Ellen Gleditsch:
Professor, Radiochemist, and Mentor

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Til mamma
med takk for alt du har gitt meg

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During my years as a Ph.D. student I have also taught laboratory courses in general and inorganic chemistry, lectured on the history of chemistry in a teacher training course, collaborated in the on-going project on collection and registration of ancient scientific instruments, glassware, and chemicals at NTNU, as well as prepared an exhibition about Ellen Gleditsch for the science library. I have given several presentations at international conferences as well as in Scandinavia. All these experiences have been valuable for my development as a researcher in the history of chemistry.

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Last, but not least I will emphasize that it has been a pleasure getting to know the history of science field and Ellen Gleditsch in particular, and that this work has given me an appetite for more.

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Annette Lykknes

Introduction: Ellen Gleditsch: Professor, Radiochemist, and Mentor

- What is needed in order to become a good researcher?
- Difficult to answer. The urge to research is presumably innate. One can probably say that scientific instinct is a necessity, scientific interest, initiative, and capacity to complete tasks. – An inspiring teacher and a scientific environment are also very important.

Gleditsch interviewed in *Mot Kreft* no. 2 (1963) pp. 20-22

Ellen Gleditsch traveled from Norway to Paris in 1907 to study radioactivity under Marie Curie. After five years abroad she returned to Norway, where she was promoted from university fellow (1911) to associate professor (1916) and full professor (1929). In Oslo she was the only authority within radioactivity and laid the foundation for what was to become Norway's centre for radiochemistry (later: nuclear chemistry). She was a pioneer in at least two respects; as a radiochemist participating in the early debates in the field, and as a female scientist, internationally as well as in Norway. In 1929 she became Norway's second female full professor, this was also early in a European context.

This dissertation will deal with Ellen Gleditsch and some important aspects of her career, as professor, radiochemist and mentor. As *Professor* Gleditsch supervised students, gave lectures, disseminated science, did research and administrative work; together with many others she participated in the shaping of a research university which developed during her career. She also experienced the daily life in an institute in which there was competition for both resources and positions, included the professorship she was finally granted after many set-backs. The *Radiochemist* Ellen Gleditsch worked and researched at Marie Curie's laboratory in Paris, and later at Bertram Boltwood's laboratory in New Haven and Stefan Meyer's Institute for Radium Research in Vienna, furthermore she planned and made efforts to establish a similar laboratory in Oslo. During her time in Paris and U.S.A. Gleditsch participated in important debates in the early period of radioactivity, including those on the determination of the radium-uranium ratio and the half-life of radium. In Norway she devoted her time to atomic weight determinations, age determinations, and radiogeological investigations - research was an important part of Gleditsch's life and career. Gleditsch was also a *Mentor* in many respects; in the international radioactivity community, as one of the first female academics and radiochemists in Norway, for her many students, and this role seems also to have been hers within her family. In Paris she looked after students from all over the world to help alleviate their home sickness, at the University of Oslo she was known as the scientific mother to many; mentoring was among Gleditsch's main qualities.

The story of Ellen Gleditsch opens for several perspectives. By focusing on her scientific practice we can get a closer understanding of the questions: What could it be like to be a scientist at the University of Oslo at the beginning to mid-twentieth Century? What were the possibilities for researchers in a small and peripheral University? How could a university career take form? Was research important? What part did travels abroad play for the training of a scientist? How important was the cultivation of international networks? What could it be like to be a female scientist at a time pervaded by a traditional pattern of gender roles, both ideologically and in every-day life? Did women have a possibility to enter men's arena and in what form did the opposition they met appear? What happened in radiochemistry at the time? Did Gleditsch participate in any important controversies and how was her work received? Did her research group take part in these debates, and what became of her students?

