# THE LIFE OF SIR JOHN CUNNINGHAM MCLENNAN PH.D., F.R.S., O.B.E., K.B.E. 1867 - 1935

by Robert Craig Brown

John Cunningham McLennan was the son of David McLennan, a Scots miller born in Aberdeenshire in 1836, and Barbara Cunningham of Glasgow whom David had married in 1864. In October 1865, David had emigrated to Canada and, eight months later, Barbara and her newborn child, Janet, joined him in Ingersoll, a small village between Woodstock and London in Southwestern Ontario, where David was a grain merchant. John was born in Ingersoll on October 14, 1867. John spent his early pre-school years there before the family moved westward to Exeter, and later to Blyth, following the fortunes of David's grain business. In 1880, the family moved again to Clinton so that Janet and John could attend Clinton High School. By then John had a brother, David, and two more sisters, Barbara and Jean. Then, in December 1882, the McLennans moved to Stratford. John passed his Matriculation at the Stratford Collegiate Institute the following summer. Another sister, Mary Louise, was born that year and, in September 1884, John's youngest brother, William Edward, was born.[1]

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John wanted to go to university. But, with the onset of depressed times and falling wheat prices in 1883-4, his father could not afford the expense. More than that, to help support the large family, John had to go to work. He chose school teaching and, over the next few years, he taught in a number of Perth County schools. On Fridays he returned home for his regular Friday evening private tutorial in mathematics with Dr. A.H. McDougall, the mathematics master at Stratford Collegiate. David McLennan nearly lost everything in the grim year of 1884 but managed to recover enough by 1887 to acquire a spacious house on Williams Avenue that became the family home. In the Fall of 1888 John enrolled in University College, University of Toronto, to study in the university's Mathematics and Physics Honours Program. He was twenty-one and older and more mature than most of his fellow undergraduates. John studied under the Professor of Physics and President of the University, W. James Louden, and graduated with first class honours at the head of his class in June, 1892.[2]

Louden appointed him Assistant Demonstrator in Physics that summer. Two years later he was given a permanent appointment in the Department and the following year, with encouragement from Louden, McLennan made his first trip to Britain and Europe. He met Sir Oliver Lodge at London University and Lodge gave him letters of introduction to several of the important physics laboratories on the continent. He returned to Toronto convinced that a future in physics would depend on experimental research. With Louden's support, that Fall the Physics Department Calendar announced that "special arrangements" could be made by graduate students "for pursuing original investigations in the laboratory"[3] The following September McLennan, finding it "quite impossible to carry on my laboratory

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work with desirable efficiency", asked Louden for separate laboratory space in Physics, then housed in University College, to carry out his "special investigations" in electricity and magnetism.[4]

In 1898-99 McLennan returned to Britain to work under the direction of J.J. Thomson at the Cavendish Laboratory at Cambridge University. Fellow students that summer included Paul Langevin, Ernest Rutherford, who was just about to leave to take up his appointment at McGill, R.J. Strutt, J.S.E. Townsend and C.T.R. Wilson.[5] McLennan immersed himself in the most recent literature on gas conductivity, then, late in the summer, spent a week in Paris ordering equipment for the Toronto laboratory before going on to Germany for several weeks to study German. By October he was back at Cavendish and beginning his experimental work. In February he was having difficulties with his project and, in April, he reported to Louden that "for three months it was just try this and try that and always fail" but, at last, he seemed to have found "a method which promises some success". In July, 1899, he was done, in Berlin writing up his results, and reporting to Louden that Thomson judged his experiment "a splendid success."[6] McLennan returned to Toronto with a promotion to Demonstrator. His first paper, "Electrical Conductivity in Gases Traversed by Cathode Rays", based on his Cavendish experiment, was published in the Transactions of the Royal Society in 1900.[7] That same year McLennan, who had enrolled in the new doctoral program in the Department at Toronto while at Cavendish, was awarded the first Ph.D. in physics at the University of Toronto.

Fig. 1 The Post-Graduates at the Cavendish Laboratory in 1898-99: Left to right: Back Row: G.H. Bryan, R.S. Willows, unidentified. Middle Row Standing: J.W. Walker, A.A. Robb, H.S. Allen, J.C. McLennan, J.S. Townsend, J.H. Vincent, unidentified. Front Row Seated: C.T.R. Wilson, J. Talbot, John Zedeny, R.G. Klempfert, Sir J.J. Thomson, G.A. Shakespeare, H.A. Wilson, J. Butler Burke.

