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Sociability, radium, and the maintenance of scientific culture and authority in twentieth-century Ireland: a case study of The Royal Dublin Society

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Abstract

This article, through a case study of the Royal Dublin Society (RDS), traces the reception, experimentation concerning, and uses of radium in early twentieth-century Ireland. Throughout the nineteenth century there was increasing state intervention in the provision of scientific and technical education in Ireland. This cumulated in the loss of the RDS's traditional role in this area. The article demonstrates that the RDS was forced to re-envisage its role as a scientific institution by actively seeking to support experimental research. Using radium as a case study the article argues for the success of this tactic. It demonstrates that radium played a central role within the RDS as a nexus for the maintenance of an experimental and philanthropic culture that permeated much of the Society's scientific output in this period. In doing this it highlights the importance of sociability in the promotion of science in Ireland in the early twentieth century. In addition, it explores the role of the RDS as an arbiter of scientific authority.

Introduction

Despite its illustrious history as a centre of cultural and scientific investigation, by the late nineteenth century the Royal Dublin Society's (RDS) role as an arbiter of scientific authority in Ireland was threatened. Increasing state interest in science and its teaching had removed much of the Society's traditional remit in these areas. By the latter part of the century it was obvious to its membership that they needed to reimagine and enrich the Society's scientific activities if it was to maintain its position as a scientific institution. The discovery of radioactivity in 1896 provided such an opportunity. This article will demonstrate that ownership of radium, and the radioactive research that this allowed, was central to the reinvigoration of the RDS. It provided an important component in its research and publication agenda allowing it to continue as a scientific institution into the twentieth century.

Increasing state interest and support for science was a noted feature of the nineteenth century. The founding of the Department of Science and Art in the 1850s by the British government to provide scientific and technical education was a reaction to the threatened demise of Britain's position as the world's premier industrial nation. Throughout the period scientific education was increasingly associated with industrial might. Steve Yearley has suggested that there was little incentive for Irish science to generate industrial wealth, and that instead, for the members of the RDS, science was about defining cultural standing.[1] As noted by Richard A. Jarrell, the fact that the RDS received an annual grant of £6,000 from the state for these purposes meant that they soon clashed with the new Department. Over the course of the nineteenth century the RDS was slowly stripped of its role in the provision of scientific and technical education. Jarrell has characterised the Society's response to the state's actions as 'defensive adaptation'.[2] This paper seeks to expand on this understanding of the actions of the RDS in the late nineteenth and early twentieth centuries to explore the strategies adopted to promote science and itself as a scientific institution in this period. It will demonstrate that this 'defensive adaptation' was a realignment by the RDS of its scientific mission, which ensured its survival as a scientific institution into the next century. Nicholas Whyte has argued that from the 1920s the RDS's standing as a scientific institution declined due to its inability to adapt to the political reality of the new Irish Free State.[3] Hence, despite the actions of the society in the nineteenth century, the political upheaval of the 1910-20s caused its demise as a scientific institution.

While the history of science in nineteenth-century Ireland has received considerable scholarly attention, this paper will attempt to address the relative lacuna in the history of twentieth-century Irish science and provide insights into the organisation of science in the period. Thus, while this paper will address the reception, experimentation concerning, and uses of radium, the central purpose of the study is to explore the organisation of science in early twentieth-century Ireland. In doing so it will explore the relationship between state and civic society in the promotion of science on the island. In essence the paper demonstrates how the RDS used the new science of radioactivity as a tool to maintain its role as a centre of scientific authority in a period when its scientific activities and prestige were under pressure from increased state interest in science.

The Royal Dublin Society

Founded as the ‘Dublin Society, for promoting husbandry and other useful arts in Ireland’ in 1731, the society was granted a Royal Charter in 1750. It initiated several scientific endeavours, including the establishment of the Botanic Gardens, Dublin (1796); the Royal Veterinary College of Ireland (1895); and the appointment of several professors. Its members saw the practical application of science as a way of promoting not just knowledge but also of improving Irish agriculture and the economy more broadly.[4] Throughout the nineteenth century it was one of the principal institutions in Ireland for the promotion of science to both elite and lay audiences, including a series of annual lectures in provincial towns.[5]

However, the Society’s burgeoning endeavours were soon curtailed by increasing state interest in science. Its professors were transferred to the newly established Museum of Irish Industry in 1854 (this was abolished in 1867 and replaced by the Royal College of Science for Ireland) and paid by Government grants. This new museum would be responsible for scientific education and, as noted by Clara Cullen, the RDS was hostile to this impingement on its traditional remit in this area.[6] With the passing of the Dublin Science and Art Museum Act, 1877, the RDS lost much of its institutional infrastructure, including most of its library, the Natural History Museum, the Botanic Gardens, and the School of Art—the library and museum collections were to form the foundation collections of the National Library and National Museum.[7] Thus, by 1877 the institution's traditional remit as a scientific organisation had been considerably undermined.

Despite the losses associated with the 1877 Act, the Society's negotiations with the government prior to its passing demonstrate much interest in continuing as a scientific institution. Its membership sought to revitalise and promote the institution as a society for the study of 'pure science'. This provoked a protest from the Royal Irish Academy (RIA), which argued that this area was its exclusive prerogative. The RDS countered this argument by drawing up a list of 168 papers on scientific topics that it had published over the previous twenty years.[8] These efforts reached fruition with the granting of a new charter for the Society in 1877 and a second supplementary charter in 1888 which directed that the Society would continue to act for 'the advancement of agriculture and other branches of industry, and for the advancement of Science and Art'. This provided the RDS with a mandate and through its laboratory the facilities to reimagine its role as a promotor and arbitrator of both applied and abstract science in Ireland. In 1889 it established a Committee for Science and its Industrial Applications to expand and organise these activities.[9]

From 1890 the Committee for Science and its Industrial Applications regularly made grants available for the promotion of scientific research, an example being a grant of £30 in 1898 to the anthropologist A.C. Haddon to aid his expedition to the Torres Straits and Borneo.[10] Toby Barnard has highlighted the role that the granting of 'premiums'—financial rewards—had in promoting the Society in the eighteenth century.[11] Thus, the RDS was following a tried and tested tactic to promote itself—in this case as a centre of scientific enquiry—as well as providing much needed resources for Irish scientists. It was within this context of enhanced financial and institutional support that radioactivity was received.

Radioactivity

The early history of radioactivity has received much scholarly attention in recent years.[12] However, much of this literature is focused on the main centres of research and less attention has been given to the impact of this new science on the organisation of science in more peripheral regions.[13] Jeff Hughes has argued that with the advent of the atomic bomb, subsequent post-war narratives of radioactive research have been shaped by 'a linear, teleological, "internalist" sequence of theoretical developments and associated "significant" experimental discoveries through which nuclear history could be given shape and meaning.'[14] Scholars have rethought how they approach the history of radioactivity by placing scientific practices in their wider social, cultural, and material contexts, and also demonstrated the impact of radioactivity on broader scientific debates.[15] It is important however to recognise that these teleological narratives have also excluded peripheral centres of research which 'failed' to contribute to the development of nuclear science.

