1 cm apart, the ionization due to rays in the air was negligible at atmospheric pressure but reached 25% of the total ionization at 80 atmospheres. He concluded that most of the ionization produced in a closed chamber is due to ß rays produced in the walls of the vessel and escaping into the gas inside the chamber.

6. See Note 1 of letter E-21 above

7. Joseph A. Gray spent three years (1909-12) as an 1851 Exhibition Scholar in Rutherford's Manchester Laboratory and published a number of papers in that period, mainly on the properties of ß-rays and the excitation of γ-rays by ß-rays. In August 1912 he was appointed Lecturer in Physics at McGill. The Cambridge collection includes three letters written by Gray to Rutherford in the autumn of 1912.

E-26 Eve to Rutherford

860 St. Catherines Road
Cote des Neiges, Montreal
19 Jan 1913

This short letter begins with a mild reproach to Rutherford for not acknowledging receipt of the half-yearly draft [mortgage interest] sent early in December. The letter continues: "H. A. Wilson was here, and his wife, for Christmas. He has offered King[1] 2500 dollars and an Assistant Professorship at Houston. I hope that we may be able to retain King here, but it is uncertain... King has quite a paper in the Phil. Trans just appearing,[2] it ran the gauntlet of Larmor[3] & Schuster[4] without any material change."

The letter continues with a series of short statements: "I have not anything good on the stocks just now...the last Phil. Mag. brought out no positive results, with the marked exception of γ rays from α rays;[5] Richardson is writing a book on radiation, Planck etc,[6] which should prove useful; I found your new work very useful."[7]

The letter ends on a more personal note: "We....hope to visit England about the middle of May. They are going to settle appointments in February."

E-26 Notes

1. Harold A. Wilson had left McGill some months earlier to become Professor of Physics at the Rice Institute in Houston, Texas (see Note 3 of letter E-22). At the beginning of 1913 Louis V. King was a Lecturer in Physics at McGill. The post offered by Wilson at Houston represented both a promotion and (almost certainly) a considerable increase in salary. In the event King did *not* accept the offer and was rapidly promoted at McGill to the rank of Assistant Professor.

2. L. V. King, "On the scattering and absorption of light in gaseous media, with applications to the intensity of sky radiation." *Phil. Trans. Roy. Soc. (Lond.)*, Ser. A, 212 (March 1913), 375-433. Rutherford agreed with Eve that this was "quite a paper" (see letter R-23 below.)

3. Papers submitted to the Royal Society (of London) must be communicated by a Fellow of the Society. King's paper (Note 2 above) was communicated by Sir Joseph Larmor, the Secretary of the Royal Society at the time. Larmor (1857-1942) was Lucasian Professor of Natural Philosophy (i.e. Physics) at Cambridge and, since King was a Cambridge student in physics, it was appropriate for Larmor to sponsor, and to referee, King's paper. Larmor made important contributions to several branches of physical science but is probably best known today for the *Larmor precession* which orbiting charges experience when subjected to a magnetic field. This phenomenon is important in nuclear magnetic resonance studies and in magnetic resonance imaging.

4. Arthur Schuster (1851-1934) was Rutherford's predecessor, from 1887 to 1907, as Professor of Physics at Manchester (see Note 10 of letter R-1). When King submitted his paper to the Royal Society in June 1912, Schuster was the Secretary-Elect of the Society. As such he probably had some editorial function with respect to the *Transactions*, although this is not explicitly stated in the printed volume. Schuster made important contributions to science in several fields, including spectroscopy, conduction of electricity through gases and terrestrial magnetism.

5. The meaning of Eve's statement concerning "the last Phil. Mag." is uncertain. Presumably the "last" *Phil. Mag.* was the January 1913 issue which probably reached Montreal a day or two before the letter was written. (The journal was published on the first day of the month.) However, apart from the paper on "γ rays from α rays," which Eve mentions: J. Chadwick, "Excitation of γ rays by α rays," *Phil. Mag.* Ser. 6, 25 (Jan. 1913), 193-97, this issue contains three other papers communicated to the journal by Rutherford, including a long paper by Bohr on the slowing down of charged particles moving through matter. To describe this issue as "without positive results" was thus somewhat tactless, and completely out-of-style for Eve. On the other hand, the December 1912 issue of *Phil. Mag.* contained nothing relating to radioactivity or radiation, apart from a short letter by Soddy and a letter from Rutherford correcting some data he had published in the October 1912 issue: E. Rutherford "On the energy of the groups of beta rays from radium," *Phil. Mag.*, Ser. 6, 24 (1912), 893-94.

6. Owen Willans Richardson (1879-1959) was an English physicist best known for his work on thermionics (he coined the term in 1909) and especially for the law relating the density of thermionic emission to the temperature of the emitting surface. He was awarded the Nobel Prize in Physics in 1928. Richardson was Professor of Physics at Princeton from 1906 to 1913, when he returned to England as Wheatstone Professor of Physics at King's College, London. It is virtually certain that Eve and Richardson were personally acquainted since some of Richardson's collaborators had worked at McGill and Richardson's wife was the sister of Eve's former colleague Harold A. Wilson. The book referred to in Eve's letter was *Electron Theory of Matter*, published in 1914 by Cambridge University Press. It is regarded as a "classic" in the field of electronics.

7. The reference to Rutherford's "new work" is unclear. It could refer to the 'goodly pile of papers' which Rutherford sent a month earlier (see letter E-24). Alternatively, this may be a reference to Rutherford's paper "On the origin of beta and gamma rays from radioactive subs-

tances" published in the October 1912 issue of *Phil. Mag.* (Ser. 6, 24), 453-62, and subsequently amended in the December 1912 issue in the letter cited in Note 5 above. This was a topic of particular interest to Eve.

R-21 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
Feb. 19th, 1913

My dear Eve,

I have arranged to give three Royal Institution Lecturers at the end of May,[1] and the last one will deal with the ionisation of the atmosphere. I should be glad if you would give me briefly your views of the present state of that subject and any modifications that you think may be necessary from the brief account in my book. I know that you have been working on the subject and possibly you can give me your general views as far as you feel inclined.

I shall be very interested to hear how matters are arranged at McGill. I have heard nothing at all recently. I have had several letters from Walker.[2] He has just been to London to see the doctors who find that his eyesight has in no way gone back and that no further operation is at present necessary. Mrs. Walker writes cheerfully, so I presume that they have hopes they have passed through the worst phase.

I understand from a letter of Barnes to my wife that there has been an epidemic of twins in the University; the latest addition being the Browns.[3] It seems to me that the ladies of McGill are unusually efficient.

By the way, have you heard of the death of Professor Ebert[4] of Munich? I have just received a notice to the effect from Munich. I never met him personally, but I should think he was a young man. He had done a good deal of excellent work, though some of it was of rather mixed quality.

Yours very sincerely,
E. Rutherford

R-21 Notes

1. Rutherford gave three lectures to the Royal Institution of Great Britain, in London, as follows:

24 May 1913:	The Alpha Rays and their connection with the Transformations
31 May 1913:	The origin of the Beta and Gamma Rays and the connection between them
7 June 1913:	The radio-active State of the Earth and Atmosphere

2. Wallace Walker was formerly Macdonald Professor of Chemistry at McGill University and Joint Director of the Chemistry and Mining Building. In January 1912 he was granted a leave of absence to the end of the session since his eyesight was threatened with serious impairment. Shortly afterwards, in March 1912, Walker resigned from McGill on medical grounds.