The first decade of the new century was a time of momentous change for the Toronto Physics Department and for McLennan. In 1902 he was promoted to Associate Professor and was joined in the Department by Eli Franklin Burton, a recent graduate who was already assisting McLennan in his research as Assistant Demonstrator. In 1904 McLennan was formally appointed Director of the physics laboratory. That same year the Ontario Government, which had been providing funding for the Department since 1901, agreed to fund a new physics building.[8] McLennan, assisted by Burton, threw himself into the work of planning, as far as funds would allow, a physics laboratory modeled on the Cavendish Laboratory at Cambridge.[9] Then, quite suddenly, in

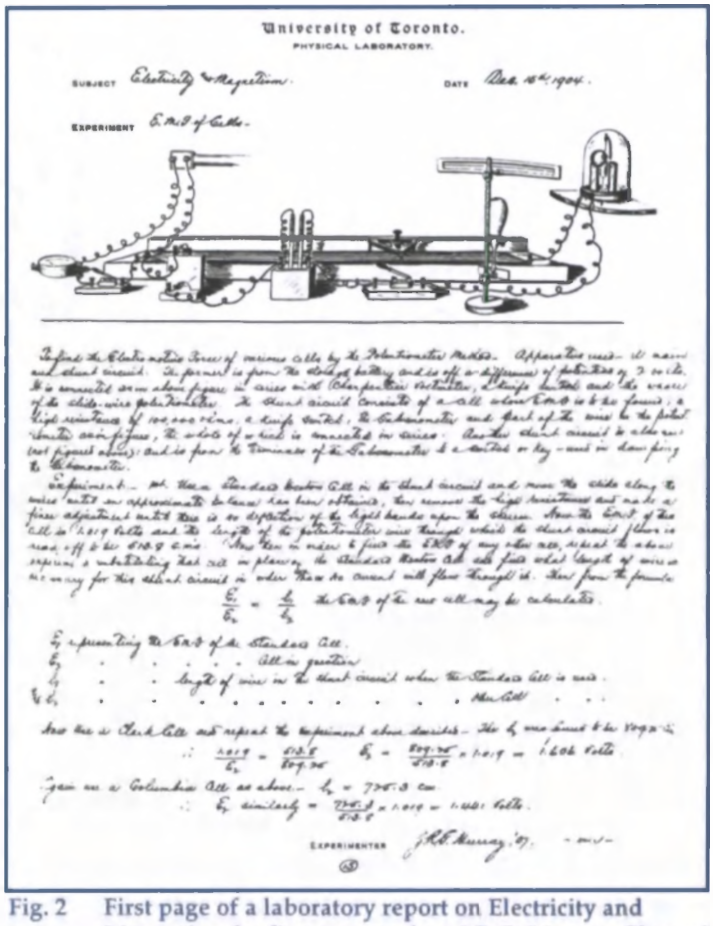
University of Toronto.
PHYSICAL LABORATORY.

Fig. 2 First page of a laboratory report on Electricity and Magnetism by first year student J.R.G. Murray, Class of 1907, December 15, 1904, at the Department of Physics, University of Toronto.

1906, Louden retired from the Presidency and the Department. In 1907, the new president, Robert Falconer, appointed McLennan Head of the Department and the new building (now the Sandford Fleming Building of the Faculty of Applied Science and Engineering) opened. McLennan's dream of heading a major physics laboratory was beginning to be realized. Graduate students started to enrol and, in 1910, the Department awarded its third Ph.D. That same year the Carnegie Foundation surveyed the "academic and industrial efficiency" of a selected number of North American physics departments. Only Toronto and Columbia passed without criticism and the report observed that, at Toronto, "the scientific results of the work done in this laboratory were of a superior character."[10]