The increasing importance of scientific research and teaching in the nineteenth century was demonstrated by greater state support for these activities.[16] In tangent with this was the growth of laboratory research in higher education institutions across the United Kingdom. By the beginning of the twentieth century the Cavendish Laboratory still maintained a dominant position as the centre of excellence for physics research on the British Isles. However, the prominence of physics was increasing. Other research laboratories expanded or opened across the United Kingdom—most significantly for radioactivity research was Ernest Rutherford's elevation to the chair of physics at the University of Manchester. Rutherford's radioactive research at Manchester and his rise to prominence demonstrates the considerable benefits to his own and these institutions' national and international standing. Indeed, it has been noted that 'the leadership of innovation in physics was shifting from Cambridge to Manchester' in this period. His subsequent return to the Cavendish demonstrates how radioactivity had impacted his career.[17]

In Ireland reformers saw science and non-denominational education as a route to economic improvement and a method of defusing sectarian tension. The growth of Irish mechanics institutes in the nineteenth century is a sign of the popularity of scientific instruction. These institutes formed strong bonds with the temperance movement. Scientific education and temperance were seen as two parts of the same quest to improve the lot of the Irish artisan.[18] Traditionally science education had been based in Trinity College, Dublin, and the RDS—both dominated by the Anglo-Irish elite. Thus, the state's increasing concern and interference in scientific education threatened to break this monopoly.[19] However, the RDS mounted a vigorous rear-guard action against this encroachment and radioactivity was a central plank in these endeavours. Its predominately Protestant and wealthy membership were in a position, through their own resources and social standing, to act for the preservation of the Society's scientific credentials.

Numerous studies have demonstrated the importance of local factors in the growth and activities of scientific institutions. Steven Shapin has highlighted that 'their failure to survive or to contribute to the advance of scientific knowledge does not diminish their historical significance.'[20] Elizabeth Neswald's research on the Galway Mechanics Institute shows that such Irish Institutes shared many characteristics of their British counterparts, but their development must be understood within a local context. Indeed, Neswald highlights the strong connection between self-improvement, scientific knowledge and education, and national improvement, some seeing this as a route toward national independence.[21] The, predominantly Protestant, land-owning, elite membership of the RDS must have viewed these connections with concern.

Thus, the RDS's scientific activities were an integral part of its members self-fashioning as civic-minded, educated, and cultured members of society, who regarded themselves as the country's natural leaders. Consequently, the retention of science as an integrate part of the Society's activities was an essential part of this group's efforts to retain its social position within, and relevance to, Irish society. It was within this context that radium was to play a central role as a nexus for the maintenance of an experimental and philanthropic culture that permeated much of the RDS's scientific output at the beginning of the twentieth century. This in turn demonstrates the important role that sociability played in the promotion of science in Ireland in this period.

Radiation and Ireland

In November 1895 Wilhelm Röntgen, while experimenting with cathode rays, discovered a new type of ray which had the ability to pass through matter. In January of the following year, Röntgen shared his revelation, which he called 'x-rays', with the world and word of the new discovery quickly spread.[22] Lawrence Badash has highlighted that no other discovery in the period aroused as much professional and public interest and Röntgen's experiments were quickly repeated around the world.[23] Ireland was not immune to the widespread interest in this new marvel and by 16 January the *Irish Examiner* was reporting on these new and mysterious rays. The potential uses of x-rays, for example in surgery, were quickly realised and others swiftly began replicating Röntgen's experiments.[24] The nature of this new form of 'light' generated much curiosity from both Irish scientists and the public.[25]

Interest in the x-ray phenomenon was demonstrated at a presentation on the topic delivered to the RDS on 18 March 1896 by Richard J. Moss.[26] While Moss had little to add to existing knowledge of these rays, his lecture attracted a large crowd and provoked much discussion. In addition, Professor William Fletcher (W.F.) Barrett (chairman of the proceedings) 'exhibited Röntgen photographs of a needle in a woman's hand.'[27] Luis A.

Campos has demonstrated that such public lectures were as much based in the tradition of showmanship as education and firmly connected to earlier exhibitions of electricity.[28] Barrett, who had used telephones to display electricity in action, is a prime example of the continuation of this tradition in Ireland.[29] Using this 'shadowgraph' the needle was successfully removed by a Dr M. Causland (22 March 1896). This was the third—recorded—successful use of the new discovery in surgery in Ireland and Röntgen rays were soon regularly used in both surgery and dentistry.[30]

While the new rays were not only exciting and useful, there was also a growing awareness of the dangers that they presented. The 'Röntgen rays were particularly apt to cause the worst kind of sunburn' and overexposure, it was warned, could lead to fingernails being shed.[31] In November 1896 the *Evening Herald* stated that anyone 'who has taken any interest in the wonderful development of the X rays, knows that those who are constantly subjected to them run the risk of injury.'[32] Hence, the potential short-term dangers, as well as benefits, of these new rays were known about soon after their discovery.

In addition to its medical uses, there were many hucksters trying to promote inventions, supposedly, based on x-rays. Hopes of the ray's ability to restore sight was but one of many promises. Another example was the Röntgen pill, which, it was claimed, having been bombarded with x-rays would be useful in medical diagnostics. The *Connaught Telegraph* glibly warn its readers not to consume too many, as: if two or three were taken at a time 'a policeman might mistake him for a conflagration, and call out the fire brigade.'[33]

Röntgen's discovery was one of many in the area of radiation in the late nineteenth and early-twentieth centuries. In 1896 Henri Becquerel, while investigating whether phosphorescent minerals produced x-rays, discovered that uranium salts emit radiation and by 1897 it had been established that this radiation carried an electrical charge. Throughout this period Irish scientists kept well abreast of such developments.[34]

Becquerel's discovery prompted the work of Pierre and Marie Curie who discovered radium in 1898 by separating it (and polonium) from pitchblende, a uranium ore.[35] Due to Marie Curie's efforts this discovery spawned a 'radium economy' where the production and manufacturing of radium was intertwined with laboratory research. For scientists such as Curie the radium economy was not about financial gain but rather securing a steady supply of radioactive material. Even with the use of industrial methods, it would take the processing of tonnes of pitchblende before the Curries possessed a tenth of a gram of radium chloride in 1902.[36]

This new element provoked much interest and by 1902 radium bromide was commercially available. This accessibility was a boon to scientists and led to a massive increase in research into this new science.[37] The fact that little was known about radium and the strange radiations that it produced meant that it was fertile ground for those hoping to advance their careers. In addition, the requirement of expensive, high-tech, apparatus was not a feature of this period. Thus, scientists made valuable discoveries with the most rudimentary, and often homemade, equipment.[38]

Knowledge and interest in this new science quickly spread; in the United Kingdom, the Royal Society was to establish a Radium Committee on 10 December 1903. Its function was to acquire radium for scientific research. The impetus for its formation was likely a lecture, by the Curies, at the Royal Institute, London, in June of that year. The Royal Society did not receive its first supply of radium until December 1906, although some individuals had access to small quantities of radium prior to this.[39]

Irish scientists were also interested in this new element and in 1903 Gerald Molly and John Alexander McClelland—both members of the RDS as well as university lecturers—petitioned the RDS's Committee for Science and its Industrial Applications to purchase a supply of radium for scientific research.[40] McCelland following postgraduate studies at

Trinity College, Cambridge, during which he gained research experience at the Cavendish Laboratory, returned to Ireland as professor of physics at University College Dublin in 1900. McClelland is a prime example of the post-1895 'out-of-Cambridge' recruits who not only contributed to the development of the school but also brought the cutting-edge research and methodologies of the Cavendish home. McClelland was one of a plethora of graduates appointed to chairs of physics across the United Kingdom and the Empire.[41] Despite this appointment he had limited resources with which to continue his scientific research. UCD's chemistry laboratory was located in a shed at the back of its premises at 85-86 St Stephen's Green, Dublin, and the physics laboratory was just as cramped. Luckily, he was elected a fellow of the Royal University of Ireland, 1901.[42] This provided him with not only a £400 annual salary but also access to the University's relatively well-equipped laboratories that were used for examinations (however, this access was deigned to his research students).[43] Thus, with experience researching radiation and now in a position to resume experimentation it was not surprising that McClelland would seek to begin investigating one of the most promising and exciting scientific fields of this period.