3. "The Browns" were presumably Professor and Mrs. E. Brown. Brown was Professor of Applied Mechanics and Hydraulics at McGill.

4. Hermann Ebert was appointed Professor of Experimental Physics at the Technical University in Munich in 1898. He pioneered the investigation of atmospheric electrical phenomena, especially measurement of the ion content of air at different heights and locations (see Note 5 of letter E-8 and Note 1 of R-23 below). Ebert was 51 at the time of his death in February, 1913, not exactly the "young man" Rutherford had imagined.

R-22 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
March 5th, 1913

My dear Eve,

I have just received notice that the International Radium Standard has been deposited in the Bureau International des Poids et Mesures at Sevres.[1] The Director asks me to collect the signatures of the International Committee[2] to inscribe in the record. Please send me your signature on a slip of paper as soon as you can.

I am hoping to hear from you soon about the negotiations at McGill. I am hard at work in the Laboratory and making good progress.

Yours very sincerely,
E. Rutherford

R-22 Notes

1. See Note 1 of R-16/17. Sèvres is a small community about 12 km from Paris.

2. "The Director" presumably refers to the International Bureau of Weights and Measures rather than the International Radium Standards Committee, which had a Secretary and two Chairmen but no Director. The Radium Committee comprised the seven members listed in R-16 above, plus Bertram Boltwood (U.S.), Arthur S. Eve (Canada) and Hans Geitel (Germany).

R-23 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
March 31st, 1913

My dear Eve

I am much obliged for your kindness in sending me the notes on atmospheric electricity. They were just what I wanted, and served as a good guide to me in bringing attention to the salient points. It is a very interesting but very puzzling subject, and I have been rather pleased to have to go into the question for my lecture next week.[1] Ebert's suggestion of the escape of the positive ions from the earth by diffusion[2] is, I think, quite reasonable, but unfortunately the probable magnitude of the effect is of quite a different order to that required.

I was sorry to hear about the death of Professor Johnson.[3] He was a fine character, and one who was always very interested in Physics.

I have been hard at work this vacation repeating and verifying Danysz's numbers of the velocity of the groups of ß rays.[4] I am very much interested in that subject, but I want to be quite sure of the accuracy of Danysz's numbers. [He changed some of his values of H by 25%(!) in his last paper.]* I think I see my way to a general explanation of the whole phenomenon. Most of the Laboratory are away on vacation, so it is rather pleasant to work, and I am not worried by other people.

I shall be interested to know of Peterson's general conclusions in regard to the Physics Department, and yourself particularly. I quite agree with you about King's Phil. Trans. paper.[5] It was a fine piece of work well carried out. I wrote to him a week or so ago congratulating him upon it.

With kind regards to Mrs. Eve,

Yours very sincerely,
E. Rutherford

* Rutherford added this sentence by hand to the typescript.

R-23 Notes

1. Rutherford's reference to "my lecture next week" is puzzling. In fact, his lecture to the Royal Institution on atmospheric electricity was given two months later, on June 7 (see Note 1 of letter R-21). Perhaps he was due to give a lecture in Manchester on this topic "next week" as a prelude to the R. I. lecture.

2. H. Ebert and K. Kurz, "Registrierung der Luftelecktrischen Zerstreuung in unmiltelbarer Nähe der Erdbodens," *Physikalische Zeitschrift*, 11 (1910), 389-405.

3. Alexander Johnson was Professor of Mathematics and Natural Philosophy at McGill (1857-71), Redpath Professor of Natural Philosophy (1871-93), Redpath Professor of Pure Mathematics (1893-1903), Dean of the Faculty of Arts (1887-1903) and Vice-Principal (1887-1903). He died suddenly in an Ottawa street on February 10, 1913 at 82 years of age.

4. Jean Danysz was a physicist in Mme Curie's laboratory in Paris. His work on the velocities and intensities of the ß-emissions from radium and its decay products was first published in 1911: J. Danysz, " Sur les rayons ß de la famille du radium," *Comptes Rendus de l'Academie des Sciences*, 153 (1911), 339-41 and 1066-68. The work involved bending the path of the ß-ray in a magnetic field of strength H gauss and recording photographically the radius of curvature (ρ cm) of the path. From

the product, Hρ, the velocity of the particle (or, rather, the ratio of this velocity to that of light) is readily calculated. Danysz identified 23 groups in the ß-spectrum of the radium series, with velocities ranging from 0.615 to 0.996 of that of light and intensities ranging from 'strong' to 'very feeble.' Danysz published a later short paper on this subject in January 1913: J. Danysz, " Sur les rayons ß des radiums B, C, D, E," *Le Radium*, 10 (1913), 4-6, but his definitive paper did not appear until October 1913: J. Danysz, " Rayons ß de la famille du radium," *Annales de chimie et de physique*, Ser. 8, 30 (1913), 241-321. Rutherford's comment in March 1913 on Danysz's 'last paper' must therefore refer to the January paper rather than the later publication, and it is difficult to make a direct comparison between the values tabulated in this paper and those in the 1911 papers. The numbering and sequence of the groups is different, and an attempt to line up the groups, e.g. group 1 in 1911 becomes group 4 in 1913, 2 becomes 5 and so on, is frustrated by discrepancies in the intensities, e.g. group 11 (feeble) translates into group 14 (strong). Rutherford's caution was therefore justified.

5. See Note 2 of letter E-26.

R-24 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
June 3rd, 1913

My dear Eve,

I have received your letter[1] and I congratulate you on your appointment to the Physics Chair. I wish you all success in your new position, and hope that you will be able to keep research going pretty steadily. You must arrange not to have all your time and energy occupied in routine, and I hope you will be able to interest a number of young people in modern lines of work.

I have given two lectures at the Royal Institution, and give my third next Saturday on the radioactive state of the atmosphere.[2] I showed the experiment of counting the α particles using a string electrometer. Geiger has devised a modified detecting vessel, which is much more sensitive and steadier than our old method, and if one has 1000 volts one can rig up the apparatus and have it going in five minutes without any worry.[3] The deflections obtained were very large. Geiger has shown by this method that he can count ß rays, and is at present at work on that point. He has not yet published an account of his work.[4]

We are hoping soon to get to the publication of several papers on ß rays, ß rays and γ rays, and I want, if possible, to clear the whole subject up before writing about it.[5]

I am glad to hear that you have been able to do something for King in the general shift up. How is Gray getting along? I have just seen W. Wilson, who has been working for McLennan. He seems to enjoy his Canadian life and tells me that Gray seems content with his work.[6]

I have forgotten what the subject for the Adams Prize is for 1914.[7] I would certainly keep a close eye on King and keep him clear of metaphysical subtleties. I think his breakdown before was partly due to thinking too much on such subjects, and when I saw him in Montreal some years ago I concluded that he had not entirely rid himself of the idea that he had made great discoveries at Cambridge.

Eileen has just had an operation for tonsils and adenoids, and is pretty well again. My wife has gone over by motor to Robin Hood's Bay[8] to look out for a seaside resort for Eileen in the summer. We are probably intending to take a motor tour through Germany to the Tyrol. I will be in Manchester till the end of July and would very much like to see you. If we have room in the house, we shall be delighted to have you and Mrs. Eve stay with us. Please let us know the probable times you have available so that we can arrange beforehand. We are expecting Boltwood[9] to come and stay with us in a fortnight's time.