By then McLennan had become a commanding presence in the University. He was head of a major department and internationally recognized laboratory. He was a member of the Royal Society of Canada. He was a founder and leader of the Alumni Association and, in 1903, had joined his mentor Louden on a cross-country tour to found local University of Toronto Alumni groups and raise funds for the building of Convocation Hall which opened a year later. He pursued his goals with aggressive and ceaseless determination. Sir William Mulock, Chancellor of the university recalled, many years later, that McLennan was known for being "positive and straightforward in the enunciation of his views". Some colleagues, less charitably, regarded him as "the stormy petrel of committees".[11] Falconer, a regular recipient of entreaties from McLennan, patiently replied to one in 1908 that, though "eagerness is commendable" in a head of department, "it may be necessary for me at times to seem reluctant, simply because I have to adjust relations according to the necessities of such a large and rapidly growing institution."[12]

Outside the university McLennan had developed strong relationships with colleagues in the small but growing number of physicists in Canada, especially with Ernest Rutherford, with whom he exchanged ideas on their mutual interest in radioactivity, with Howard T. Barnes, Rutherford's successor at McGill, and with A.L. Clark at Queen's.[13] In 1904 he had been called to Ottawa to give expert testimony, advocating the adoption of the metric system of weights and measures, to the Standing Committee on Agriculture and Colonization of the House of Commons. In Toronto he was a prominent figure in the Royal Canadian Institute where he vigorously promoted the cause of industrial research.

McLennan had two main research interests in these years, the natural radioactivity of substances and the electrical conductivity of the atmosphere. Between 1900 and 1910 McLennan published seventeen papers, the majority of them on his investigations of radioactivity in metals, gases, and oils. Several were in the Transactions of the Royal Society of Canada; others in the British journals Philosophical Magazine and Physical Review. A particularly important paper, published in the Physical Review in 1903, in collaboration with Burton, announced the discovery of penetrating radiation passing through the atmosphere.[14] Burton soon developed his own research interest in colloidal solutions, but also became McLennan's right hand man, his "first assistant" for whom he had "profound respect and admiration for his ability as a teacher, an organizer of laboratory classes, and as an investigator."[15] Having gotten to know McLennan very well, shortly after McLennan's death, Burton summed up McLennan as a researcher. "Vivid imagination and his indomitable energy in carrying his programme forward" were his strong points, Burton noted. "His forte was not, in essence, originality, which is so remarkable in the work of J.J. Thomson and Rutherford, but, when he once got on the scent of an investigation, no one could show more trained imagination or single-mindedness in carrying it forward."[16]

Much of McLennan's research was stimulated by annual summer trips to Britain, which began in the early 1900's. There, and on the continent, McLennan paid regular visits to fellow researchers, continually seeking for new areas of research which he could take back to Toronto for his own investigations and, in the last years of the decade, those of a growing number of graduate students. Gradually his interests shifted to the emerging field of analysis of spectra. In 1911 he devoted his Presidential Address to Section III of the Royal Society of Canada to a report on the most recent advances in spectroscopy research.[17] By 1914 he was publishing papers of his own in the field.

Throughout these years McLennan dedicated his life almost exclusively to his work. Days were occupied, morning and afternoon, with lectures and laboratory work for a steadily growing number of students and administering the Department which Lorne Gilchrist

and H.A. McTaggert had joined in mid-decade. Evenings found McLennan at his bench, engaged in his research. He had many acquaintances, increasing numbers of students, and a small but cohesive group of colleagues. But his relationships with others were formal apart from a strong friendship with Professor J.C. Fields in Mathematics. That changed in 1910 when he married Elsie Ramsay, the eldest daughter of William Ramsay, the owner of a large estate, Bowland, in Scotland. William Ramsay had come to Canada in 1854 and prospered as a merchant in Toronto. He became the largest shareholder of the Imperial Bank and Vice President of the Toronto, Grey and Bruce Railway, and then, in 1882, retired to Bowland. Thereafter Ramsay made frequent visits to Toronto. It was on one of these visits in the 1900's that McLennan met Elsie. In September, 1910, with Fields as best man, John and Elsie were married at Bowland and quickly returned to Toronto. Elsie McLennan became McLennan's beloved companion, the attractive and engaging hostess of an annual party for staff and students of the department each winter, a prominent figure in Toronto society, and an enthusiastic supporter of the Toronto Symphony and the Women's Auxiliary of the Canadian Institute for the Blind.[18]