The narrative about Ellen Gleditsch therefore goes beyond writing a story about her. It also gives insight into the specific university culture Gleditsch was a part of and the institutional, cultural and political frames within which her research was shaped. The scientist Gleditsch was not only formed by her field and the institutions at which she worked or studied, she herself also participated in the shaping of her immediate surroundings and institute. By using scientific biography the study of how scientific thoughts and ideas develop in the head and heart of an individual scientist can be combined with social, scientific, institutional, political, economical and cultural contexts, thus bridging internalist and externalist approaches to science. Biographies in general deal exactly with this: how one person at the same time is shaped from, and shapes the surroundings in which she lives, and how one single person both reflects that which surrounds her, and vice versa.[1] I will soon return to which aspects of Gleditsch's life I will focus on, first I will look at some of the phases that biography as a genre has been through.

Biography and the History of Science

Scientific biographies have always been important in telling histories of science - in total about four thousand biographies in book format of scientists, engineers and medical doctors have appeared in the Latin, French, English, Italian, Dutch or Scandinavian languages since the early seventeenth century - but their form and popularity have varied.[2] Until the twentieth century biography was primarily a tribute to outstanding individuals, such as kings and political leaders, and these heroic tales, whose aim was to preach a moral and present the glorious and hard-working main character, were especially prevalent in the nineteenth century and beginning of the twentieth century, at which time the scientific biography as genre reached its peak. In 1918, in Lyttan Strachey's book *Eminant Victorians*, heroic tale biographies were for the first time criticized, and Strachey sought biographies that gave a broader picture of a person's life, showing both pleasant and darker sides.[3] Strachey's book is

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[1] Anne Kristine Børresen, "Johan H. L. Vogt: Naturforsker og industribygger," in: Anne Kristine Børresen and Mikael Hård (eds.), *Kunnskap og kultur: Vitenskapens roller i det norske samfunn, 1760-2000* (Tapir akademisk forlag, 2004), pp. 137-174.

[2] Thomas Söderqvist, "Introduction," in: Thomas Söderqvist (ed.), *The History and Poetics of Scientific Biography* (Aldershot: Ashgate, in press). I am grateful to Söderqvist for making drafts of the papers available to me. For a thorough discussion on biography through history, see Michael Schortland and Richard Yeo, "Introduction," in: Michael Shortland and Richard Yeo (eds.), *Telling lives in Science: Essays on scientific biography* (Cambridge: Cambridge University Press, 1996), pp. 1-44; Thomas Söderqvist, "Existential projects and existential choice in science: science biography as an edifying genre," in: *ibid*, pp. 45-84; and Thomas Söderqvist, "Forskerbiografiens historie," *Slagmark: Tidsskrift for idéhistorie* no. 28-29, pp. 51-70.

[3] Lytton Strachey, *Eminent Victorians* (New York: Modern Library, 1918), p. viii.

considered as a turning point in biography writing, where historical context became more important and sources started to be scrutinized.[4]

From the mid-twentieth century the biography as a genre lost status among historians. For twenty to thirty years they were reckoned too narrowly oriented towards individuals. The history of science was in this period increasingly influenced by philosophers such as Carl Hempel, Karl Popper and Imre Lakatos, later referred to as internalists. For them the logical structure of science was more important than the scientist's personality, and science could be understood and analyzed as if external sociological and historical factors did not influence its progress.[5] The declining popularity of the biography was also a reaction to the many hagiographic biographies as these presentations in no way exploited the many possibilities a biography could offer.

About the same time a new perspective in the history of science was launched. With Robert K. Merton's *Science, Technology and Society in Seventeenth-Century England* attention was directed towards the society in which scientists lived and away from the autonomous individual.[6] In this atmosphere, where in particular social, economical and political factors of scientific milieus were studied, biography as a genre hardly survived. Instead historians of science from the inter-war period until the 1980s concentrated on the emergence of scientific ideas, traditions and disciplines, and the institutional and societal frames around the scientific milieus. The scientist's background, personality, and relation to colleagues at home or abroad were reckoned almost irrelevant when an analysis of their

