RUTHERFORD AND HIS LEGACY TO CANADA

by John M. Robson

Though it is undeniable that several European and American universities have significantly affected Canadian physics, it is probably equally undeniable that the one individual who has most influenced this development is Ernest Rutherford. The direct effect of his stay at McGill and the subsequent impetus it gave to physics research at other Canadian universities and laboratories, coupled with the heritage of the many students who were touched by his personality and style, led to Canada being at the forefront of nuclear physics for a significant period during this century.

Rutherford's work at McGill and the later influence of his colleagues and students led to Canada being at the forefront of physics research for several decades of this century.

During his eight and a half years at McGill, Rutherford identified the basic properties of radioactivity. These included the exponential decay and growth, the nature of the emanations from radium and thorium (Rn 222 and Rn 220), their active deposits, and, with the collaboration of Frederick Soddy, a colleague in the McGill Chemistry Department, the transformation theory of radioactivity. Though they now seem quite natural, these were truly revolutionary concepts at the time. They were followed by the first proof that alpha rays were heavy charged particles and by the tentative suggestion that they were ionised helium atoms. Then, after several experiments on the successive decay products of radium, he proposed a decay series which was very close to that accepted today. Furthermore, in collaboration with Howard Barnes, a colleague from the Physics Department, he showed that the energy associated with a radioactive disintegration was orders of magnitude greater than could be expected from atomic or molecular changes. Though part of all this work was done in collaboration with colleagues, research students, and visitors, Rutherford was the idea man and the leader. His reputation soon attracted many to his laboratory at McGill and several of them, including A.S. Eve and Otto Hahn, made important contributions on their own, though no doubt inspired and influenced by him. While at McGill he published 69 scientific papers and two editions of his definitive book *Radio-activity* [1].

Quite apart from these astonishing contributions as a physicist, all of which are documented elsewhere in greater detail [2-5], Rutherford changed dramatically the image and role of the "Professor" from the austere and unapproachable master to one who took a very deep and personal interest in the lives as well as the work of his coworkers and students - one who was always approachable and who exerted encouragement and praise as often as possible, and who always gave credit where credit was due.

John Cox, the Head of the Physics Department at McGill during Rutherford's stay, had immediately recognised what a catch he had, and it is a great credit to him that he gave him much more time for research than a junior professor usually gets. The Department was already quite well known due to the fame of his predecessor, H.L. Callendar, but it was Rutherford who gave it an international reputation, the shadow of which has continued to this day. The influence on his friend, J.C. McLennan, helped to secure, for Toronto, a Physics Laboratory as good as that at McGill [2] and his prestige soon

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affected other Canadian universities. H.L. Bronson, who worked with him at McGill, later became Professor at Dalhousie. A fitting tribute to Rutherford was made by William Macdonald, the tobacco merchant who gave millions for various purposes to McGill; he said that all his expenditures were fully justified by Rutherford's results alone.

Rutherford at Cavendish

The list of Rutherford's colleagues and students from Manchester and Cambridge who later worked at Canadian Universities and research institutions is long and distinguished. The McGill Physics Department was dominated until the late 50s by professors who either had a Cambridge Ph.D. or post doctoral experience. Some readers may remember A. Norman Shaw, Louis King, W. Watson, David Keys and Ferdi Terroux, amongst others. Terroux, in a lasting tribute, created the Rutherford Museum where students and visitors can now see the original equipment used by Rutherford and his colleagues and students at McGill. Several, including W. Watson, went to Toronto, J.A. Gray and B.W. Sargent to Queen's, R. Boyle to Alberta, R.K. McClung to Manitoba, and G. Laurence to the NRC laboratories, but it was at Chalk River that his legacy really had a dramatic influence. First John Cockcroft, and then Ben Lewis, had learned from Rutherford. They realized and insisted that strong, well supported research programs in both the pure and the applied sciences were essential in the developing laboratory. Both had inherited Rutherford's love of research and took great personal interest in the work underway, especially in the physics area; I recall well how Cockcroft would come around the labs with his little black notebook in which he would write notes as we described the latest progress in our experiments.