John and Elsie McLennan were in Scotland when war was declared in August, 1914. They returned to Toronto in September, just as the First Canadian Division of the Canadian Expeditionary Force was leaving for training in England. In Toronto the city was alive with patriotism and expressions of support for the British Empire. Hundreds of volunteers crowded into the headquarters of the city's militia regiments seeking to enlist. The City of Toronto promised to pay the full wages for six months for city employees who signed up, and to insure the life of every citizen who served in the CEF. The newspapers were filled with justifications of participation in the war – a just war – by public figures and noted clerics. Volunteer organizations raised funds for Belgian Relief and a host of other causes. At the University President Falconer was fighting to defend three of his staff of German origin, two members of the German Department and the Professor of Oriental Languages, against demands that they be fired.[19]

McLennan, just short of his forty-seventh birthday, was too old and unqualified to sign up (in the early days of the war recruiting officers looked for volunteers who had had some military experience). Two of his younger colleagues, Gilchrist and McTaggart, were not and, early in 1915, both left the Department to serve as x-ray specialists in the Canadian Army Medical Corps. That left all the teaching and laboratory supervision of the large department to McLennan, Burton and John Satterly, a D.Sc. from the University of London who had joined the department in 1912. Early in the 1914 Fall term, McLennan received a letter from Sir Oliver Lodge, Principal of the University of Birmingham, asking why he had not applied for the Chair of Physics at Birmingham which had been vacant since the death of J.H. Poynting the preceding March. McLennan cabled his application on 5 November. Shortly after, the Toronto Daily Star, the Stratford Daily Beacon, and other papers announced that McLennan had an "attractive" and "very flattering" offer of the Chair at Birmingham. The Alumni Association, of which McLennan was a founder and officer, responded with an urgent resolution dispatched to the President, the Premier, and the Chairman of the Board of Governors proclaiming the possible loss of McLennan a "calamity" and pledging "to leave no stone unturned to secure his services in perpetuity to Alma Mater." Two weeks later another hastily called meeting of the Alumni Association heard testimonials on McLennan's behalf from a number of distinguished citizens including the Honourable Lyman P. Duff, Justice of the Supreme Court of Canada. President Falconer told the crowd that, though the finances of the University "were not yet in satisfactory shape", he hoped that "shortly better provision would be made for Professor McLennan's important Department." McLennan then told the meeting that his chief concern was that 'Physics should have its rightful place in the institution" and that he had "not yet decided what course he would take."[20] But news from Lodge took the decision out of McLennan's hands. Because of the war and the commandeering of Birmingham's laboratories for the war effort, no appointment would be made.[21] McLennan returned to his students and his research.

Then, in July 1915, while in Britain, McLennan was invited to join the Advisory Council of the new Department of Scientific and Industrial Research (DSIR). It, and the Bureau of Inventions and Research, established at the same time as responses to the Munitions Crisis of that year, were attempts by the British Government to organize the best civilian scientific advice available to industry and to the Admiralty.[22] McLennan's British colleagues knew of

his strong advocacy, through the Royal Canadian Institute, of establishing linkages between industry and scientific research in Canadian universities, and of his participation, in May 1915, in a meeting of university leaders with Sir George Foster, Canada's Minister of Trade and Commerce, to discuss formation of a Commerce Commission to establish relationships between Canadian manufacturers, university scientists and scientific societies, the Royal Society and the Royal Canadian Institute.[23] The DSIR, with its special mandate to link industry and science in the British war effort, fit exactly with McLennan's interests. It was his first opportunity to serve the war effort.