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[4] See e.g. Marianne Egeland, "Lytton Strachey og den nye biografi," in: Marianne Egeland, *Hvem bestemmer over livet? Biografien som historisk og litterær genre* (Oslo: Universitetsforlaget, 2000), pp. 67-72.
[5] Thomas Söderqvist, "Att skriva interaktiv forskerbiografi," *Vest* no. 1 (1992), 9-19.
[6] Robert K. Merton, *Science, Technology and Society in Seventeenth-Century England* (New York: Harper & Row, 1970), first published in 1938 as a part of *Osiris*, volume 4, part 2; L. Pearce Williams, "The Life of Science and Scientific Lives," *Physics* **28** (1991), 199-213.

choices and practices was made.[7] Furthermore, biography was considered too literary and thus non-scientific.[8]

Later, as many genres do, scientific biography saw its renaissance. Thomas Hankins defended the use of biography in the history of science in 1979 and emphasized its possibilities, earlier biographies had simply been unsuccessful because the result appeared inharmonious when an author tried to combine personal aspects and technical details of the scientists work. However according to Hankins the genre offered an unprecedented opportunity: "We have, in the case of an individual, his scientific, philosophical, social and political ideas wrapped up in a single package."[9] Biography was therefore a possible means to combine, or integrate, external factors with internal history of science, resulting, hopefully, in a new understanding of a researcher or a community of scientists emerging.

In the 1980s biographies in the history of science appeared in increasing numbers again. Saturation of institutional history and emphasis on structures in science may partly explain this.[10] But also the gradual interest in the humanities towards so-called "new cultural history," with influence from anthropology, ethnology, folklore, linguistics, and literature, contributed to a change of focus which was more easily integrated in a biography.[11] The general historians at the time gradually turned towards history of every-day life as experienced by common people - from general histories to more complex histories that could be windows for the understanding of more general trends.[12] Biography is a type of micro-history, integrating several perspectives in one story, be it institutional, social, internalist or externalist. A biographical focus in the history of science allows the actors to speak and

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[7] Shortland and Yeo, "Introduction."
[8] Söderqvist, "Att skriva interaktiv forskarbiografi."
[9] Thomas Hankins, "In defence of biography: The use of biography in the history of science," *History of Science* **17** (1979), 1-16, on p. 5.
[10] Söderqvist, "Att skriva interaktiv forskarbiografi;" Söderqvist, "Forskerbiografiens historie."
[11] See e.g. Lynn Hunt, "Introduction," in: Lynn Hunt (ed.), *The New Cultural History* (Berkeley: University of California Press, 1989), pp. 1-22.
[12] Georg G. Iggers, *Historiography in the Twentieth Century: From Scientific Objectivity to the Postmodern Challenge* (Hannover and London: Wesleyan University Press, 1997), pp. 101-102; Ingar Kaldal, *Alltagsgesichte og mikrohistorie* (Universitetet i Trondheim, Historisk Institutt, 1994), Skriftserie fra Historisk Institutt, no. 2.

influence on our understanding of history, and "use an individual's experience … for gaining an understanding of the structural and normative."[13]

The emergence of Science and Technology Studies (STS) in the 1980s also opened for scientist-focused analyses. In Bruno Latour and Steve Woolgar's ethnographical studies of laboratories, scientists were observed in their daily work.[14] Their work revealed new aspects of scientific activities, light was shed on how scientific facts are constructed. Books and articles followed, focus on the lonely genius' struggles in science became outdated, at least within STS, instead the scientist's practices and methods, networking and alliances with other actors in and outside the scientific milieu were analyzed.[15] In the study of science as practice less prominent persons in the scientific milieu, who had previously received scant attention in historical and/or sociological studies, were now legitimate studies, e.g., Stephen Shapin researched and documented the importance of technicians and assistants, previously invisible in the history of science, in the development of Robert Boyle's instruments.[16]

After the 1980s biographies became more critical, aims were now to combine an interest in a scientist with the understanding of the scientific processes behind the work (science in the making) or the complex, institutional and cultural context the science is shaped by and in (science in context).[17] In the next decade further interest in the biographical genre in the history of science appeared, in 1995 Australian historians of science, Michael Shortland and Richard Yeo, solicited a number of essays on biography which were published five years

[13] Charles Rosenberg, "Woods or trees? Ideas and actors in the history of science," *Isis* **79** (1988), 565-570, on p. 569.