Rutherford's determination to provide for his 'boys' equipment and materials which were the most advanced possible enabled them to keep ahead of his 'competitors'. This rubbed off onto his colleagues and students and had a profound influence in helping Canada to leap ahead in the 50's and 60's. Cockcroft and Lewis exploited it in persuading the Canadian government to fund the NRX, NRU reactors, and the series of Van de Graff accelerators which catapulted Canadian physics into the forefront in the wonderful days of the 1950's and 60's . The follow-up by others with TRIUMF and the TASCC facilities continued this tradition later. It is a sad commentary on the present state of scientific support that TASCC was subsequently closed and that some other facilities such as ING and KAON were not pursued.

Cockcroft laid the plans for the NRX reactor, perhaps the most far sighted scientific investment ever made in Canada. The lab was fortunate in having so many Cambridge graduates who had been Rutherford's students or colleagues: George Laurence, Bernard Kinsey, Don Hurst, Hugh Carmichael, Arthur Ward, Les Cook, as well as the next director, W. Ben Lewis. Some, such as Laurence and Ward, made major

contributions to the development of the CANDU program [6] and others, such as Kinsey, quickly developed major research programs and encouraged and helped others to do likewise; they all played significant roles in the successful nuclear programs in Canada. But Lewis' drive and determination were the main influence in making Chalk River one of the most productive laboratories in the world during the 30 year period following the start of the NRX reactor in 1947. Both Cockcroft and Lewis had inherited Rutherford's appreciation that facilities and opportunities were far more important than salaries in attracting bright young scientists to remain in or come to Canada in those hay days of Chalk River's glory. The enthusiasm and vitality in the labs, especially in the experimental and theoretical physics research groups, were quite exhilarating, and several of us were driven by it to far greater accomplishments than we might have ever hoped to achieve elsewhere.

It is difficult to overestimate the influence of Lewis on this and later development of Canadian physics; the realization that significant research could be done in Canada soon spread from Chalk River to Canadian universities. The parallel enthusiasm and accomplishments at the NRC labs in Ottawa doubly enhanced this spreading of confidence to the universities. Though Rutherford's direct legacy was less there than at Chalk River, it was nevertheless present in the outlook on research of many of its renowned scientists. Rutherford encouraged many visitors to spend a few months in his laboratory observing and learning his techniques and style of research. In this vein, one of the more far sighted and fruitful programs instituted at Chalk River and NRC was the invitation to science professors at Canadian universities to spend a few months during their summer vacation period with one or two of their graduate students there. Under this program, they not only had the opportunity to use the available state-of-the-art facilities, but they were exposed to the excitement and enthusiasm which pervaded the labs at that time. They carried this back to their universities, and the quality of research and teaching was subtly, but significantly, enhanced.

Rutherford was seldom concerned with the practical applications of his nuclear research, but he did have a lasting interest in the influence and benefits of radiation in medicine. However, the main applications of his work were to come later. Though involved with research funding through the Royal Society, he was spared the dramatic dependence of research on governments. But nowadays, as the funding of research has become significant, government granting agencies are becoming increasingly concerned, usually with the possible economic feedback. To justify the expenditures to their electorates they are veering towards a link between grants and short term results. Though this is partially understandable, it overlooks the real reason that a country must support fundamental research, especially long term research. This is the need to develop and maintain a tradition of teaching and research which will create a viable and active scientific infrastructure.

A scientific infrastructure is a complex thing! It involves scientists, engineers, technicians and a few competent administrators in well-equipped facilities who can take quick advantage of scientific and technological developments which may occur anywhere. Such groups might be in industry, government laboratories, university cooperatives, or private think tanks. But they must be there for a country such as Canada to take advantage of the immense opportunities presented by the present technological revolution. And it all comes back to the need for a strong and viable fundamental research climate which will produce the manpower for this infrastructure. Immigration may help, and obviously has done so in the past, but it is not the real answer. As Rutherford might have said: you have to have the "boys" and give them facilities and keep at them.

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