Another soon followed. At the Front, British observation balloons filled with hydrogen were frequently set on fire by enemy incendiary bullets with considerable loss of life. Sir Richard Threlfall and Sir Ernest Rutherford persuaded the Board of Inventions and Research, in 1915, that helium would be a good substitute for hydrogen if an adequate supply could be found for British airships and observation balloons. In December, the Board asked McLennan to do a survey of helium resources in the Empire to determine if helium extracted from natural gas could be commercially produced in sufficient quantity for war-time use.[24] McLennan began collecting samples of gas from wells in southwestern Ontario for analysis at the Physics Department. There Burton, Satterly, and Professor H.F. Dawes of McMaster University (then located on Bloor Street adjacent to the University of Toronto) analyzed the gas after teaching hours. They found that the Ontario gas contained .33% helium. In April of 1916 McLennan went to Alberta to collect samples from a well in the Bow Island Field in central Alberta and from the pipeline carrying gas from the field to Calgary. It contained .36% helium and proved to be the richest source in the Empire.[25] In the Fall of 1917 McLennan received authorization to establish an extraction plant on the outskirts of Hamilton, Ontario, using gas supplied by the National Gas Company and equipment donated by L'Air Liquide of Toronto. By then McLennan was at work on other projects in England. He got John Patterson, an engineer from the University of Toronto, who was a senior officer of the Canadian Meteorological Service, to join the research team and operate the plant. In due course the team succeeded in extracting small quantities of helium but, by the Fall of 1918 the supply of gas from Ontario wells was declining and the project moved its extraction apparatus to Calgary to use gas from the Bow Island field. Between October 1919 and April 1920, the Calgary plant managed to produce 60,000 cubic feet of helium which was shipped to McLennan and the Admiralty in England. By then the idea of using helium from Empire gas wells in British airships had been abandoned. Though large quantities of helium from United States wells had become available after the American entry into the war, the airplane had replaced airships for most military purposes and helium proved to be considerably more costly than hydrogen.[26]

In the summer of 1917, while working with the Admiralty during his annual visit to Britain, McLennan was among the first group of Imperial persons to be awarded membership in the Order of the British Empire.[27] He was also asked to stay on and continue his work in anti-submarine warfare research. Germany's unrestricted submarine warfare campaign against allied shipping was at its height and the British were desperately searching for devices to

Fig. 3 John and Elsie McLennan leaving Buckingham Palace, August 25, 1917, after the O.B.E. was conferred on McLennan by King George V.

combat the enemy submarines. President Falconer, an enthusiastic Imperialist and supporter of the war effort, told McLennan that the Board of Governors approved a leave of absence for the duration and that the University would pay his salary while he worked in Britain.[28] He had two main projects for the BIR. He was helping the development of an "indicator loop", an underwater magnetic coil or loop which, when laid on the floor of the sea, could detect the passage of ships and indicate it by galvonometric recording. When linked to a cluster of mines which could be fired from shore, the "loop" system could destroy an enemy ship passing through the system. McLennan's other project was to develop workable magnetic and contact fuses for undersea mines. At the time British mines were notoriously unreliable: many broke from their moorings in all but the calmest waters and most failed to explode when struck by an enemy ship, while others had fuses so unstable that they exploded in moderately rough seas.[29] His main laboratory was in South Kensington and he had also set up a smaller laboratory in King's College to continue his research on helium.

There were few skilled hands to help as nearly every capable scientist in Britain was already engaged in war work. He turned to Sir Edward Kemp, Minister for the Overseas Forces of Canada, for help, pleading that he needed "scientific men" and that "I hardly know where to look for them".[30] Eventually a sizeable group of former students was released from the CEF and others came from Toronto to work for him. Three of these former students were Robert Cooley, who came from an Overseas Training Company in Toronto, Albert Roger Self, who was released from the Corps of Signals, and Horace Holmes, "one of the most brilliant students I ever had", who was released from the 12th Field Ambulance of the CAMC. All three worked in Cambridge at a factory making magnetic mines, and in Portsmouth taking measurements of the magnetic effects of ships. Many years later they recorded their memory of the times. McLennan was "kindly but very aggressive", Holmes recalled. Self found his old professor "very demanding" but "we managed". By mid-1918 the indicator loops had been developed and were being deployed. And more reliable contact fuses began to be produced. But students remembered that magnetic fuses "never came to a proper success. They never got past the problem of these things firing when the weather got rotten and shook them.[31]

After the Armistice, at the end of 1918, the Director of Experiments and Research for the Admiralty, Charles Merz, reported that small loop systems with mines were "now in service" and much larger loops used only to detect passing ships had given "useful results in practice". Firing systems for magnetic mines were presently "being tested in rough water" and he recommended that the work be continued. McLennan, the report added, was also working on a magnetic firing device for torpedoes and tests of the device were about to begin.[32]