With kind regards and congratulations to yourself and Mrs. Eve.

Yours very sincerely
E. Rutherford

R-24 Notes

1. The letter from Eve to which Rutherford refers has not been preserved. Indeed, there

is a gap of 13 months between E-26 (19 Jan. 1913) and E-27 (27 Feb. 1914). The "Physics Chair" to which Eve was appointed was the Macdonald Chair formerly occupied by Rutherford and subsequently by H. A. Wilson until his resignation in June 1912 (see Note 8 of letter R-9). The post had been vacant for a year. It should be noted that this post was not that of Chairman of the Physics Department (officially, still designated as "Director of the Physics Building"); this position remained occupied by Barnes.

2. See Note 1 of letter R-21.

3. A string electrometer comprises a fine silvered quartz fibre suspended between two parallel plates, where one plate is at + 100 volts, the other at −100 V. When a small voltage is applied to the fibre, a deflection occurs and this can be measured with a microscope. The advantage of a string electrometer, as compared with a quadrant electrometer, is the rapidity of its response to any change in voltage. This property is very useful for counting single particles since the passage of each particle through a suitable ionization vessel such as a 'Geiger detector' (see Note 4 below) causes a momentary pulse of ionization current and hence a pulse of voltage which can be detected by an electrometer if its response time is short.

4. Hans Geiger was no longer at Manchester, having moved back to Germany (Berlin-Charlottenburg) in 1912: see Note 5 of letter R-9). However, the *Rutherford Correspondence Catalog* lists no fewer than 10 letters from Geiger to Rutherford in the period October 1912–May 1913 and it is therefore not surprising that Rutherford was aware of Geiger's recent work. The modified detector, in a form more closely resembling the modern 'Geiger counter' than the device described by Rutherford and Geiger in 1908 (see Note 7 of letter R-5), was published later in 1913: H. Geiger, "Demonstration einer einfachen Methode zur Zählung von α- und ß-Strahlung," *Physikalische Zeitschrift*, 14 (Nov. 1913), 1129.

5. The phrase "ß rays, ß rays and γ rays" refers to the relationship between the two types of radiation as well as the properties of each. In the 18 months following this letter, Rutherford and 12 of his colleagues and students published about 20 papers on these topics. Some of these papers were listed in Note 2 of letter R-20 above, and a full bibliography is to be found in Birks: *Rutherford at Manchester*. It is doubtful, however, whether even this large output accomplished Rutherford's aim to "clear the whole subject up."

6. Louis V. King was promoted from Assistant to Associate Professor of Physics at McGill (see also letter E-26). William Wilson was a graduate student in Physics at Manchester from 1906 ot 1911, during which period he published 10 papers on various aspects of radioactivity. He then moved to the University of Toronto where he held a teaching appointment under J. C. McLennan, the Professor of Physics. McLennan made important contributions to the study of the radioactivity of rocks, air and water. Gray: see Note 7 of letter R-20.

7. John Couch Adams (1819-1892) was a Fellow of St. John's College, Cambridge and (1859) Professor of Astronomy and Geometry at Cambridge. In 1845 he calculated the mass and orbit of an unknown planet needed to explain irregularities in the motion of the planet Uranus. As a result of his work (and, even more so, the simultaneous calculations of the French astronomer, Urbain Le Verrier), the planet Neptune was discovered a year later, in September 1846. In 1848 Adams was awarded the Copley Medal of the Royal Society and, in the same year, the Adams Prize was founded in his honour by members of St. John's College. The prize was to be awarded biennially for the best essay on "some subject of Pure Mathematics, Astronomy or other branch of Natural Philosophy." The competition was restricted to persons holding a degree in Cambridge University. The subject for 1914 (announced in March 1913) was "The phenomena of the disturbed motion of fluids, including the resistance encountered by bodies moving through them." The value of the award was about £220. Louis King submitted a treatise but was not awarded the prize. The winner (announced on 9 April 1915) was Geoffrey Ingram Taylor, Fellow of Trinity College, Cambridge, for an essay titled *Turbulent Motion in Fluids*. The Adams Prize is still

awarded biennually and remains a highly prestigious award.

8. Robin Hood's Bay is between Scarborough and Whitby on the north-east (Yorkshire) coast of England.

9. At this time Bertram Boltwood was Professor of Radiochemistry at Yale. He spent the summer of 1913 in Europe (Holland, Germany and Austria) and had evidently promised to visit the Rutherfords in Manchester either at the beginning or the end of the trip. On 2 April 1913 Mary Rutherford wrote to Boltwood: "We are delighted to hear you are coming over & want you to promise to come to us first, as soon as you arrive in June, as we may not be here early in September." [Badash: *Rutherford and Boltwood*, 284.] This is the only reference to Boltwood's visit in the Rutherford-Boltwood correspondence.

R-25 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
Dec. 15th, 1913

My dear Eve,

I received this morning a draft for £12.16.10 and enclose herewith a formal receipt.

I am very glad to hear that things are going well with you. I am hard at work on a number of problems, theoretical and practical. The experiments to determine the wave length of the rays is proceeding well, but the effects are so relatively weak and the radiations so mixed that it takes a lot of work to disentangle them. There is no doubt, however, in my mind that the radiation consists of groups of definite frequency. We are examining the question by the electrical as well as by the photographic method. The problem is much more difficult than the ordinary X ray problem, as some of the waves are ten times shorter, and the angle of selective reflection is, in the case of penetrating rays, under 1°.[1]

I asked Marsden[2] here to examine for me the effect of sending particles through hydrogen. As I anticipated, he found that he could detect scintillations over nearly four times the range of the α rays. There appears to be no doubt that a small fraction of the hydrogen atoms are set in motion with speeds considerably greater than the α particle. Such a result is to be expected from my theory of the nucleus atom, and I am writing up the whole question shortly.[3] Other experiments are going on on γ rays, counting ß particles, recoil atoms, diffusion of actinium emanation, and so on.

We are all well and in good form, and are trying to settle the route by which we travel to Australia.[5] We are not certain whether to go by Canada or the Cape.

Give my kind regards to Barnes, Grey and King.[6]

With best wishes to you all for a merry Christmas and Happy New Year.

Yours very sincerely,
E. Rutherford

R-25 Notes

1. Bragg's law (see Note 3 of letter R-20) states that the sine of θ, the angle of "reflection" (by planes of atoms in the crystal) is proportional to the wavelength of the radiation. It follows that the deviation of the "reflected" beam from the incident (primary) beam is 2θ. Also, for small angles, sin θ is approximately equal to θ (in radians). Hence, for short wavelength radiation such as radium γ-rays the deviation of the diffracted rays from the primary beam is small and accurate measurement is difficult. X-ray diffraction studies, in which the aim is to study the crystal structure rather than the radiation, are therefore performed with relatively long wavelength X-rays generated at low kilovoltages.

2. Ernest Marsden (1889-1970) was Lecturer in Physics and John Harling Fellow at Manchester University. In 1914 he moved to New Zealand as Professor of Physics at Victoria University College in Wellington. Later he became Secretary of the N. Z. Department of Scientific and Industrial Research (1927-47) and Scientific Liaison Officer for New Zealand in London (1947-57). He was knighted in 1958. Marsden's five-year stay in Manchester resulted in 13 publications, in collaboration with various colleagues including Geiger.