[14] See e.g. Bruno Latour and Steve Woolgar, *Laboratory Life: The Social Construction of Scientific Facts* (Beverly Hills: Sage Publications, 1979) and Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Milton Keynes: Open University Press, 1987) (Mikael Hård and Anne Kristine Børresen, "Vitenskap som kulturell ressurs," in: Børresen and Hård, *Kunnskap og kultur*, pp. 11-26).

[15] See e.g. Karin Knorr-Cetina, Roger Krohn and Richard Whitely (eds.), *The Social Process of Scientific Investigation* (Dordrecht: Reidel, 1981), Sociology of the Sciences, no. 4; and Michael Lynch, *Art and Artifact in Laboratory Science: A Study of Shop Work and Shop Talk in a Research Laboratory* (London: Routledge, 1985).

[16] Steven Shapin, "The Invisible Technician," *American Scientist* **77** (1989), 555-563; Hård and Børresen, "Vitenskap som kulturell ressurs."

[17] Malcoml Oster, "Biography, Culture, and Science: The Formative Years of Robert Boyle," *History of Science* **31** (1993), 177-226; Thomas Söderqvist, *Hvilken kamp for at undslippe. En biografi om immunologen og nobelpristageren Niels Kaj Jerne* (Copenhagen: Borgen, 1998), p. 26; Børresen, "Johan H. L. Vogt."

later by the Cambridge University Press under the title *Telling Lives in Science*;[18] in 1995 a symposium at the Oregon State University in Corvallis discussed the life and work of Linus Pauling within the framework of the art of biography in general,[19] an international meeting on biography was also arranged in Denmark in 2002, and more publications have followed.[20] This increasing attention has also led to a renewed interest in different ways of writing a biography.

A New Approach to the Biography Genre

Years of work with the biography of the Danish immunologist Niels Kaj Jerne, induced Thomas Söderqvist to launch a new biographical genre in 1996, distinct from the social biography and the philosophically approached biography; the existential biography.[21] This type of biography should comprise an analysis of the scientist's life, on the scientists' own premises, and not merely a "case study" for the understanding of other aspects of the history of science. While the sociologists look at the scientist as a socially constructed individual, the existential approach investigates how he is confronted with his freedom or fear, consequences of his choices, or of guilt - scientific work and rational thinking are intertwined with the existential project, and involve existential choices, according to Söderqvist.[22]

In my opinion the existential biography is a very interesting approach to understanding a scientist's private and professional spheres, which are of course interrelated. We cannot distinguish between Ellen Gleditsch the chemist, the family woman, or the politically engaged person. All impulses of her life, as well as her own reactions and emotions facing milestones

[18] Shortland and Yeo, *Telling Lives in Science.*
[19] Ramesh S. Krishnamurty (ed.), *The Pauling Symposium: A Discourse on the Art of Biography* (Corvallis, Oregon: Oregon State University Libraries, 1996).
[20] "Workshop on The Poetics of Biography in Science, Technology and Medicine," Copenhagen May 22-25, 2002 with forthcoming proceedings: Söderqvist (ed.), *The History and Poetics of Scientific Biography*; Antonella La Vergata (ed.), *Le biografie scientifiche* (special issue of the Italian history of ideas journal *Intersezioni*, 1995); special issue of the Dutch history of science journal *Gewina* no. 23 (2000).
[21] The term "existential biography" has been used before, but not in Söderqvist's sense, see Söderqvist, "Existential projects," pp. 62-63.
[22] Söderqvist, *Hvilken kamp for at undslippe*, pp. 29-31; Söderqvist, "Existential projects," p. 61.