In order to do this McClelland needed to engage with the emerging Radium economy. Following its discovery, demand for radium had been insatiable. Its production was an arduous task which involve strenuous physical labour to separate miniscule amounts of radium from tonnes of pitchblende ore. To extract adequate quantities of the element this process needed to take place at an industrial level. The Curies are a perfect example of the strategies adopted to accumulate radium. Marie Curie sought to connect the development of radioactive research to the foundation and expansion of a radioactive industry. Thus, Curie's research was aided not only by state grants but also access to radium afforded to her by her close association with the developing radium industry. However, despite the nascent stirrings of a radium industry, access to the element was limited. Adding to difficulties with production, the Austrian government banned export of uranium ore from the St. Joachimsthal mine for industrial use in 1903. While Curie could overcome such difficulties due to her prominent place as the discoverer of radium, others were not so fortunate.[44]

In the US physicists were to turn to industry to solve their funding problems, as Jon Agar has demonstrated, and the option to engage in commercial work was also open to physics professors in Britain.[45] However, this was not possible for Irish scientists. A lack of an electrical or radium industry meant that there was little redress to this avenue of funding. In addition, this abstract research held out little appeal to the state. Instead the RDS and its traditional philanthropic role in the promotion of science was essential for the acquisition of radium.

Irish scientists could not refine radium and, thus, the only option open to them was its purchase on the international market. On 10 November 1903 the RDS science committee voted the sum of £30 for the purchase of radium. While the radium remained the property of the Society, it would be 'placed at the service' of Molloy and McClelland for a period of six months. On 26 November the RDS took its first delivery of radium when it received two tubes, each containing five milligrams of radium bromide, at a total cost of £15. This was followed by a further fifty milligrams in January 1904, at a cost of £30.[46]

The radium bromide's arrival in November 1903 provided a catalyst for an array of experiments and presentations on the subjects of radium and radioactivity. Experimenters were soon attempting to ascertain the properties of radium and its potential effects on organic matter. In December 1903, H.H. Dixon read a paper at the RDS outlining experiments that he and J.T. Wigham had undertaken to investigate the possible biological impacts of radium.[47] Dixon's experiments had two purposes: firstly, he sought to investigate the impact of radium on the growth of plants and secondly to investigate the 'inhibitory' effect of radium bromide on various bacteria.

Using seedlings Dixon established that while plants were not radiotropic, exposure to radium did stunt plant growth.[48] Despite this, there was no indication that it caused abnormal or pathological effects. While the experiments provided little of worth to those seeking to utilise radium, they do point to some important perceptions concerning radioactivity. These included the notion that radium, which had the ability to emit its own energy without any external stimulus, could be a tool for the infusion of some type of life-force into organic matter. Such debates were global and possession of radium allowed Irish scientists to engage with these in turn demonstrating the importance of the RDS in the promotion of science in early twentieth-century Ireland. Thus, by providing access to radium it had provided a useful tool in its efforts to reinvigorate itself as a centre of scientific enquiry.[49] In a second set of experiments Dixon investigated the element's effect on the bacteria that cause anthrax and typhus, two diseases which had serious impacts for farmers and the general public respectively. This demonstrates another popular trope concerning radioactivity in the science's formative years: that it could become an important therapeutic tool.[50]

McClelland quickly utilised the radioactive source provided by RDS funding. In a 1904 publication he revealed a method of testing the electrical capacities of radioactive substances using a quadrant electrometer, a relatively simple piece of equipment, thus demonstrating considerable awareness of developments in the science.[51] Given that an International Radium Standard was not set until 1912, when 20 milligrams of radium was placed at the International Office of Weights and Measurements, such experiments were a necessary part of scientists' ongoing efforts to measure and standardise radioactivity (this would be an essential part of any potential radio therapy).[52] While a relatively simple experiment, this did provide Irish scientists with a method of checking radioactivity using the limited equipment available. The lack of proper facilities to carry out research into radioactivity was noted by Professor Johnson Symington. [53] He stated that 'Rutherford' would have found ‘no laboratory in Ireland’ with ‘the equipment necessary for the conduct of his experimental work.’[54] Thus, with limited facilities and funds available the RDS provided Irish scientists with important resources with which to pursue their work. These grants and the promise of publication in one of its scientific journals made the RDS an important arbiter of scientific knowledge in Ireland.

The Royal Dublin Society’s publications

The purchase of radium and possibility of publication meant that the RDS was to be one of the primary Irish institutions for the dissemination of research into radioactivity. The Society provided many opportunities for this. In addition to its publications, from 1836 the Society ran regular ‘evening scientific meetings’. These consisted of lectures on a wide variety of topics ranging from time signals to x-rays.[55] The purpose of these meetings was ‘the reading and discussion of scientific papers’, which provided entertainment and elucidation to members of the RDS but also served as important opportunities to disseminate emerging knowledge.[56] John Joly (a polymath; elected Fellow of the Royal Society (of London), 1892; a prominent member of the RDS; and Professor of Geology at Trinity College, Dublin) noted that presenting such papers provided a forum where research and findings were ‘listened to’ and in return would receive ‘friendly and useful criticism’.[57]

The importance of the RDS as a venue for the dissemination of scientific research must be understood in the context of the limited nature of such opportunities in Ireland. The existing universities were small, as were their science departments. Thus academics were reliant on several learned societies for collaboration and the pursuit of scientific rigour through peer review. Two important Irish bodies that provided scientific credibility in nineteenth- and early twentieth-century Ireland were the Royal Irish Academy (RIA) and the RDS.[58] Consequently, the acceptance of presentations at the RDS was a method of validating one's scientific research, subjecting it to the rigour of open discussion amongst one's scientific and social peers, as well as disseminating knowledge.

Presentations deemed of sufficient quality would be chosen for publication in one of the Society's scientific journals: *The Scientific Proceedings of the Royal Dublin Society* and *The Scientific Transactions of the Royal Dublin Society.* These had been relaunched by Richard J. Moss and George Johnstone Stoney in 1877 (in 1909 the *Transactions* were discontinued, with the *Proceedings* remaining as the Society's only scientific journal).[59] Negotiations with the government had resulted in a substantial grant to aid these publications and they were seen as essential to the Society's efforts to promote science. These funds allowed the RDS to print copious amounts of extremely high-quality illustrations and the journal was noted for the speed of publication. Thus, the new journals provided a valuable facility for Irish scientists.[60]

As a stipulation for those presenting at its scientific meetings, the RDS got first refusal on the subsequent publication of the paper.[61] Thus, while the provision of resources and publication opportunities offered much to scientists and greatly aided their scientific endeavours, these efforts in turn helped sustain the Society in a period when its remit as a scientific institute was under increasing threat from the state. Such journals provided much of the limited opportunities for the publication of scientific research in Ireland (the journals of the Royal Irish Academy also represented a valuable outlet) and their importance as a tool for the dissemination of this research cannot be overemphasised.[62] Papers chosen for publication would be quickly published and placed for sale in Ireland and the rest of the UK but their reach extended beyond this. Through an array of reciprocal arrangements these journals were exchanged with learned societies and research groups throughout the globe (these numbered 375 in 1899, 474 in 1915, and reached 567 by 1953). A sample of the institutions receiving these journals gives some small indication of its reach: The Surveyor General, Natal;

Museum of São Paulo, Brazil; Connecticut Academy; South African Museum; Yerkes Observatory; and the American Mathematical Society.[63] As can be seen, publication in the Society's journals meant dissemination of one's research on a global scale. This only added to the importance of such publications to scientists, such as McClelland, far from the main centres of research into radioactivity. Thus, presentations at the RDS's scientific meetings should not be seen as merely a recreational and local activity for its members but rather as an important opportunity to disseminate research findings and participate in a global discourse around this emerging science.