3. Rutherford's resolve to "write up the whole question shortly" resulted in three papers in Volume 27 (Ser. 6) of the *Philosophical Magazine* in the first half of 1914: E. Rutherford, "The structure of the atom," pp. 488-98; C. G. Darwin, "Collision of α-particles with light atoms," pp. 499-506; and E. Marsden, "The passage of α-particles through hydrogen," pp. 824-30. As the titles indicate, the experimental work with α-particles was described in the papers by Darwin and Marsden, and the latter referred to his paper as a "preliminary account." However, apart from a short follow-up paper in 1915: E. Marsden and W. C. Lantsberry, "The passage of α-particles through hydrogen II," *Phil. Mag.*, Ser. 6, 30 (1915), 240-43, the intervention of the First World War prevented any further discussion of this topic until 1919. Rutherford's own paper, and in particular the relationship between his 1911 and 1914 papers on the nuclear atom, is discussed in the Introduction to the present article.

4. The volume of activity in Rutherford's laboratory is indicated by the fact that, in the 12 months following this letter, Rutherford and his colleagues published about 15 papers on the four topics mentioned, not counting papers on other topics under investigation by the department. (See also Note 5 of letter R-24.)

5. Rutherford had arranged to take his wife and daughter to Australia and New Zealand during the summer of 1914. The trip would combine attendance at the British Association annual meeting (in 4 Australian cities in September) with vacation and visits to family and friends in New Zealand. In the event, they travelled via the Cape on the outward journey and via Canada on the return trip.

6. Barnes: see Note 1 of letter E-21, Note 5 of letter E-29, and letter R-20. Grey: this is almost certainly a typographical error for Gray (see Note 7 of letter R-20). King: see Notes 1 and 2 of letter E-26.

R-26 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
Jan. 19th, 1914

My dear Eve,

Many thanks for your kind letter of congratulations on the New Year's honour.[1] I may say to you that it was very unexpected and not altogether desirable, for I feel such forms of recognition are not very suitable to people like myself. However, I am, of course, pleased at this public recognition of my labours, and hope that my activity will not be lessened by this transformation.

I have been deluged with letters of congratulations etc. and no sooner do I get control of the English ones when this morning I get a great batch from Canada, and the New Zealand ones have still to follow. For this reason please excuse a typewritten letter, as I am absolutely weary of putting pen to paper.

We saw, of course, in the papers about the Montreal water famine and the fire there, which no doubt made you all feel rather nervous.[2] It sounds rather ridiculous for a city of the size and importance of Montreal. I must confess that it would appear that this old decadent country does do some things better than Canada.

I am running over to Washington in April for a hurried trip to deliver two lectures before the National Academy of Sciences.[3] I hope to see a good many of my friends, but doubt whether I shall have time to visit Montreal.[4]

University lectures are now in full swing again, and I am kept pretty busy. I suppose I shall have to go down to London some time in the next month decked out in all the glory of a special uniform to be authentically knighted. It will be rather trying, but I hope I shall be able to get some amusement out of it.

Give my kind regards to Mrs. Eve, and with best wishes to you all.

Yours very sincerely,
E. Rutherford

R-26 Notes

1. Eve's congratulatory letter is no longer extant. The New Year's honour was a Knighthood: Sir Ernest Rutherford. In its editorial comment (Jan. 1, 1914) on the honours list, the London *Times* evidently did not consider that a Nobel Laureate and Fellow of the

Royal Society was worthy of special mention. That privilege was reserved for a judge, a Member of Parliament and the editor of Punch. In a letter of congratulations dated 11 January 1914, Bertram Boltwood wrote "...I cannot possibly express my delight at the well-deserved honour (notice the u) which has been bestowed upon you ... The list of New Year's honours as published in the hopelessly incompetent newspapers of this country [U.S.A.], did not include your name, although they gave the impression of completeness..." [Badash, *Rutherford and Boltwood*, 289]. In his reply on 27 January 1914, Rutherford wrote: "Eileen is of opinion that her parents have not that natural "swank" to carry off such a decoration with dignity but I am afraid such distinctions make very little difference to yours truly, for I have enough democratic tendencies to see the humorous side of this business." [*Ibid.*, 290]. See also Note 8 of letter E-27.

2. On December 27, 1913, the London *Times* reported that Montreal was suffering a severe water shortage owing to the collapse of a concrete inlet pipe in the municipal plant. Hospitals were compelled to purchase aerated water by the ton, while the poor used melted snow. Tubs of water were placed in the streets in crowded sections of the city. Many factories were forced to close. A further break in the conduit occurred on December 31. The water supply was restored on January 3, 1914, but the municipal authorities admitted that the repairs were only temporary and a further breakdown was feared. On January 14, 1914 Montreal was again in the news: the *Times* reported that a fire in a warehouse in the business section ("Old Montreal") had threatened the whole area including Notre Dame Cathedral. The firefighters were hampered by a temperature of -25°F (-32°C) (nearly every fireman was frostbitten) and by the outbreak of several other fires.

3. Rutherford had been elected a "Foreign Associate" of the (U.S.) National Academy of Sciences in 1911. His 1914 lectures to the Academy were delivered on April 21 and 23 in the auditorium of the National Museum in Washington, D.C. They were the first "Hale lectures," named in honour of the late William Ellery Hale of Chicago, and were open to the public. The subject of both presentations was "The Constitution of Matter and the Evolution of the Elements." The use of the word 'evolution' was apparently deliberate since the Academy had planned a series of lectures on the subject of evolution, i.e. "to outline the broad features of inorganic and organic evolution in the light of recent research." (National Academy of Sciences, Annual Report for 1914). The texts of Rutherford's lectures were published in the *Smithsonian Report for 1915*, pp. 167-202.

4. In fact, Rutherford did come to Montreal: see letters R-27, E-27 and E-28.

R-27 Rutherford to Eve (Figure 5)

17 Wilmslow Road
Withington, Manchester
Feb. 17th, 1914

My dear Eve,

I think I told you that I was going to America early in April to deliver some lectures in Washington from April 21st to 23rd. I think I shall be able to arrange to travel via Canada, and may quite likely go by the Calgarian that leaves on March 28th, and I should consequently get to Montreal about the 4th or 5th, and will be able to stay there three or four days. I shall then go South to Boston, New Haven, New York and Washington, and return probably by the Laurentic on April 25th, as I have to get back as early as possible in the University term. I hope to have an opportunity of seeing you and your family and many of my old friends in Montreal in this way.

If it is quite convenient to you, I should be glad if you could put me up for my stay. Don't hesitate to say no if circumstances are such!*

Yours very sincerely,
E. Rutherford

* The last sentence was added by hand

E-27 Eve to Rutherford

McGill University
The Macdonald Physics Building
27 Feb 1914

At the top of the letter, underlined, Eve writes "See P.S. first." The postscript reads as follows: "I took this letter to the Janitor's office

and was posting it and there and then found your letter of 17th Feb.[1] Yes by all means come to us, it will be splendid, and we shall be delighted. I thought you were all on your way to the Southern Hemisphere then."[2]

In view of this postscript, most of the letter itself is irrelevant, but Eve sends it all the same. It reads as follows: "We were all very glad to learn that you are coming through Montreal in April. My wife and I would be proud and delighted if you & Lady Rutherford would come and stay with us, also Eileen of course.[3] Please understand that we want you to come to us very badly; also if more central quarters[4] would suit you better, you must suit your own convenience first of all. I hope that my meaning is clear, and that you understand that this is a very genuine invitation on our part, and I think that we could make you comfortable, but I know that others may have a larger claim, and might look after you better."