and obstacles, in work, at home or elsewhere, are interconnected, and constitute small pieces of a whole – the portrait of Ellen Gleditsch. However to write an existential biography in its proper sense, one requires a variety of sources revealing her feelings in life and career. Few of Gleditsch's letters that I have read, include thoughts, feelings and reactions during joyous and hard times, her reasons for choosing and acting the way she did, or on her private life, friendships or romantic relationships. Söderqvist's main character, Jerne, had kept letters, manuscripts, protocols, bills, receipts and more from the age of sixteen as well as his diary. All this he allowed his biographer to read and study, and moreover Jerne added nuances through many conversations with Söderqvist before he died. In my work on Gleditsch, I do not incorporate many of these aspects due mainly to lack of sources. In some situations I can only indicate what it was like to be Ellen Gleditsch, in others personal information is available, e.g. thanks to helpful cooperation by several relatives and former students. My story about Ellen Gleditsch is not a purely social project, neither is it a chemical one. However I have tried to present her career as a result of such factors, as well as many others. I will now discuss the different approaches in my story on Gleditsch, and argue for my choices.

Towards a Biography of Ellen Gleditsch

As discussed, scientific biography offers several possibilities for an understanding of a certain time, scientific community, or research practices. Through a close look at an individual we can learn how personality and surroundings are intertwined in a career and get insight into a scientific milieu. To know the person Ellen Gleditsch and her background is important in order to understand her, however my aim has never been to write a biography following her from birth to death, nor to give a personal portrait of Gleditsch. I have chosen some periods and events in her life because I think these shed light on her career, as well as on how an academic milieu in Norway functioned at that time, in which way her scientific life was integrated in a institutional, cultural, political and economical context, and which strategies a woman in a masculine culture chose. My narrative about Ellen Gleditsch is thus, first and foremost, on her career, i.e. Ellen Gleditsch the scientist, with emphasis on the years 1907-1946, with the purpose to understand more of the (scientific) society in which she lived her life.

As is obvious to the reader, this dissertation is not a traditional biography, in the sense of being a monograph with a beginning and an end. Instead my thesis consists of three independent papers about Gleditsch's career with varying foci, each a complete story with its own beginning and end. In this way particular aspects are cultivated simultaneously in each paper, and each paper can be read independently of the others. I have chosen this form also as a student in a chemistry department having this tradition, where I formally belong, and more important because peer reviews throughout the work educate, trigger questions, enhance foci and force reflections.

It is not only the overall structure that may discern my work from traditional historical research, although evidently there are a number of varieties therein as well. I really appreciate and value biographies from historians with their eloquent and capturing narratives, and I am almost envious of their style and perspectives. My work may in this tradition seem colorless, stringent and too concise, as well as documented beyond most needs. I am, however, trained as a scientist with a concern for detail, imbedded fear for undocumented statements and for perspectives beyond the table top. During my project I have however also learned to appreciate this concern for detail, as when I read fascinating literature of which I eagerly obtained references, if there were any, to end up disappointed as I found little corresponding to the citing text. I therefore reckon the part of my thesis in font ten to be an important part, and I hope it will be of interest to at least some readers.

In paper 1, “Ellen Gleditsch: Pioneer Woman in Radiochemistry,” the story is about the young chemist Ellen Gleditsch, who arrived in Paris in 1907 and started cooperating with Marie Curie. The milieu at the Laboratoire Curie in Paris where Gleditsch worked is outlined as well as the fruits harvested from her time there, namely the extensive personal network of women working in radioactivity, and several publications from her research. Her scientific contributions from Paris; the lithium controversy and the determination of the radium-uranium ratio, are thoroughly discussed in the context of contemporary scientific debates. In this paper it is Gleditsch the pioneer and protégé of Curie, and Gleditsch the representative for many women in radioactivity research, that is portrayed, although a summary of her later contributions and achievements is also mentioned.