In December, 1918, a major change in the research work at the Admiralty was approved. The BIR was replaced by a Scientific Research and Experiment Department headed by McLennan. He would also be director of an Admiralty Central Research Institution and Scientific Advisor to the Admiralty.[33] McLennan told President Falconer that the new central research institution was estimated to cost £1.3 million and that its establishment and staffing would be "a task great enough for any one man". Funding for the central research institution was "problematical" and without it "I would not care to stay on here, as I have hoped all my life I would have more opportunity for research than I have hitherto had". He added that, "if the burden of lecturing could be lessened in Toronto and I could have more time for research that is the life that I should prefer to follow." He had told the Admiralty that he had to have a definite decision by April 30.[34]

McLennan wanted the job very much. "It is all so big, away beyond anything I ever dreamed of, that it makes me almost tremble when I see the responsibility of it," he wrote.[35] The April deadline passed. In June he told Robert Boyle, a Rutherford student who was Head of Physics at the University of Alberta and who, with Paul Langevin in Paris, had developed, at the end of the war, the first experimental ASDIC (SONAR) devices to detect submarines, that he thought he would be remaining in England. Still there was no decision on funding for the central research institute. In mid-September McLennan told Rutherford that he was leaving for Canada and taking some of the helium with him. He was also sending some helium to Cambridge and hoped that Rutherford, Thomson, Rayleigh and Sir Willam Pope would use it. But McLennan still had hope. If the situation changed at the Admiralty in the next few months, "I will come back to England."[36]

It was not to be. John McLennan's war was over. Back in Toronto, after the University had given him a "grand reception", he worked to transfer some equipment from the Admiralty to his laboratory, began plans to liquify hydrogen and helium in the laboratory and to establish a cryogenic laboratory in the Physics Department.[37]

In the Spring of 1919, on a brief visit to Canada while the fate of his post as Scientific Advisor to the Admiralty was still undecided, McLennan joined several other scientists and a representative of the Canadian Manufacturers Association before a Select Committee of the House of Commons to advocate the creation of a national research institute for Canada. He and most of the others were the original members of the Honorary Advisory Council on Scientific and Industrial Research, the predecessor to the National Research Council, which had been created in 1916. He strongly supported the establishment of a national research institute and was a leader in the effort to secure funds from the Government of Canada for the Advisory Council to award fellowships and bursaries to outstanding graduate students in the pure and applied sciences. By 1919 the student grants program and a smaller program of grants in aid of research to universities had begun and increased funding was anticipated. In 1918 the Advisory Council, under the leadership of Professor A.B. Macallum, formerly Professor of Biochemistry at the University of Toronto, recommended the establishment of a central research institute. Sir Robert Borden's Government, deeply engaged in the war effort, was not interested. But, in January 1919, a committee of Cabinet had approved the recommendation and sent it to the Select Committee for further consideration.[38]

The primary function of Canada's universities, McLennan told the Committee, was "to educate and train men and women." Industrial research to aid "the creation of national wealth" he added, "is a pure business proposition directed in a certain way without regard to education" and "the establishment of a Central [Research] Institution as the nucleus of a new system ... will permeate and develop the whole country, by utilizing the services of the men and women whom we have trained."[39] McLennan reminded the Committee of the contributions Canadian scientists like Boyle of Alberta, Eve of McGill and himself and others at Toronto had made to the war effort. He feared that more Canadian scientists would follow those who already were "steadily leaving this country". To counter that trend, to improve the productivity and efficiency of Canadian industry, he urged the establishment of a "Central Research Institute as a beginning in working out a scheme for the scientific development of industry in this country."[40] The Committee reported, in July, that "Scientific Research in Canada requires and deserves generous encouragement and support from the Dominion Government" but added that further consideration be given to the institute proposal.[41] In 1921 a Bill to create a national research institution passed the House of Commons but was defeated by the Senate. It was not until 1928, under the leadership of Henry Marshall Tory, that the National Research Council got approval for a national laboratory based in Ottawa.