The remainder of the letter comprises three short items of news: "Young Ostwald[5] is giving us 5 excellent lectures on Colloid Chemistry, professors doctors and medical students crowd the Chemistry Theatre. Ruttan[6] fell on some ice and tore the muscles from his knee cap. It is a long job I fear. He is at the R. V. H.[7] My mother sent me a glowing account of your visit to Southport,[8] and it was nice of you to go."

E-27 Notes

1. Letter R-27. It may be noted, in passing, that the 10 days required in 1914 for delivery in Montreal of a letter from England has improved only marginally with the advent of airmail.

2. As stated in Note 5 of letter R-25, Rutherford had arranged to take his wife and daughter to Australia and New Zealand during the summer of 1914. Eve evidently assumed that the visit to North America in April was the first stage of the journey to the Southern Hemisphere and Rutherford would therefore be accompanied by his family. In fact the North American trip was separate. On his return to England in June, Rutherford wrote to Boltwood: "Since my arrival, I have been exceedingly occupied trying to get things ready for my departure, which takes place in about 10 days' time. (Badash: *Rutherford and Boltwood*, 293.)

3. Eileen was the daughter (and only child) of Professor and Mrs. Rutherford.

4. The Eve family home in the Côte des Neiges suburb of Montreal was several kilometres from the centre of Montreal, including McGill University. Nowadays Côte des Neiges is considered an "inner" suburb.

5. Carl Wilhelm Ostwald (1883-1943) is considered to be the founder of colloid chemistry. The son of Friedrich Wilhelm Ostwald (1853-1932), one of the founders of physical chemistry, Carl Wilhelm was educated in Leipzig and became Professor of Colloid Chemistry there in 1915. He spent considerable time in the U.S., as a research assistant in Berkeley, California (1904-06) and later as a popular itinerant lecturer.

6. Robert Ruttan was Chairman of Chemistry at McGill from 1913 to 1928 and Dean of Graduate Studies, 1924-27.

7. Royal Victoria Hospital, Montreal.

8. Southport is a seaside resort on the west coast of England, about 60 km from Manchester. On January 25, 1914, Eve's mother wrote to her son and daughter-in-law from the Prince of Wales Hotel, Southport: "... so kind of Betty [Mrs. Elizabeth Eve] to write when she must be so busy—I was so glad of her suggestion about the Rutherfords & wrote to them at once & they both had lunch with me yesterday—I was so pleased to see them especially him—he agreed with me about your being a dear boy—we had a good laugh together—she is more delighted at her title than he is. He is as nice & natural as of old." (Eve correspondence collection at McGill University). It is not known, however, whether the Rutherfords made a special visit to Southport, or were there on other business.

E-28 Eve to Rutherford

860 St. Catherines Road
Cote des Neiges, Montreal
1 March 1914

The main purpose of this short letter is to invite Rutherford to address a joint meeting

of the McGill Physical and Chemical Societies on Tuesday afternoon, April 7th. "We could have the meeting on Monday, if preferred. We are thinking of sending tickets to Governors, Professors, Doctors and honours students, and you may be sure of a roomful and a hearty welcome. Please pick your own subject, but possibly the Constitution of the Atom would be a good subject.[1] Of course we leave that to you...everyone here is delighted that you are coming to Montreal."

Eve follows up his previous reference to Ostwald's lectures on colloid chemistry at McGill:[2] "...the Chemistry theatre overflowed every evening. Get him to Manchester, if you get a chance ... he is an excellent lecturer, and good company."

The letter ends on a familiar note: "Last week we thought spring was beginning and now it snows harder than ever."

E-28 Notes

1. The Minutes of the McGill Physical Society indicate that the joint meeting took place on Thursday, April 9, 1914, and the title of Rutherford's lecture was "The Detection of Atoms and their Structure." (See letter R-28 below.) The minutes state that "The meeting was attended by many members of Faculty and friends and by a number of undergraduates." The following day the *Montreal Gazette* reported the meeting under the heading "Expert describes atom's structure."

2. See Note 5 of letter E-27 above. A carbon copy of the text of Ostwald's five lectures is held in the Archives of McGill University.

R-28 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
March 14th, 1914

My dear Eve,

I received your two letters on the same day,[1] and am very glad to hear that you can arrange to put me up. I was intending to travel by the Calgarian, but have just been informed that owing to labour troubles she will not be ready in time, so I am travelling by the Tunisian to Halifax, leaving here on March 28th. I will wire you on arrival at the latter place so that you may know the time of my arrival.

I note what you say about a meeting of the Physical and Chemical Societies on April 7th. I presume there will be no difficulty in being there on time. I shall, of course, be quite glad to give a lecture before them, and would suggest as my title, "The detection of atoms and their structure."[2] I shall probably bring a string electrometer with me, and some of my small Clark cells, but will probably want an extra 500 volts if I show the experiment. I also may have with me sufficient material for another experiment, which will be difficult to get made in a hurry.

I am looking forward to my trip but hope the weather will not be too boisterous on the way over. I shall be glad if you will remember that I am a lazy man, and do not want all my time completely filled up with engagements before my arrival. If any suggestions are made, you will understand the sort of things that I would be glad to consider.[3]

We have Professor and Mrs. Laby staying with us, and they are going back to New Zealand via Canada.[4] They will call on you in Montreal, and I should be grateful for any attention you can show them. We have had them staying in our house for the last five days and Mrs. Laby has been ill with influenza most of that time, and will have to be taken care of for some time. Au revoir.

With kind regards,

Yours very sincerely,
E. Rutherford

R-28 Notes

1. Letters E-27 (27 Feb. 1914) and E-28 (1 Mar. 1914).

2. See Note 1 of letter E-28.

3. At first sight, Rutherford's description of himself as "a lazy man" is astonishing. A possible interpretation is as follows: Rutherford devoted a high proportion of his waking hours to science, during which periods he worked hard and efficiently. But he did not believe that work should exclude other activities: on the

Feb. 17th., 1914.

My dear Eve.

I think I told you that I was going to America early in April to deliver some lectures in Wasgington from April 21st to 23rd. I think I shall be able to arrange to travel via Canada, and may quite likely go by the Calgarian that leaves on March 28th, and I should consequently get to Montreal about the 4th or 5th, and will be able to stay there three or four days. I shall than go South to Boston, New Haven, New York and Washington, and return probably by the Laurentic on April 25th., as I have to get back as early as possible in the University term. I hope to have an opportunity of seeing you and your family and many of my old friends in Montreal in this way.

If it is quite convenient to you, I should be glad if you could put me up for my stay. Don't hesitate & say no if circumstances are such!

Yours very sincerely,

E Rutherford.

Figure 5. Complete text of short letter from Rutherford to Eve (R-27) dated February 17, 1914. (The Manchester address is embossed on the notepaper and does not reproduce photographically.)

contrary, he enjoyed his home and garden, reading, talking, playing golf. In addition, he and his wife took regular vacations. Rutherford is saying to Eve in this letter: "A trip to North America is an opportunity for relaxation as well as for serious work. Please make sure that there is time for both."