In paper 2, “Appreciated Abroad, Depreciated at Home. The Career of a Radiochemist in Norway: Ellen Gleditsch (1879-1968),” Gleditsch’s story in the context of women in science is told. At Gleditsch’s time it was generally accepted that women could not and should not become scientists, they were held to lack strength, rigor, and clarity of mind for an occupation that properly belonged to men.[23] Through her choice of career Gleditsch challenged common prejudices about women’s role in society and academia specifically, and she did meet obstacles during her work. However, in contrast to many other women in academia, she was part of a congenial international network, of women working in radioactivity, and also within the International Federation of University Women. The main issue in this paper is the professorial appointment in 1929, when Gleditsch met opposition both from her predecessor and the rector of the university. Gleditsch was, as the title states, appreciated abroad, but depreciated at home.

Paper 3, “From Fertile Centers to Seeding the Periphery. Ellen Gleditsch: Duty and Responsibility in a Research and Teaching Career, 1916-1946,” also concerns Gleditsch’s

[23] Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven, Connecticut: Yale University Press, 1985), p. 77.

career at home, i.e. in Norway, but does not in particular deal with her role as a *female* scientist. Instead a closer look at which practices comprised her university career has been taken - including struggles for new facilities and financial support, administration and responsibilities, teaching and supervising, as well as her scientific work. Gleditsch, who had been “nourished” in the famous contemporary centers of her subject, wished to establish a teaching and research laboratory of radiochemistry at the University of Oslo, however realities in the periphery of home did not allow this. Although she trained a handful of candidates in radiochemistry, it was eventually under her student, Alexis Pappas, who was appointed professor a decade after her retirement, that this “mission” was accomplished, not least because the general economic situation in Norway and at the University had improved. Through an investigation of her scientific works and the contexts in which they appeared, the dynamics between center and periphery can be further understood.

In my story about the scientist Ellen Gleditsch I have tried to integrate several perspectives, though obviously many had to be disregarded, especially within the limited time of a Ph.D. project. For example feminist theory and political history have only been touched lightly upon. As a chemist, I was interested in and responsible for studying Gleditsch’s research, and to discuss it in a broader context. After all, her work appropriated most of her time. Although I am trained as a chemist with courses in radiochemistry I have hardly conducted any experiments in this field. To study her work and methods, and also contemporary investigations and debates, has therefore been a considerable challenge. Likewise to grasp some of the meticulous laboratory techniques used at the time was similarly difficult, also my wish to present the scientific discussions in an understandable way for a non-expert reader must be added to this. But to me this part is important for the understanding of the scientist. As Hankins argues in his defence of biography: “It may seem tedious to the reader who is only curious about the personality of a ‘great man,’ but is essential for the historian of science."[24] Judging from book reviews of some biographies of women scientists, it is obviously regarded as important to get the science correct.[25]

A narrative can take different forms. William Clark argues to displace a historiographical discourse drawn from political history (with terms like "whiggish" and "revolution") by one drawn from literary criticism or poetics, distinguishing between four classes of narrative; Romance, Comedy, Tragedy, and Satire.[26] According to Clark, the romantic voice is memory, a story-teller, and also nostalgic, of times past and golden.[27] Jan Golinsky, referring to Clark's categories of narrative, argues that often when scientists are writing the histories of their fields or predecessors, they write narratives with a romantic hue because they (as in the hagiographies) present scientists as heroes, readily accommodate wrong paths mistakenly taken, as well as intervals when little or no progress was made. According to Golinsky, "while scientists frequently employ the history of their field so as to locate themselves and their aims in continuous relationship to it, historians are more likely to emphasize the discontinuities that divide the temporal fabric."[28] When I started my Ph.D. work almost five years ago, ignorant as I was, I was attracted to the romantic genre, although at the time I was scarcely familiar, although dormantly aware, of this type of literature. Over the years my competency in history of chemistry as well as on Ellen Gleditsch grew, and I developed receptiveness to external and social factors influencing the history of science. Gleditsch's career itself also invited other aspects than the romantic. It has been argued that a biographer often develops too close a personal and emotional relationship to his or her subject

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[24] Hankins, "In Defence of Biography," p. 8.