The importance and impact of the RDS's publications is illustrated in McClelland's nomination certificate for the Royal Society. In recognising McClelland's contribution to the field of radioactivity a large portion of the publications cited are those in RDS journals, thus demonstrating their reach, impact, and importance. The certificate also states that 'the line of work opened up in these papers has been taken up by many investigators', further demonstrating the international reach of Irish research. This combined with the calibre of the proposers, including J.J. Thomson, Ernest Rutherford, C.T.R. Wilson, H.A. Wilson, R.J. Strutt, S. Young, John Joly, J.S. Townsend, and E.T. Whittaker, demonstrates that provincial scientific centres could make contributions to scientific discourse in the early twentieth century.[64]

RDS as scientific arbiter

The importance of these scientific publications also highlights the role of the Society as an arbiter of science. Research into radioactivity was literally rewriting the laws of nature and what shape these new laws would take. Even certainty that the pronouncements of scientists regarding their findings were accurate was not always a given. The transmutation of radium, initially into radium emanation (radon) but eventually lead, was often compared to the alchemical quest to change lead into gold. Scientists were—initially at least—concerned that such comparisons would undermine the credibility of their findings.[65] It was in this context that institutions such as the RDS provided legitimacy and authority to their proclamations.

Much of this early research was reliant on human observation. Apparatus, such as calcium sulphide screens, could demonstrate the presence of radiation through phosphorescence. However, such experimentation relied on human eyesight and interpretation. For this reason, the repeatability of a scientific experiment was essential for its credibility. A paper in 1904 on N-Rays by Felix Edward (F.E.) Hackett[66] (presented to the RDS by McClelland) is a good illustration of the difficulties these experimenters faced. The discovery of N-rays was announced by René Blondlot in 1903, as a result of his attempts to polarise x-rays. Blondlot claimed that N-rays were emitted from living and inert objects; yet, there was much contemporary disagreement regarding their existence.[67] In 1904 *Revue Scientifique* had examined Blondlot's claims and found that the rays did not exist. Hackett begins his paper by highlighting the disagreements about the existence of N-rays and the point that experiments to observe N-rays were, in many cases, not repeatable. He states that this was due to 'the effects being so small that they cannot be observed without special training.' Thus, it was not the experiment or thesis that was at fault but the experimenter. Indeed, Hackett's article goes on to highlight that difficulties in seeing N-rays was due to the human eye and the nature of phosphorescent screens.[68]

In his experiment Hackett notes that 'substances under strain were found the most suitable sources of N-rays. Wood or cork compressed, tempered steel, and unannealed glass were used for this purpose. As other more intense sources emit heat in addition to N-rays. Their use could not be satisfactory.' Hackett claims that 'when a source of N-rays was brought up behind the screen, the pattern came out more clearly.' Thus, for him there was no doubt as to the existence of N-rays; rather the fault was that 'an ordinary person without any previous training found great difficulty in detecting small changes' and that 'it was not surprising, then, that so many have failed to see the effects.'[69] This acclamation of trained scientists was similar to Blondlot's own pronouncements. According to Irving M. Klotz the relative ease with which N-rays were accepted was a product of the context in which they were 'discovered'. The discovery of an array of 'rays' since 1895 and the contested debate around their existence meant that scientists and the general public were much more open to the possibility of discovering more.[70]

While N-rays were subsequently proven to be non-existent, the rays rather being a product of the human eye, Hackett's paper demonstrates the difficulties with proclamations of scientific truth and that experimental data is the product of human interpretation. As such, scientific institutions such as the RDS were essential in providing authority to the pronouncements of scientists. Mary Jo Nye has argued that French acceptance of N-rays was a symptom of worries of the loss of national prestige in the area of science.[71] Such concerns on a national and institutional level could explain the acceptance of Hackett's N-ray paper by the RDS. Additionally, such experiments connected the RDS to an international network of scientific discourse where repeatability of experiments was essential for the validation of their accuracy. As the case of N-rays demonstrates, scientific knowledge was not blindly received, but rather assimilated, experimented upon and reassembled in a local context.

Scientists associated with the RDS were to make many such investigations, interrogating existing scientific claims and contributing to emerging knowledge. One example was the concept of transmutation. Irish scientists such as McClelland were well aware of the latest development in such theories and he had integrated them into his teaching.[72] He was to investigate this phenomenon, presenting a paper, 'On the emanation given off by radium', on the 12 January 1903. The content of this emanation (radon) was extremely important for providing proof of transmutation. John Finnegan highlighted this to the Belfast Natural History and Philosophical Society in 1904. The previous summer Ramsay had discovered that with the decay of radium emanation, helium was produced. This seemed to support Rutherford's speculation that radium was 'being constantly transformed into helium' (although Rutherford thought that these were α-rays).[73] Finnegan stated that 'assuming the truth of these laboratory results, we find ourselves in presence of quite startling phenomena'; thus, Ramsay's findings would have to be 'confirmed'.[74] During his investigation McClelland confirmed Rutherford's theory that radium emanation (radon) had no charge; hence, endorsing an important part of the theory of radioactive transformation. In the process he not only relied on his method of testing activity using a quadrant electrometer but also developed expertise in drawing off radium emanation from radium.[75] Interest in transmutation was further demonstrated by a presentation to the RDS by Richard J. Moss, the RDS's chemical analyst and registrar, 'On the state in which Helium exists in Pitchblende'[76]

McClelland followed up on these experiments throughout the 1900s, building up his own, and institutional knowledge within the RDS, of radium and its isotopes in the process. Hence, McClelland's experiments should not be seen as the recreational pursuits of provincial scientists but rather as an integral part of a broad scientific discourse in which truth claims were not taken at face value but subjected to the test of repeatability. This gave scientific investigation meaning to the Society's members. Through it, they were demonstrating their own status as members of a scientific and cultural elite.

McClelland made a number of contributions to the Society's lecture series and journals on a range of topics related to radioactivity. These included investigations of the nature of the γ-rays emitted by radium and of secondary radiation and its implications for understanding atomic structure. In studying γ-rays he sought to understand whether they were electromagnetic radiation, similar to x-rays, or charged particles, as were alpha and beta radiation. He was able to do this using his electrometer technique. In examining secondary radiation, McClelland used fifty milligrams of partially screened radium to send a 'pencil' of beta and gamma rays to a plate, in order to investigate the amount of secondary radiation various substances produced. Again, using his electrometer technique, McClelland gained much insight into the penetrating powers of these rays and their role in the production of secondary radiation. These experiments also allowed him to theorise that 'the impact of the β-rays produces a disturbance sufficient to cause the disintegration of the atom in substances which, in the normal state, are in stable equilibrium.'[77]

Secondary radiation was an important subject of investigation for the membership of the RDS and by the end of the 1900s, it had built up a considerable body of knowledge about this topic.[78] Central to this research was the finding that secondary radiation was an entirely atomic phenomenon. Given the experimental nature of the science this was cutting-edge research and mimicked much that was happening elsewhere in Europe. Thus, the research of scientists associated with the RDS in the period 1903-9 was primarily concerned with secondary radiation and through that atomic structure. They had established that the amount of secondary radiation released was directly proportionate to atomic mass. However, they could not deduce the mechanisms by which sub-atomic particles were released.[79]