Macallum, having launched the Advisory Council, resigned as Chair to accept a Professorship at McGill. A long wrangle over a successor followed and McLennan received strong support from Hume Croyn, the MP from Toronto who had headed the 1919 Special Committee, and Lloyd Harris, a prominent businessman who had represented Canada at Washington during the later stages of the war. He did not have Macallum's blessing, Macallum favoured A.S. Mackenzie, a physicist from Dalhousie nor that of fellow Advisory Council member R.F. Ruttan from Montreal, who regarded McLennan as "extremely energetic and is experienced" but "lacks tact and would doubtless make a great many enemies". Arthur Meighen, the Prime Minister, who had known of McLennan since his student days at Toronto at the end of the 1890's, "could think of no one his superior" as a scientist, but was concerned that "temperamentally he is disposed to animosity."[42] Between 1921 and 1923 three others served short terms as Chairman before Tory was appointed in 1923. McLennan remained on the Council and was one of its most active members throughout the years.

In the 1920's the student scholarship program and the grants in aid of research were the cornerstone of the work of the Advisory Council/National Research Council. McLennan was among the most assiduous supporters of funding for his students and for research projects in the Physics Laboratory. And the most successful. Yves Gingras, the historian of physics in Canada, noted that McLennan got half of all the bursaries (studentships and fellowships) granted in physics as well as $25,000 in grants in aid of his projects between 1918 and 1932, the year he left

Toronto. McLennan had the most students and supervised more than twenty of the twenty-seven doctorates in physics awarded in Canada in that period.[43] Gordon Shrum, one of those students who received both fellowship and post-doctoral awards, recalled McLennan telling him that "We don't want support for scientific research just to keep scientists busy: we want scientists to be looked upon by the public as people who can do things for them that they can't do themselves."[44]

Elizabeth Allin, another of McLennan's students, and a long-time faculty member who wrote a fine brief history of the Department after retirement, recalled student life in the laboratory at the time. Each morning McLennan, the workshop foreman, T.S. Plaskett, the glass blower, R.H. Chappell, and, frequently, a junior member of the faculty, visited the work station of each graduate student. "What's new?" McLennan would ask. "It was unwise to have nothing to discuss since this was regarded as evidence of lack of endeavour." Students were expected to be in the laboratory every weekday during the academic year, working on their projects, doing demonstration duties, or attending lectures. Every other Thursday at 4:00pm, faculty graduate students, and senior undergraduates were expected to attend the departmental seminar which invariably began with a talk by McLennan. At the end Elsie McLennan appeared to pour tea. On alternate Thursdays the 4:00pm hour was given over to a meeting of the Mathematics and Physics Society. Those graduate students not supported by the National Research Council held Assistant Demonstratorships with an annual stipend of $750. In the summer months, students prepared their work for publication, attended summer school elsewhere, or worked to help support themselves.[45]

For McLennan, who was fifty-two when he returned to Toronto in 1919, this was the most productive period of his career. Between 1919 and 1932 he published more than one hundred and fifty papers, well more than half of them with his graduate students.[46] Shrum was especially important for McLennan's work in cryogenics and spectroscopy. He had been an undergraduate in physics until he enlisted in the Artillery of the CEF in 1916. He fought at Vimy, was wounded at Passchendaele, returned to the Front to fight in the battles of the "last 100 days", and was awarded the Military Medal.[47] Shrum returned to Toronto in the Fall of 1920 and McLennan immediately set him in charge of building the equipment to liquify helium. After many trials, it was accomplished at the beginning of 1923. It had been done only once before, in 1908, by the Dutch physicist Kamerlingh-Onnes, who provided advice to McLennan after the war. Very quickly thereafter Shrum could produce the liquid helium almost on demand. McLennan, overjoyed by this technological achievement in his laboratory, arranged an evening lecture in the laboratory for the University's Board of Governors. Just as he was concluding a report on his research, McLennan was informed that the gas had been liquified. McLennan stopped and ushered the Governors into the laboratory to see the gas. The headline in the Globe the next day read: "Stand In Wonder As Local Wizard Liquefies Helium."[48]

Later that year Shrum completed his doctoral studies with a thesis on the hydrogen spectrum. Shrum spent another year in Toronto as a post-doctoral fellow working with McLennan and then took a position in the Corning Glass Company in New York State. He returned in the Spring of 1925. Vegard, a Norwegian physicist, had recently announced that he had discovered that the source of the auroral green line was nitrogen in the atmosphere. Neither Shrum nor McLennan were convinced, and Shrum set to work to find the auroral green line. He did, and demonstrated that its source was oxygen, not nitrogen. The discovery, later confirmed by other scientists, was very important at the time. McLennan announced it in Nature on 14 March, 1925, with himself as the sole author. Shrum was incensed. "You know, I'll share everything with you," he told McLennan, "but I hate to give you my good luck completely." A second piece in Nature on 25 April was co-authored, as was a major paper on the origin of the auroral green line in the Proceedings of the Royal Society (London) later in the year.[49] It was the high point of McLennan's research career. He was awarded the Royal Society's Gold Medal in 1927 and delivered the Bakerian Lecture before the Royal Society in London, on "The Aurora and Its Spectrum" in 1928.