[25] Lawrence Badash, "Book Review: Susan Quinn, Marie Curie: A Life," *Isis* **88** (1997), 318-319; David B. McLay, "Review Article: Lise Meitner and Erwin Schrödinger: Biographies of Two Austrian Physicists of Nobel Stature," *Minerva* **37** (1999), 75-94.

[26] Wiliam Clark, "Narratology and the History of Science," *Studies in the History and Philosophy of Science* **26** (1995), 1-71. Christopher A. Chilvers also discusses the use of "tragedy in a manner that reveals its complex socially dynamic and historical character" in the history of science, see Christopher A. Chilvers, "The Tragedy of Comrade Hessen," in: Söderqvist (ed.), *The History and Poetics of Scientific Biography*.

[27] Clark, "Narratology," pp. 9-10.

[28] Jan Golinsky, *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge: Cambridge University Press, 1998), pp. 192ff, quote on p. 194.

during the process.[29] Quite likely this also applies to me, however by being aware of this, I hope to have avoided the most obvious potholes and thus presented a fairly sober story, including both successful and unsuccessful parts of Gleditsch's story. It is comforting to know that Clarke, too, found it hard to reconcile "rather romantic views of science with those of the new professionalism in the history of science" without writing whiggish history. Clifford Geertz, reviewing Haraway's *Primate Visions*, and Ian Hacking, Shapin's and Shaffer's *Leviathan and the Air-pump*, had accused them of being whiggish histories, which made Clark react: "Now consternation turns to elucidations. If one may not aspire to write like those works, then who wants to be a clever professional historian of science?"[30]

On Historiography

When I started my project on Ellen Gleditsch in 2000, two publications on Gleditsch existed; Torleiv Kronen and Alexis Pappas' biography in Norwegian; *Ellen Gleditsch: Et liv i forskning og medmenneskelighet* (Ellen Gleditsch: A life in research and human sympathy) from 1987, and an article entitled "Ellen Gleditsch: Professor and Humanist," in Marelene and Geoffrey Rayner-Canham's edited volume *A Devotion to Their Science* from 1997.[31] The article is mainly based on the biography by Kronen and Pappas, so my discussion will be limited to their book, which has been a valuable source of information and a good starting point for my project. The book, however, doesn't give a contextual discussion of Gleditsch's scientific work or the institutional frame of her career, and important issues such as the

[29] Birgitte Possing, "Biografien ud fra et kvinde- og et historievidenskabeligt sysnpunkt," in: Sune Åkerman, Ronny Ambjörnsson og Pär Ringby (eds.), *Att skriva människan: Essäer om biografin som livshistoria och vetenskapelig genre* (Stockholm: Carlsson, 1997), 61-74.
[30] Clark, "Narratology," p. 3.
[31] Torleiv Kronen and Alexis Pappas, *Ellen Gleditsch: Et liv i forskning og medmenneskelighet* (Oslo: Aventura forlag, 1987) and Anne Marie Weidler Kubanek and Grete Grzegorek, "Ellen Gleditsch: Professor and Humanist," in: Marelene and Geoffrey Rayner-Canham, *A Devotion to Their Science: Pioneer Women of Radioactivity* (Montreal & Kingston, London and Buffalo: McGill-Queen's University Press, 1997), pp. 51-75.

professor appointment are only lightly treated.[32] My thesis therefore complements and extends their book. After 1997, when the Rayner-Canhams' book on women in radioactivity appeared, an interest in these women researchers increased and Ellen Gleditsch became better known. New projects on Gleditsch are therefore met with interest by many in the field of history of science.