McClelland's work with radioactivity brought him much recognition. He was elected Secretary of the RIA in 1906, a Fellow of the Royal Society in 1909, and awarded a Boyle Medal from the RDS in 1917.[80] This was the Society's highest award for scientific excellence and it was conferred for his contribution to Irish science, primarily for research that dealt '(a) with ionisation as resulting from addition of electrons to gaseous molecules or to aggregates of such: and (b) with the more recently discovered forms of radiation associated pre-eminently with radioactivity.' McClelland's decision to investigate radioactivity had certainly proved a worthwhile one. By 1917 the membership of the RDS considered him a 'pioneer in investigating the nature of the radiations associated with radio-activity'.[81]

Following a lull in publications from 1908-12 McClelland returned to research work, with a new focus on atmospheric aerosols. Another interesting aspect of this later work was that the bulk of it was published in the *Proceedings of the Royal Irish Academy* (RIA).[82] (He became secretary of the RIA in 1906 and was elected a member in 1920).[83] The takeover of the Royal University's laboratory facilities by University College Dublin (UCD) in 1909, when the Royal University was disestablished following the founding of the National University of Ireland, provided a vastly improved situation for scientists researching at the University. McClelland soon had research students, who had previously been barred, at work in these laboratories.[84]

The bulk of Irish radioactive research was carried out between 1903 and 1909. The primitive nature of understanding concerning this new science created many opportunities for ambitious and motivated scientists. Irish scientists had similar research objectives as those in Britain. For example, many articles in the *Proceedings of the Royal Society* explored similar topics during the 1900s.[85] Indeed, McClelland contributed to the journal on the subject of secondary radiation[86] and two of his articles on secondary radiation and the absorption of *y*-rays are cited by Rutherford in this 1905 book *Radio-activity.* While John Joly's work was also cited on two occasion.[87] Thus, during these formative years Irish scientists assisted by the RDS were able to make important contributions to this emerging science. This demonstrates the success of the Society's strategy of using radium to maintain its scientific relevance.

Internationally, in the subsequent years there was a sustained focus on secondary radiation; however, research centres, such as Paris, also focused on radioactive standards, preparation of radium, and its industrial and medical applications.[88] By 1910 radioactive researchers and material were concentrated at the main research centres, such as Paris, Montreal, Berlin and Vienna, and increasing amounts of radioactive material was needed to continue research.[89] Irish scientists had not refined radium from pitchblende and had only a small quantity of the element that the RDS had purchased with which to work. Hence, despite increasing interest in the medical applications of radioactivity, they could make little contribution to broader international research objectives. As the science progressed so did the complexity of research[90] and with the return of Rutherford to the UK in 1907 British researchers became increasingly interested in the use of radioactivity to investigate the atomic interior.[91] This research needed advance equipment and resources (including new radioactive substances) which even specialist laboratories, such as the Cavendish, had difficulties acquiring.[92] Thus, as the science advanced it became more difficult for scientists peripheral to these main research centres, with limited resources, to make valuable contributions to it.

At the RDS focus shifted to the impact of radioactivity on human understanding of the world and its age. Central to this was the work of Prof. John Joly which explored the impact of radioactivity on geological processes. Eventually it was realised that radioactivity provided a mechanism that allowed estimates of the age of the earth to be extended considerably, which in turn had knock-on effects for other scientific theories such as evolution. While Joly's work had important implications for wider understandings of the age of the earth, it relied on a theoretical understanding of the properties of radioactivity rather than physical experimentation.[93]

John Joly and radium 1909-1914

Parallel with ongoing investigations concerning the nature of radium and radioactivity had been its application to therapeutic purposes. Joly and Dr Walter C. Stevenson,[94] of Dr Steevens' Hospital Dublin, began using radium bromide to treat rodent ulcers (this is a type of skin cancer) early in the twentieth century. The success of these treatments prompted Joly to request that the RDS establish a Radium Institute in Ireland, with the purpose of extracting radium emanation (radon) to treat cancer.[95]

Following a public appeal, which provided the RDS with funds (including £1,000 supplied by the society itself) to substantially increase its supply of radium, it established a Radium Institute in 1914.[96] This new interest in the therapeutic uses of radium brought renewed research which focused on the production and use of radium emanation for cancer treatment with. There was limited experimental physics research, such as Felix Hackett's presentation on the production of polonium from radium emanation in January 1919.[97] It was this process that would allow scientists at the Cavendish to produce the polonium used to establish the existence of the neutron in 1932.[98] However, the RDS was now soundly focused on the medical applications of radium. Its Radium Institute continued producing emanation until 1953, when its activities were superseded by the Cancer Association of Ireland. This provided an important outlet for the Society's scientific and philanthropic energies in turn ensuring its continued importance to Irish society.

Conclusion

The reception of radioactivity in Ireland appears broadly similar to events in other countries: excitement, experimentation, and exploration of its medical applications. Jon Agar has argued for the development of twentieth-century physics within a 'working world' context where it was encouraged and funded because of its industrial applications.[99] But while there is much validity to this argument when exploring science in Britain, Germany, and the US, the case of Ireland offers up different insights. Here the lack of opportunities to engage with and benefit from advanced electrical or chemical industries meant that science was conducted in an anachronistic context. While the state had some interest in the promotion of scientific education as part of a general policy of social improvement, this did not extent to experimental research and Irish scientists were reliant on sociability to pursue such work. These local factors also heavy influenced the reception and uses of radioactivity.

With the encroachment of the state upon the RDS's traditional remit in the area of popular scientific education, the Society was forced to realign its scientific activities to this new reality if it was to survive as a scientific institution. This meant a renewed interest in experimental science and with it enhanced publication and funding opportunities for science. These arrangements were to prove beneficial to the promotion of the new science of radioactivity at the beginning of the twentieth century. The purchase of radium by the RDS provided it and Irish scientists with a valuable opportunity to engage in an emerging global discourse surrounding this new science. Although radioactivity was but a small part of the RDS's scientific endeavours it provides an insight into the organisation of Irish science in the period.

Radium allow the RDS to continue to fashion itself as an arbiter of scientific authority. The Society was an essential part of the Irish engagement with radium, providing funds, presentation and publication venues, and a collegial atmosphere within which radioactive knowledge was assimilated, experimented upon, and reassembled within a local context. The extension of this research into the realm of therapeutic treatment appealed to the philanthropic impulses of the Society's membership and the ability of the RDS to do this justified its continuance as a scientific and philanthropic institution well into the new century.

Thus, while the contribution of Irish science to the development of advance radioactive and nuclear science was limited, this study provides important insights into the organisation of Irish science and role of radioactivity within this. Rather than the loss of its role in scientific education being the beginning of the end for the Society as a scientific institution, it instead spurred the development of new outlets for its members' scientific energies.

Finally, to return to Jeff Hughes' call to explore the history of this radioactivity from a range of historical perspectives. This case study has demonstrated that radium (and radioactivity) had many 'lives' not just that leading to the discovery of nuclear power but it also had the potential to significantly influence the conduct of science in provincial settings. Hence, further studies of this new science away from the perceived centres of excellence will allow for a fuller understanding of the impacts that radioactivity had on the conduct and popularity of science at the beginning of the twentieth century.

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[1] Steve Yearley, 'Colonial science and dependent development: the case of the Irish experience', *Sociological Review* (1989) 37, pp 308-331, at p. 318.

[2] Richard A. Jarrell, 'The department of science and art and control of Irish science, 1853-1905' *Irish Historical Studies* (1983) 23:92, pp 330-347, at pp 331-339.

[3] Nicholas Whyte, *Science, Colonialism and Ireland*, Cork: Cork University Press, 1999, pp 62-64.

[4] Henry F. Berry, *A History of the Royal Dublin Society*, Dublin: Royal Dublin Society, 1915, pp 186-97, 343, 255; James Meenan and Desmond Clarke, *RDS: The Royal Dublin Society, 1731-1981*, Dublin: Gill and MacMillan, 1981, p. 138.