4. Thomas Howell Laby (1880-1946) was an Australian physicist who (like Rutherford) had undertaken graduate research at the Cavendish Laboratory through an 1851 Exhibition Scholarship. At the time of this correspondence, Laby was a professor of physics at Wellington, New Zealand. Laby contributed to several branches of physics, including heat and X-rays, but is probably best remembered as the joint author (with George W. C. Kaye) of "Tables of Physical and Chemical Constants." The first edition of "Kaye and Laby" was published in 1911, the 15th in 1986 (prepared by an Editorial Committee of British scientists, since both original authors had since died.)

E-29 Eve to Rutherford

McGill University, Montreal
The Macdonald Physics Building
18 May 1914

This is Eve's first letter after Rutherford's stay in Montreal in April, and contains a number of (largely unrelated) items of news and comment. Eve begins by stating that he has heard from Dr. Viol,[1] who had visited Washington, that Rutherford's lectures in that city were a great success. In the same paragraph Eve notes that "The Standard Chemical Co. of Pittsburgh seem to turn out about a gramme of radium a month."[2]

Eve thanks Rutherford for coming to Montreal: "Your visit here was much appreciated, and it was very nice of you to come."

Next, news of McGill personnel. "You will have heard that Dean and Mrs. Walton have left McGill for a Govt appointment in Cairo.[3] McIntosh[4] goes in 1915 as Prof. of Chemistry to the new University of B. C. Also it is now an open secret ... that Barnes is going in 1915 as Prof. of Physics to B. C. also. I am sorry he is going ... but he made up his mind, partly because he thought it would be good for the children.[5] I do not know what they will do about his post. I recommended Peterson[6] to take a big boat and catch a whale! But I don't much think they will!"

Eve says that he likes Rutherford's (and Andrade's) paper in the May *Phil. Mag.*[7] "Things are tumbling into shape at a great rate." However, "J.J.T.'s article is too electrostatic."[8]

The letter ends on a family note: "Your godson Dick is very pleased with his Mecano, and he wants me to take a whole holiday soon, and work through all the different Mecano diagrams at once."[9]

A postscript to the letter is as follows: "I have a perfect Geiger detector now, and run it (with electrophones etc) [with] 4 Leyden Jars at 1450 volts. Pye silvered the thread (quartz) for me in the building. I have been trying to hear the electrons with a telephone, but without success yet."[10]

E-29 Notes

1. Charles C. Viol was an Assistant in Chemistry at the University of Chicago.

2. Within a few years of the isolation of 0.1 g of pure radium by Mme. Curie in 1902, radium was being produced on an industrial scale in several countries. The demand for radium, and hence its price, increased rapidly once its value in the treatment of cancer was recognized. According to Robert Reid, "Marie Curie," (New York: Saturday Review Press/E. P. Dutton & Co., 1974) the cost (in English money) of radium salts rose from £400 per gram in 1903 to £15,000 in 1912. During World War I the price was again inflated by demand for radium for use in gunsights and compass cards, and reached £20,000 (or U. S. $100,000) per gram by 1920. Ironically, the discoverer of radium, Marie Curie, derived no financial benefit from the bonanza since she had not patented her method of separating the element.

3. Frederick P. Walton was Dean of Law at McGill from 1897 to 1914. The Annual Report of McGill University 1913-14 states that "Dean Walton was on furlough for a year in Cairo when he received a flattering invitation from

the Government of Egypt to undertake the work of drafting a new code." His new post was that of Legal Advisor to the Egyptian Government.

4. Douglas McIntosh was Professor of Physical Chemistry at McGill.

5. Barnes' resignation from McGill was supposed to take effect as from September 1, 1915. Eve's comment that the proposed move was partly in the interest of the children was correct. In a letter to Rutherford dated June 2, 1914, Barnes wrote: "I am sorry to leave this old laboratory but I feel that a change of place will do me no harm. The climate at Vancouver is much milder than here and we can all live much more out of doors. I feel that the boys will have a better chance." In the event, however, the promised facilities at the new University of British Columbia in Vancouver failed to materialize and Barnes withdrew his resignation. He remained at McGill, as Director of the Macdonald Physics Building, during the difficult years of the War, but in 1918 a serious breakdown obliged him to resign. (See also Note 1 of letter E-21.)

6. William Peterson was Principal of McGill University. (See also Note 7 of letter R-9 in Part II.)

7. Rutherford and E. N. da C. Andrade, "The wavelength of soft gamma rays from radium B," *Phil. Mag.*, Ser. 6, 27 (1914), 854-68.

8. J. J. Thomson, "The forces between atoms and chemical affinity," *Phil. Mag.* Ser. 6, 27 (1914), 757-89.

9. Meccano (Eve's spelling was in error): defined in the *Oxford English Dictionary* as "1908. Trade name of a set of miniature parts from which engineering models can be constructed."

10. The "Geiger detector," now usually called a "Geiger counter," was developed by Geiger and Rutherford in 1907-08 (see Note 7 of letter R-5) and subsequently modified and improved. The instrument requires a steady voltage in the range 1000-1500 volts, hence the need for "Leyden Jars" which are essentially large capacitors designed to store electric charge and hence build up a high voltage. The Geiger counter is able to detect the passage of individual charged particles, such as electrons or α-particles, and modern instruments usually provide an audible indication of each particle, in the form of clicks emitted by a loudspeaker or earphone. However the early instruments did not have this facility and Eve's comment indicates that the provision of an audible signal is not as simple as we assume today.

E-30 Eve to Rutherford (Figure 6)

860 St. Catherines Road
Cote des Neiges, Montreal
3 June 1914

The ostensible purpose of this letter is to send "the usual draft [due early in June], which will catch you in England I hope."

Eve begins the "news" part of the letter by stating that he has invented a new word *radiant* for radioactive substance. "Thus there are about 37 radiants. Polonium is a radiant, etc. Try it."[1]

The letter continues "We are just back from Tennis at the Pitchers.[2] H. A. Wilson is coming here on Monday from Texas.[3] I met his wife at tennis today. They go to the coast of Main[e]. Please remember me to the Labys, when you see them."[4]

Next, some science news: "We had an excellent set of papers at Section III, Royal Society of Canada, which met at Montreal & the attendance was good.[5] I tried to rouse a discussion on the atom but could not provoke one. King[6] found that you do not need h for blue sky and scattering work. He has found Walker's formula for black body radiation[7] in Chwolson's Lehrbuch der Physik.[8] It was obtained by a Russian in 1888! That is a joke on Larmor[9] and Walker."

The letter ends on a sad note: "We lost Dr. and Mrs. Barlow,[10] he was a geologist, on the ill-fated Empress."[11]

E-30 Notes

1. Eve's suggestion received no response from Rutherford. Indeed, the latter's reply to this letter does not even mention the proposal

(see letter R-30). Nevertheless Eve was right to point out that a shorter name for 'radioactive substance' is needed and, indeed, such a term is now in common use: *radionuclide*.

2. Harriet Pitcher, née Brooks, was Eve's sister-in-law and a former graduate student of Rutherford's. In 1907 she married Frank Pitcher, a former Demonstrator in the Macdonald Physics Building (see Note 11 of letter E-1). A short biographical study of Brooks is that of M. E. Rayner-Canham and G. W. Rayner-Canham, "Harriet Brooks--Pioneer nuclear scientist," *Am. J. Phys.* 57 (1989), 899-902. (These authors have also written a full biography of Brooks, to be published by McGill-Queen's University Press, Montreal).