By now nearly all of McLennan's papers were published in collaboration with his students. In 1928 all but two were with students, including two with H.J.C. Ireton, who would be a long-time member of the department. Elizabeth Allin joined the list in 1929 with one paper and two more in 1930. Over the three year period fifty seven papers appeared.[50] In June, 1930, President Falconer wrote to tell him that the

Board of Governors had approved his appointment as Dean of the Graduate School. "I only hope," McLennan replied from England, "that in the short time that I can hold the post I may be able to give you some effective help in developing graduate work in the University."[51]

Fig. 4 Lord Rutherford and Sir John C. McLennan at the British Association Meeting, Norwich, England, September 7, 1935, a month before McLennan's sudden death.

McLennan did not enjoy the appointment. He was anxious to improve the "social life" of graduate students, more especially women graduate students, and to reorganize the work of the School. But his main goal was to centralize the oversight of research at the University in the Graduate School and rename the faculty as the School of Graduate Studies and Research. The other faculties and departments would have none of it and fought, successfully, to preserve their entrenched autonomy from the supervision of the powerful, outspoken former Head of the Physics Department. As his friend and colleague, A.S. Eve at McGill, delicately put it in McLennan's obituary a few years later, the "academic freedom and the liberty of departmental control could not lightly be sacrificed."[52] The following Spring, with Elsie's health deteriorating, and frustrated by his failure to bring research at the University of Toronto under the mandate of the School of Graduate Studies, McLennan gave notice to Falconer of his determination to resign from the Deanship and the University at the end of June, 1932. He reminded the President that "for forty years I have given my all to the University of Toronto" and rehearsed all the contributions he had made. He was worried about his pension and hoped that the Board of Governors would "treat me considerately." "For practically the whole of that time," he added, " I have had to maintain the home at Stratford and to keep from three to four members of my family. As a consequence I have never been able to save anything and the only money I have now is what I hold in trust for Mrs. McLennan."[53] McLennan returned in the Fall and was granted leave with full pay for the Spring term in 1932 prior to his formal resignation. He did not sever his connection with the department; arrangements were made for him to be an Annual Visiting Professor.

McLennan and Elsie moved to England and built a fine home, "Ramsay Lodge", with a laboratory for his work, in Surrey. McLennan immediately became involved as an expert advisor, with Lord Rayleigh and others, to report to the Royal College of Physicians of London and the Royal College of Surgeons of England on the scientific basis for mass radium beam therapy treatment for cancer. In mid-December the advisors reported that treatment of cancer by massive doses of radiation was of medical value and recommended Britain acquire the required units of radium and treatment apparatus to carry out research on the treatment process. Then disaster struck. On 20 March, 1933, just months after the McLennan's had moved into Ramsay Lodge, Elsie died. McLennan was absolutely devastated. She had been his devoted companion for twenty-three years and perhaps the only close friend he had. For the rest of his life McLennan was a desperately lonely man.[54]

In June McLennan became Chairman of the Executive Committee of the radium research group. He persuaded Union Minière du Haut Katanga to donate ten units of radium to the work and set up a laboratory at the Radium Institute with funding from the Medical Research Council and the Department of Scientific and Industrial Research and other organizations. With seven associates to assist him, research treatments of cancer by radium therapy began early in 1934. McLennan never saw it to completion. Nor did he have much time to enjoy the honour he cherished most, the announcement in the 1935 Honours List of Knighthood in the Order of the British Empire, for his long, distinguished service to the Empire. In October, 1935, he went to Paris for meetings of the International Bureau of Weights and Measures. On the ninth he took the boat train to Calais. Shortly after leaving Paris, John Cunningham McLennan, scientist and Knight of the Realm, was stricken and died, suddenly and alone, in his compartment.[55]

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