[5] Berry, op. cit. (4), pp 6-13, 275-77; Enda Leaney, 'Missionaries of science: provincial lectures in nineteenth-century Ireland' *Irish Historical Studies* (2005), 34:135, pp 266-288.

[6] Phyllis E. M. Clinch, 'Botany and the botanic gardens' in Meenan and Clarke, op. cit. (4), pp 185-206, at p. 199; Clara Cullen, 'The museum of Irish industry, Robert Kane and education for all in the Dublin of the 1850s and 1860s' *History of Education* (2009) 38:1, pp 99-113, at pp 100, 106.

[7] James Meenan and Desmond Clarke, 'The RDS1731-1981' in Meenan and Clarke, op. cit. (4), pp 1-55, at p. 37.

[8] Berry, op. cit. (4), p. 306.

[9] Denis Crowley, 'Chemistry', in Meenan and Clarke, op. cit. (4), pp 167-85, at pp 171-72, 174-75, James Meenan and Desmond Clarke, 'The RDS 1731-1981', in Meenan and Clarke, op. cit. (4), pp 1-55, at pp 34, 37; Berry, op. cit. (4), pp 189, 283-84, 305-8, 325, 343, 356, 371-3.

[10] Minute, 8 March 1898, in Committee of Science and its Industrial Applications, 1889-1914, Royal Dublin Society (henceforth RDS), RDS/MAN/SCI; Berry, op. cit. (4), pp 370-1.

[11] Toby Barnard,' The Dublin Society and other improving societies, 1731-85' in James Kelly and Martyn J. Powell (eds), *Clubs and Societies in Eighteenth-Century Ireland,* Dublin: Four Courts Press, 2010, pp 53-88, at p. 60.

[12] For example: Timothy J. Jorgenson, *Strange Glow: the Story of Radiation,* Princeton: Princeton University Press, 2016; Neil Todd, 'The radium committee of the Royal Society and the fate of the substances purchased by it', *Notes and Records of the Royal Society of London* (2012) 66:2, pp. 169-173; Marjorie C. Malley, *Radioactivity: a History of a Mysterious Science,* Oxford: Oxford University Press, 2011; Jeff Hughes, 'The French connection: the Joliot-Curies and nuclear research in Paris, 1925-1933', *History & Technology* (1997) 13:4, pp. 325-343; Xavier Roque, 'Marie Curie and the radium industry: a preliminary sketch', *History and Technology* (1997) 13:4, pp. 267-91; Luis A. Campos, *Radium and the Secret of Life,* Chicago and London: The University of Chicago Press, 2015.

[13] For example see Néstor Herran, '"Science to the Glory of God". The popular science magazine *Iberica* and its coverage of radioactivity, 1914-1936' *Science and Education,* (2012) 2, pp 335-353; Mary Jo Nye, *Science in*

the Provinces: Scientific Communities and Provincial Leadership in France, 1860-1930, Berkeley: University of California Press, 1986.

[14] Jeff Hughes, 'Radioactivity and nuclear physics', in Mary Jo Nye, *The Cambridge History of Science* (vol. 5) *The Modern Physical and Mathematical Sciences,* Cambridge: Cambridge University Press, 2002, pp 352-374, at p. 351; see also Jeff Hughes, Essay review 'Deconstructing the bomb: recent perspectives on nuclear history', *British Journal for the History of Science* (2004) 37:4, pp. 455-464, at pp. 458-459.

[15] Campos, op. cit. (12).

[16] R.M. MacLeod, 'The Royal Society and the government grant: notes on the administration of scientific research, 1849-1914' in *The Historical Journal* (1971) 14:2, pp 323-358.

[17] Jeff Hughes, 'Redefining the context: Oxford and the Wider Wold of British Physics, 1900-1940' in Robert Fox and Graeme Gooday (eds), *Physics in Oxford, 1839-1939: Laboratories, Learning, and College Life,* Oxford: Oxford University Press, 2005, pp 270-274; Macolm Longair, *Maxwell's Enduring Legacy: a scientific history of the Cavendish Laboratory,* Cambridge: Cambridge University Press, 2016, p. 179.

[18] Elizabeth Neswald, 'Science, sociability and the improvement of Ireland: the Galway Mechanics' Institute, 1826-51' *The British Journal for the History of Science* (2006) 39:4, pp 503-534.

[19] Enda Leaney, 'Missionaries of science: provincial lectures in nineteenth-century Ireland' *Irish Historical Studies* (2005) 34:135, pp 266-288, at p. 266-7.

[20] Steven A. Shapin, 'The Pottery Philosophical Society, 1819-1835: an examination of the cultural uses of provincial science' *Science Studies* (1972) 2, pp 311-336.

[21] Neswald, op. cit. (18).

[22] Jorgenson, op. cit. (12), pp. 23-26.

[23] Lawrence Badash, *Radioactivity in America: Growth and Decay of a Science,* Baltimore: Johns Hopkins University Press, 1979, pp 9-10.

[24] *Irish Examiner,* 16 January, 29 January 1896, 8 February. 1896; *Southern Star,* 18 January 1896; *Freeman's Journal,* 27 January, 29 January 1896.

[25] *Irish Examiner,* 1 January 1898; *Freeman's Journal,* 29 January 1896; Minute, 13 December 1898, in Committee of Science and its Industrial Applications, 1889-1914, RDS/MAN SCI.

[26] Moss, having studied chemistry at the Royal College of Science, Dublin, was appointed keeper of minerals (1875) and chemical analyst at the RDS. He developed the Society's laboratory, allowing it to provide support

for its work in the improvement of agriculture. Moss was, subsequently, appointed registrar of the RDS in 1878; this involved additional administrative duties, but he continued to be heavily involved in the scientific work of the Society. Source: Enda Leaney, 'Moss, Richard Jackson' in James McGuire and James Quinn (eds), *Dictionary of Irish Biography,* Cambridge: Cambridge University Press, 2009, see http://dib.cambridge.org, accessed 22 June 2017; Berry, op. cit. (4), p. 291.

[27] See *Freeman's Journal*, 19 March 1896. Barrett had been appointed professor of physics at the Royal College of Science in 1873. He was active in research during the late nineteenth and early twentieth centuries, also developing an interest in spiritualism.

[28] Campos, op. cit. (12).

[29] *Belfast Newsletter,* 3, 9, 29 January 1878; *Irish Times,* 6 April, 16 August 1878; *The Times,* 3 Dec. 1892.

[30] *Kerry News,* 27 March 1896; *Evening Herald,* 20 August 1896.

[31] *Evening Herald,* 30 July 1896.

[32] *Evening Herald,* 7 November 1986.

[33] *Connaught Telegraph*, 29 August 1896; *Irish Examiner,* 29 August, 25 November 1896.

[34] *Freeman's Journal,* 18 November 1896.

[35] John Finnegan, 'Abstract of a paper on radium' in *Report and Proceedings of the Belfast Natural History and Philosophical Society* (1904), pp. 44-9, at p. 44.

[36] Jon Agar, *Science in the Twentieth Century and Beyond,* Cambridge: Polity Press, 2012, p. 24.

[37] Todd, op. cit. (12), pp. 169-170.

[38] Malley, op. cit. (12), p. 143.

[39] Todd, op. cit. (12), pp. 169-173.

[40] Molloy was born 10 September 1834 in Terenure, Co Dublin. He studied for the priesthood at Maynooth College and was ordained in 1857 and, subsequently, appointed professor of theology. In 1874 he was appointed Professor of Natural Philosophy at the Catholic University of Ireland, based in Dublin, and in 1903 he was elected vice-chancellor of the Royal University of Ireland. He was involved in the promotion of science and education throughout his life and regularly gave lectures on physics and popular science at the RDS and University College Dublin (UCD). He had been an early proponent of x-rays and had experimented with their production.