3. Harold A. Wilson: see Note 8 of letter R-9 and Note 3 of letter E-22.

4. See Note 4 of letter R-28.

5. Section III (Physical Sciences) of the Royal Society of Canada met in Montreal on May 26-28, 1914. Apart from a brief Presidential Address by R. F. Stupart, Director of the Meteorological Service of Canada, the leading paper in the session was that of A. S. Eve, "Modern Views on the Constitution of the Atom," *Trans. Roy. Soc. Can.*, Ser. 3, 8 (1914), 9-18. Members of the McGill Physics Laboratory, including Barnes and King, contributed 10 other papers, over half the total number of presentations in the 3-day meeting of the Section.

6. King: see Notes 1 and 2 of letter E-26. It is possible that Eve's reference to King at this point in the letter was prompted by the Royal Society of Canada meeting just mentioned, since King's paper at the meeting was concerned with the absorption of solar radiation by the Earth's atmosphere.

7. A *black body* is an ideal body or system that absorbs all the radiation incident on it. When such a body is heated it emits radiation of various wavelengths (mainly infrared but also visible light at high temperatures) and an important problem in 19th century physics was to explain the distribution (spectrum) of wavelengths at any given temperature. The "classical" formula, known as the *Rayleigh-Jeans law*, agrees with experimental results at long wavelengths but not at all at short wavelengths. In 1900 Max Planck modifed the classical formula by postulating that energy is not emitted or absorbed by the black body in a continuous fashion but in discrete packets or *quanta*, such that the size of the energy quantum (E) is inversely proportional to the wavelength (λ) of the radiation. The constant of proportionality (h) in the relationship $E = hc/\lambda$ is known as *Planck's constant* (c is the velocity of light, also a constant).

George W. Walker, FRS, was Superintendent of the Eskdalemuir Magnetic Observatory in the Lake District, England. He was evidently a member of the group of scientists who vigorously opposed the introduction of quantum concepts and sought to eliminate Planck's constant wherever it appeared. On November 13, 1913, Walker read a paper at a meeting of the Royal Society: "A Suggestion as to the Origin of Black Body Radiation," *Proc. Roy. Soc.*, Ser. A, 89 (March 1914), 393-98. Walker postulated that "there must be many formulae which will express the data as well as Planck's form," and he deduced such a formula on the basis of his earlier work on the motion of a charged sphere. He concluded that: (i) the experimental data on black-body radiation can be well represented by a formula of the dynamical type, and (ii) Newtonian dynamics and the electrodynamics of Larmor are capable of giving an explanation of that formula. Sir Joseph Larmor's name was linked further with this work in that he was thanked for helpful discussion and suggestions. Walker's formula was, however, quickly forgotten as evidence for the quantum nature of radiation accumulated and was soon overwhelming.

8. Orest Daniilovich Chwolson was a Professor of Physics at the Imperial University of St. Petersburg. His textbook of physics, in 4 volumes, was published in the 1890s. A German translation of Volume II of the 2nd (1903) Russian edition was published in 1904 and covered sound and radiant energy (*Lehrbuch der Physik*, Braunschweig: Friedrich Vieweg und Sohn). The book (p. 225) credits Wladimir A. Michelson of Moscow with the first formula for black-body radiation, published in the *Journal de la Société Physico-chimique Russe*, 19 (1887), 79. A shortened version of this paper was subsequently pub-

lished in Paris in the *Journal de physique théorique et appliquée*, Ser. 2, 6 (1887), 467-79, and an English translation of the latter appeared in 1888: W. A. Michelson, "Theoretical essay on the distribution of energy in the spectra of solids," *Phil. Mag.*, Ser. 5, 25 (1888), 425-35. Eve's information, with its 1888 date, was presumably derived from the latter paper. Reviews of volumes 1 and 2 of *Lehrbuch der Physik* were given in *Physical Review*, 17 (1903), 318-19 and 20 (1905), 64 respectively.

9. Sir Joseph Larmor: see Note 3 of letter E-26 above. Larmor was certainly interested in the problem of black body radiation and published several papers on this topic over the years, e.g. J. Larmor: "On the Relations of Radiation to Temperature," *Nature*, 63 (Dec. 27, 1900), 216-18. However, the linkage of Larmor with Walker in Eve's letter appears to be based on the paper cited in Note 7 above.

10. Alfred E. Barlow was a Sessional Lecturer in Economic Geology at McGill.

11. At about 1:30 a.m. on May 29, 1914, the Canadian Pacific Railway liner Empress of Ireland, bound from Quebec City to Liverpool, was struck amidships by the Norwegian collier Storstad. The accident occurred in the St. Lawrence River, about 200 miles east of Quebec City. The Empress had been compelled by fog to lie off Father Point, near Rimouski. The liner sank within 10 or 15 minutes and most passengers had no time to board lifeboats. On the 1,367 passengers and crew on board only 396 were rescued. This tragedy almost rivalled that of the Titanic (1503 lost).

R-29 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
June 4th, 1914

Dear Eve,

I have just received your letter in whose contents I was much interested, especially the rumour about Barnes.[1] I am not surprised that Walton is pulling out for good.[2] I think they found it a little lonely in Montreal when so many of their friends departed.

I saw the name of R. Boyle in the list of survivors of the Empress of Ireland and telegraphed Barnes to know if our friend was all right. His reply was such that I do not yet know whether Boyle was on board or not.[3] I know it was about the time that Boyle was intending to sail. I expect, however, that I shall see him personally about the time you get this letter.

You mentioned that you suggested to Peterson that he should offer sufficient bait to catch a whale; but you will have to be sure that it is a "right whale." The difficulty is at the moment that there are few heavy weights available in Physics between the ages of 30 and 40. There was a period of from five to ten years in which few people of promise emerged. I think your best chance would be to try and get one of the promising young fellows, for example, Geiger,[4] Moseley[5] or young Bragg.[6] The last two are, in my opinion, the coming people in this country. They are, of course, somewhat lacking in experience, but they have even more than I had when I went to McGill. Young Bragg is going to get his Fellowship at Trinity and has recently been made a sort of Director of Scientific Studies in that College. Moseley is in some respects the most promising of all and a fine fellow. He is making the Australasian tour with his mother this summer and will pass through Montreal in about a fortnight's time. I expect he will call at the University and I suggest you give Peterson a chance to look at him. I will give him a letter to you. He is travelling in a few days' time and was intending to go by the return trip of the Empress of Ireland. Another fairly promising youngster is Marsden, who is Lecturer and Research Assistant in my Department. He is a good experimenter, but is not so strong, I think, as either Bragg or Moseley. Of course, King of your Department is really a first class man, but I can quite understand the difficulty in giving him a more responsible post.[7]

By the way, did I pay you for the telegrams I sent from Montreal? If I did not, please subtract the amount from the next interest you send me.

Give my remembrances to Joan and Dick and your lady. I have, of course, been kept very busy since my return.

Yours ever,
E. Rutherford

R-29 Notes

1. Eve's letter was that of 18 May 1914 (E-29). See Note 5 of that letter for "the rumour about Barnes," i. e. Barnes' proposed move to British Columbia.

2. See Note 3 of letter E-29.

3. Robert W. Boyle was Professor of Physics at the University of Alberta. Previously he had worked with Rutherford at McGill and had obtained his PhD there in 1909. He then moved to Manchester, where his research was mainly on the properties of radium emanation (radon). The Alberta appointment came in 1912. It seems that Boyle was not on the Empress of Ireland. In a letter to Rutherford dated June 2, 1914 (which had clearly not yet arrived when the latter wrote on June 4), Barnes wrote: "I received your cable about Boyle and replied that he was safe. Boyle was here for a meeting of the Royal Society [of Canada] last week and left for Boston from which place he sailed."