McClelland was born near Coleraine, Co. Londonderry, 1 December 1870, he excelled as a student, graduating from Queen's College, Galway, with a first-class honours BA in 1892 and an MA the following year. McClelland's academic excellence saw him awarded an 1851 Exhibition Scholarship in 1895. This enabled him to pursue further research studies at Trinity College, Cambridge, under J.J. Thomson and C.T.R. Wilson at the Cavendish laboratory. At the Cavendish laboratory McClelland was involved in research on the newly discovered x-rays. In 1897 he graduated from Cambridge with a research BA degree and, subsequently, received an MA. In 1900 he was appointed Professor of Physics at University College, Dublin (UCD).

[41] Jeff Hughes, op. cit. (17), pp 267-300, at p. 271.

[42] The University's laboratories were subsumed into UCD in 1908.

[43] Thomas O'Connor, 'John A McClelland' in Mark McCartney and Andrew Whitaker, *Physicists of Ireland: Passion and Precision,* Bristol and Philadelphia: CRC Press, 2003, pp. 176-183; Charles Mollan, 'John Alexander McClelland' in Charles Mollan, *It's Part of What We Are: Science and Irish Culture, no. 3,* 2 vol. Dublin: Royal Dublin Society, 2007, pp. 1383-1384; Thomas O'Connor, 'The scientific work of John A. McClelland: a recently discovered manuscript', *Physics in Perspective* (2010) 12, pp. 266-306, at p. 270; John Coolahan, 'From Royal University to National University, 1879-1908', in John Dunne, John Coolahan, Maurice Manning, Gearóid Ó'Tuathaigh (eds.), *The National University of Ireland,* Dublin: University College Dublin Press, 2008, p. 5; Fathers of the Society of Jesus, *A Page of Irish history: Story of University College, Dublin, 1883-1909,* Dublin & Cork: Talbot, 1930, pp. 207-208

[44] Roque, op. cit. (12), pp 268-207.

[45] Agar, op. cit. (37), pp 42-3; Maria Rentetzi, 'The U.S. radium industry: industrial in-house research and the Commercialization of science' *Minerva* (2008) 46:4, pp 437-462, at pp 439-440; Anna Guagnini, 'Ivory towers? The commercial Activity of British professors of engineering and physics, 1880-1914' *History and Technology: An International Journal* (2017) 33:1, pp 70-108.

[46] Minute, 10 November 1903 (with later additions in margins), in Committee of Science and its Industrial Applications, 1889-1914, RDS/MAN/SCI.

[47] Dixon was born in Dublin in 1869 and had been appointed assistant to Edward Perceval Wright, Professor of Botany at Trinity College, Dublin, in 1892; in 1904 he succeeded Wright.

[48] Meaning they did not tend to turn toward radium in a similar manner that they would to sunlight.

[49] H.H. Dixon and J.T. Wigham, 'Preliminary note on the action of the radiations from radium bromide on some organisms, with 3 plates', *The Scientific Proceedings of the Royal Dublin Society* (1904) 10, pp. 178-192, at pp. 178-180; see also Luis Campos, 'The birth of living radium', *Representations* (2007) 97:1, pp 1-27, at p. 2; Luis A. Campos, op. cit. (12); Malley, op. cit. (12), pp. 150-151.

[50] Dixon and Wigham, op. cit. (50), pp. 180-185.

[51] J.A. McClelland, 'The comparison of capacities in electrical work: an application of radio-active substances', *The Scientific Proceedings of the Royal Dublin Society* (1904) 10, pp. 167-177, at pp 168-176.

[52] Agar, op. cit. (37), p. 24.

[53] Symington was Professor of Anatomy at Queen's University Belfast and an early proponent of the medical use of x-rays, see A. D. Gough, 'Developments in Northern Ireland' in J.C. Carr, *A Century of Medical Radiation in Ireland—an Anthology*, ?, 1995, pp 48-60, at p. 48.

[54] Finnegan, op. cit. (36), pp. 48-49.

[55] Berry, op. cit. (4), p. 360; 12 January 1904, 8 November 1904, in Committee of Science and its Industrial Applications, 1889-1914, RDS/MAN/SCI.

[56] Sir Howard Grubb, address at presentation of Boyle medal to John Joly, p. 1, in 25 April 1911, Proceedings Scientific Meetings, 21 Nov. 1894 to 24 May 1927, RDS/MAN/SCI.

[57] John Joly, address at presentation of Boyle medal to John Joly, p. 6, in 25 April 1911, Proceedings Scientific Meetings, 21 Nov. 1894 to 24 May 1927, RDS/MAN/SCI.

[58] Siobhn Fitzpatrick, '"Uniting…whatever is pleasing with whatever is useful the advancement of speculative knowledge with the history of mankind": the scientific *Transactions of the Royal Irish Academy*' in Siobhán Fitzpatrick (ed.), *Science at the Royal Irish Academy*, Dublin: Royal Irish Academy, 2012, pp. 37-43, at p. 46.

[59] Whyte, op. cit. (3), p. 58; Berry, op. cit. (4), pp. 369-370; Jean Archer, 'Science loners: the journal of the Geological Society of Dublin and its successors' in Barbara Hayley and Enda McKay (eds.), *Three Hundred Years of Irish Periodicals*, Lilliput Press: Mullingar, 1987, pp. 49-68, at p.49.

[60] Charles Mollan, 'Science and its industrial applications' in Meenan and Clarke, op. cit. (4), pp 207-221, at p. 212-214.

[61] 'Evening scientific meetings' in *The Scientific Proceedings of the Royal Dublin Society* (1904) 10:1, inside cover.

[62] Archer, op. cit. (60), pp. 49-50.

[63] 9 & 12 January 1900, in Committee of Science and its Industrial Applications, 1889-1914, RDS/MAN/SCI; Mollan, op. cit. (61), p. 214.

[64] Certificate of a candidate for election, John Alexander McClelland, The Royal Society, EC/1909/18, GB 117, see https://collections.royalsociety.org/, accessed on 22 June 2017.

[65] Campos, op. cit. (50), p. 3.

[66] F.E. Hackett was born 15 August 1882 in Omagh, Co. Tyrone. He undertook his studies at UCD and edited the college magazine, *St Stephen's,* from 1902-3. In 1905 his was elected a junior fellow of the Royal University of Ireland. This allowed him access to the University's laboratory, where working with J.A. McClelland he utilised the RDS's radium. Hackett received his Ph.D. from Johns Hopkins University in 1908, returning to Ireland the following year as a physics lecturer at Queens College, Galway.

[67] Mary Jo Nye, 'N-rays: an episode in the history and psychology of science', *Historical Studies in the Natural Sciences* (1980) 11:1, pp 125-156, at p. 125; Anon, 'The N Rays' Review of Les Rayons N by Dr Bordier, *The British Medical Journal* (Jan. 1905) 1:2299, p. 139.

[68] F.E. Hacket, 'The photometry of N-rays', *The Scientific Transactions of the Royal Dublin Society* (1904) 8:10, pp. 127-138, at pp. 127-129, 132; J. B. Gough, 'Blondlot, René-Prosper' in *Complete Dictionary of Scientific Biography, vol. 2,* available at Gale virtual reference library, go.galegroup.com, accessed on 30 June 2017

[69] Hacket, op. cit. (69), pp. 134-135.

[70] Irving M. Klotz, 'The N-Ray Affair' in *Scientific American* (May 1980) 242:5, pp 168-175, at p. 168, 175, see also Nye, op. cit. (13), pp 57-71.