4. Geiger: See Note 5 of letter R-9 and Note 10 of letter E-29.

5. Moseley: See Note 5 of letter R-20.

6. Young Bragg, i.e. William Lawrence Bragg: See Note 3 of letter R-20.

7. Louis King was a brilliant physicist but it seems that he was emotionally unstable. In letter R-24 (23 June 1913) Rutherford referred openly to "his breakdown before." Earlier, on 30 September 1912, Barnes wrote to Rutherford: "I have been troubled about King. He has shown signs of returning trouble and while I think it will be a long time possibly before it develops it would be better for him to make a change ... Could you offer him a post—he would be much happier working with you as he evidently thinks himself too large for us" (Cambridge University Collection). Rutherford did not offer King a post, but in June 1913 he was promoted to Associate Professor at McGill (see Note 6 of letter R-24).

R-30 Rutherford to Eve

17 Wilmslow Road
Withington, Manchester
June 15, 1914

Dear Eve,

I enclose herewith the formal receipt for your draft of £12.15.8.

Before the receipt of this letter you will probably have seen Moseley in Montreal. I am sure you will find him a good fellow.

I heard personally from Barnes that he was going to Vancouver, and have written to him about the matter. I think on the whole that it is a wise step, for I think it will be a good thing for him to get away from Montreal and make a fresh start elsewhere.[1] I shall, of course, be very glad to help you in any way I can in trying to get a suitable man, or men, to take his place.

We are leaving in a fortnight's time, and I am in the midst of Examinations, and I feel that I have very much to do before I leave.

It is rather amusing that the same formula as Walker's was found so long ago.[2] I would certainly inform Walker and Larmor of the fact.

We have just had Boyle with us, he is in excellent form. We are all well.

With kind regards,

Yours sincerely,
E. Rutherford

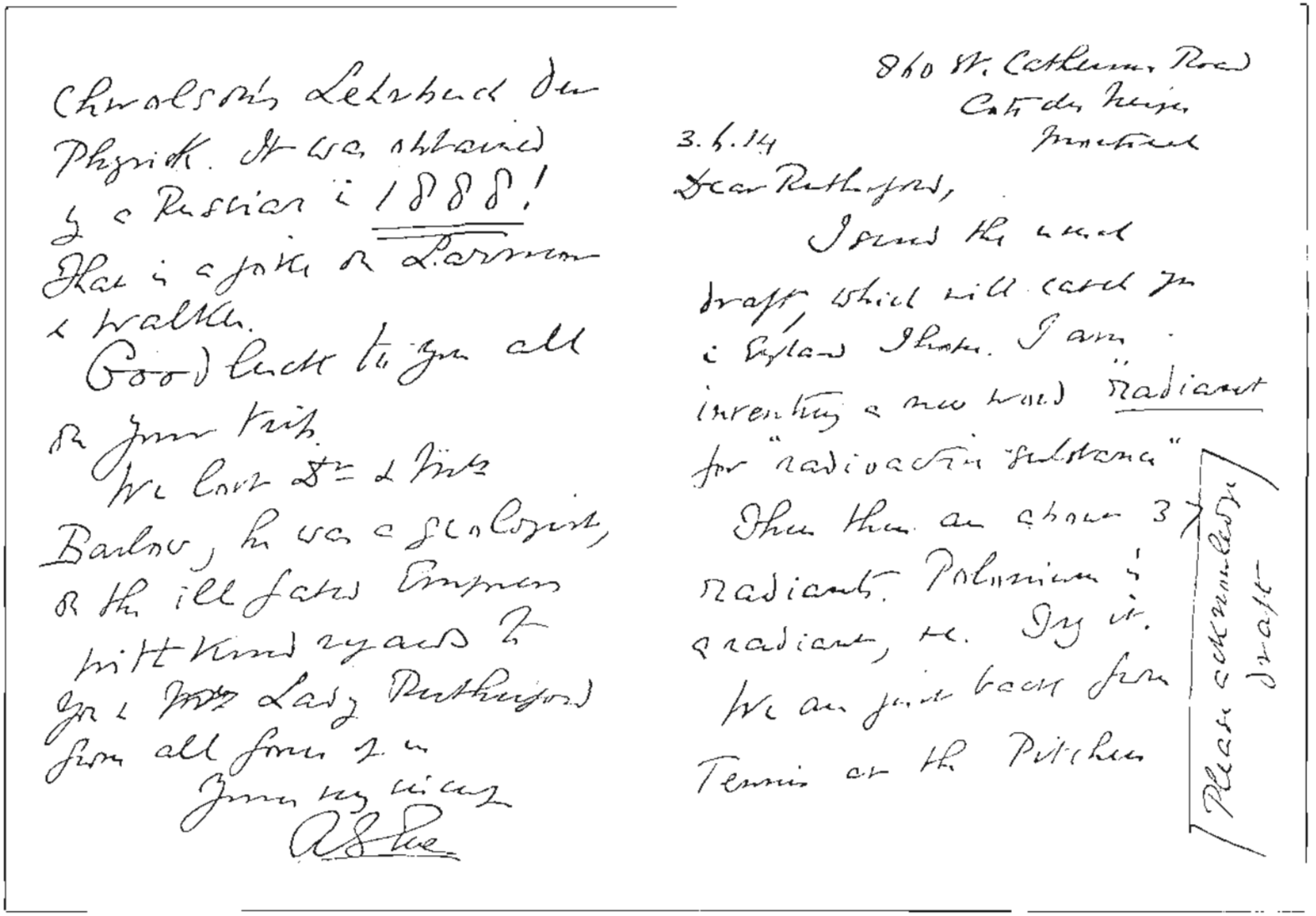
P.S. [Added by hand] I hear today Rachel Core [?][3] is to be married in a day or two—the other person is unknown to me.

R-30 Notes

1. Barnes' letter to Rutherford of June 2, 1914, announcing the proposed move to Vancouver was cited in Note 5 of letter E-29. The letter also stated: "I shall be much better of [in the new post] as to salary and funds for apparatus...I hope you will approve of the change for I did not have a suitable chance to discuss it with you." As mentioned in the same Note, in the event Barnes did not move to B. C. but remained as Director of Physics at McGill until 1918.

2. See Note 7 of letter E-30.

3. I am unable to determine the exact name and to identify the lady concerned. She was



Chwolsons Lehrbuch der Physik. It was obtained by a Russian in 1888! That is a joke of Larmor & Walker.

Good luck to you all & from Fritz

We have Dr & Mrs Barlow, he was a geologist, & the ill fated Empress

With kind regards to you & Mrs Lady Rutherford from all from Fritz

Yours very sincerely

A S Eve

860 St. Catherine Road
Cote des Neiges
Montreal

3.6.14

Dear Rutherford,

I send the usual draft which will call for a Cyclone Shortly. I am inventing a new word "radiant" for "radioactive substance"

Thus there are about 3 radiants. Polonium is radiant, &c. Try it.

We are just back from Tennis at the Pitchers

Please communicate to Prof. Soddy

Figure 6. First and last pages of a letter (E-30) from Eve to Rutherford dated June 3, 1914.

presumably known to Eve as well as to Rutherford.

Acknowledgements

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