[71] Mary jo Nye, op. cit. (13), pp. 71-2.

[72] J.P.D., 'Some remarks on radium *not* by Professor M'Clelland', *St. Stephen's: A Record of University Life* (1904) 2:3, p. 30; K.S.P., 'Further remarks and some suggestions on radium (on an article by J.P. Doyle)', *St. Stephen's: A Record of University Life* (1904) 2:3, p. 72.

[73] Alpha-rays are, of course, helium nuclei.

[74] Finnegan, op. cit. (36), pp. 44-49.

[75] J.A. McClelland, 'On the emanation given off by radium', *The Scientific Transactions of the Royal Dublin Society* (1904) 8:6, pp. 89-94; John J. Nolan, 'The scientific work of the later Professor M'Clelland' in Thomas

O'Connor, 'The scientific work of John A. McClelland: a recently discovered manuscript', *Physics in Perspective* (2010) 12, pp. 266-306, p. 294.

[76] Richard J. Moss, 'On the State in which Helium exists in pitchblende', *The Scientific Transactions of the Royal Dublin Society* (1904) 8:12, pp. 153-168.

[77] J.A. McClelland, 'The penetrating radium rays' in *The Scientific Transactions of the Royal Dublin Society*, (1904) 8:14, pp 90-108; J.A. McClelland, 'On secondary radiation' in *The Scientific Transactions of the Royal Dublin Society* (1904) 8:14, pp 169-80.

[78] J.A. McClelland, 'On secondary radiation (part II), and atomic structure', *The Scientific Transactions of the Royal Dublin Society* (1905) 9:1, pp. 1-8; J.A. McClelland, 'The energy of secondary radiation', *The Scientific Transactions of the Royal Dublin Society* (1906) 9:2, pp. 9-26; J.A. McClelland and F.E. Hackett, 'Secondary radiation from compounds', *The Scientific Transactions of the Royal Dublin Society* (1906) 9:3, pp. 27-36; J.A. McClelland and F.E. Hackett, 'The absorption of β rays by matter', *The Scientific Transactions of the Royal Dublin Society* (1907) 9:14, pp. 37-50; F.E. Hackett, 'The secondary radiation excited by γ rays' in *The Scientific Transactions of the Royal Dublin Society* (1909) 9:4, pp. 204-218.

[79] J.A. McClelland and F.E. Hackett, 'The absorption of β rays by matter', *The Scientific Transactions of the Royal Dublin Society* (1907) 9:14, pp 35-36; J.A. McClelland, 'Secondary β-rays' in *Proceedings of the Royal Society of London* (1908) 80, pp. 501-515.

[80] Mollan, op. cit. (44), p. 1386.

[81] Report of the Committee consisting of the honorary officers, recommending the award of the Boyle Medal to Prof. J.A. McClelland, F.R.S., in 19 Dec. 1917, Proceedings Scientific Meetings, 21 November 1894 to 24 May 1927, RDS/MAN/SCI; Science Committee, 'The award of the Boyle Medal to Professor John A. McClelland, M.A., D.Sc., F.R.S., 1917', *The Scientific Proceedings of the Royal Dublin Society* (1917) 15:49, pp. 677-79, at p. 677.

[82] O'Connor, op. cit. (76), p. 266.

[83] Membership of the Royal Irish Academy (MRIA) was, and is, the highest academic honour in Ireland.

[84] Fathers of the Society of Jesus, op. cit. (44), p. 577.

[85] For example, William Crookes, 'The emanations of radium' in *Proceedings of the Royal Society of London* (1902-3) 121, pp. 405-408;William Ramsay and Frederick Soddy, 'Experiments in Radioactivity, and the production of helium from radium', *Proceedings of the Royal Society of London* (1903-4) 72, pp. 204-207; R.J.

Strutt, 'On the intensely penetrating rays of radium', *Proceedings of the Royal Society of London* (1903-4) 72, pp. 208-10; Alan B. Green, 'A note on the action of radium on micro-organisms', *Proceedings of the Royal Society of London* (1904) 73, pp. 375-381; R.J. Strutt, 'On the distribution of radium in the Earth's Crust, and on the Earth's internal heat', *Proceedings of the Royal Society of London: Series A, Containing Papers of a Mathematical and Physical Character* (1906) 77, pp. 472-85; J.A. Crowther, 'On the scattering of the β-rays from uranium by matter', *Proceedings of the Royal Society of London: Series A, Containing Papers of a Mathematical and Physical Character* (1908) 80, pp. 186-206; H. Geiger, 'On the Scattering of the α-particles by matter', *Proceedings of the Royal Society of London: Series A, Containing Papers of a Mathematical and Physical Character* (1908) 81:546, pp. 174-177.

[86] J.A. McClelland, 'Secondary β-rays', *Proceedings of the Royal Society of London: Series A, Containing Papers of a Mathematical and Physical Character* (1908) 80, pp. 501-515.

Some of McClelland's papers to the RDS were also to be reprinted in a number of journals, for example see: J.A. McClelland, 'The penetrating radium rays', *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* (1904) 8:43, pp. 67-77; J.A. McClelland, 'On secondary radiation', *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* (1905) 9:50, pp. 230-243; J.A. McClelland, 'The comparison of capacities in electrical work; an application of radioactive substances', *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* (1904) 7:40, pp. 362-371; J.A. McClelland, 'On the emanation given off by radium', *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* (1904) 7:40, pp. 355-362.

[87] E. Rutherford, *Radio-activity*, 2nd ed., Cambridge: Cambridge University Press, 1905, pp 181, 192, 211, 492.

[88] Hughes, op. cit. (12), p. 327.

[89] Hughes, op. cit. (14), at pp. 355-356.

[90] For example see E. Rutherford and H. Geiger, 'An electrical method of counting the number of α-particles from radio-active substances', *Proceedings of the Royal Society of London: Series A, Containing Papers of a Mathematical and Physical Character* (1908) 81:546, pp. 141-161; Ernest Rutherford and Hans Geiger, 'The charge and nature of the α-particle', *Proceedings of the Royal Society of London: Series A, Containing Papers of a Mathematical and Physical Character* (1908) 81:546, pp. 162-173; J.A. Crowther, 'On the scattering of homogenous β-rays and the number of electrons in the atom', *Proceedings of the Royal Society of London. Series A, Containing Papers of a Mathematical and Physical Character* (1910) 83:565, pp. 226-247.

[91] For example see: Ernest Rutherford, 'Bakerian Lecture. Nuclear constitution of atoms', *Proceedings of the Royal Society of London: Series A, Containing Papers of a Mathematical and Physical Character* (1920) 97:686, pp. 374-400; Hughes, op. cit. (12), p. 327; Hughes, op. cit. (14), p. 356.

[92] Jorgenson, op. cit. (12), pp 58-61.

[93] Patrick N. Wyse Jackson, 'John Joly (1857-1933) and his determinations of the age of the Earth' in *Geological Society Special Publication* (2001) 190, pp 107-19, at pp 113-115, see https://www.tcd.ie/Geology/assets/pdf/John%20Joly%20-%20The%20Age%20of%20the%20Earth.pdf, accessed on 19 July 2017.

[94] Stevenson had been appointed assistant surgeon and radiologist at Dr Steevens' Hospital, Dublin, in 1904.

[95] John Joly, *History of the Irish Radium Institute*, Dublin: Royal Dublin Society, 1931, p. 23.

[96] Joly, op. cit. (96), p. 24.

[97] Hackett was born in Co. Tyrone in 1882. He studied in UCD and in 1905 was appointed a junior fellow of the Royal College of Science.

[98] Jorgenson, op. cit. (12), pp 60-61.

[99] Agar, op. cit. (37), pp 27-43.