The classical work on the history of radiochemistry is Lawrence Badash's book *Radioactivity in America: Growth and Decay of a Science* from 1979, based on his doctoral thesis from 1964.[33] Badash was thrilled when he received a microfilm roll with Ernest Rutherford and Bertram B. Boltwood's correspondence, and he soon "discovered" that Boltwood and a number of his collaborators were important figures in the history of radioactivity. The book spans the period from 1900 to 1920 and covers American scientific debates on radioactivity and was also a valuable source for me in order to gain an overview of the field at the time. To the best of my knowledge no similar source exists, although there are several publications on other figures and debates in the history of radioactivity such as Thaddeus Trenn's *The Self-Splitting Atom: The History of the Rutherford-Soddy Collaboration* from 1977,[34] Jeff Hughes' dissertation on the Cavendish laboratory from 1993,[35] as well as numerous biographies of well-known researchers in the field.[36] Lawrence

[32] The book was critized for lacking contextual frames, and much more. See book reviews: Arne Schouen, "Grått om Ellen Gleditsch," *Dagbladet* September 25, 1987, p. 38; Robert Marc Friedman, "En kvindelig forskerpioner," *Forskningspolitikk* no. 1 (1988), 15-16.

[33] Lawrence Badash, *Radioactivity in America: Growth and Decay of a Science* (Baltimore and London: The Johns Hopkins University Press, 1979); Lawrence Badash, *The Early Developments in Radioactivity, With Emphasis on Contributions from the United States* (Dissertation, Faculty of the Graduate School of Yale University, New Haven, 1964).

[34] Thaddeus J. Trenn, *The Self-Splitting Atom: The History of the Rutherford-Soddy Collaboration* (London: Taylor and Francis, Ltd., 1977).

[35] Jeff Hughes, *The Radioactivitsts: Community, Controversy and the Rise of Nuclear Physics* (Ph.D. thesis in the History and Philosophy of Science, University of Cambridge, 1993).

[36] See e.g. Eve Curie, *Madame Curie* (New York: Doubleday, Doran and Company, 1937); Robert Reid, *Marie Curie* (New York: Dutton, 1974); Susan Quinn, *Marie Curie: A Life* (London: Heinemann, 1995); J. L. Davis, "The Research School of Marie Curie in the Paris Faculty, 1907-14," *Annals of Science* **52** (1995), 321-355; Soraya Boudia, *Marie Curie et son laboratoire: Sciences et industrie de la radioactivité en France* (Paris: Éditions des archives contemporaines, 2001); Anna Hurwic, *Pierre Curie* (Paris: Flammarion, 1995); Loïc Barbo, *Curie: Le Rêve Scientific* (Paris: Belin, 1999); A. S. Eve, *Rutherford: being the life and letters of the Rt. Hon. Lord Rutherford, O.M.* (Cambridge: Cambridge University Press, 1939); Mark Oliphant, *Rutherford:*

Badash has also written many papers on the history of radioactivity as well as edited a volume on the correspondence of Rutherford and Boltwood in 1969.[37] In some of these treatises Gleditsch's work is mentioned, however no profound or separate presentation exists.

Although female researchers have been mentioned in encyclopaedias for centuries, the history of women in science is a new phenomenon which started around the 1970s. In 1987 Londa Schiebinger, reviewing the field, argued that the increase in numbers of women scientists as well as the contemporary women's movements were important influences on this. One branch of the history of women in science seeks to "brush off the dust of obscurity from those women whose scientific contributions have been neglected by mainstream (or in Mary O'Brian's phrase, 'malestream') historians of science" and focuses on the patterns of scientific work conducted by more ordinary female scientists rather than the exceptional ones,[38] a perspective presented in Margaret Rossiter's two volumes of *Women Scientists in America*, from 1982 and 1995.[39] In 1981 a special symposium entitled "The Contribution of Women to the Development of History of Science and Technology" was held at the 15th

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recollections of the Cambridge days (Amsterdam, 1972); David Wilson, *Rutherford: Simple genius* (London: Hodder and Stoughton, 1983); J. B. Birks, *Rutherford at Manchester* (London: Heywood, 1962); Morris W. Travers, *A Life of Sir William Ramsay. K.C.B., F.R.S.* (London: Edward Arnold, 1956); Wolfgang L. Reiter, "Stefan Meyer: Pioneer of Radioactivity," *Physics in Perspective* **3** (2001), 106-127; Ruth Sime, *Lise Meitner: A Life in Physics* (Berkeley, University of California Press, 1996); Marelene F. Rayner-Canham and Geoffrey Rayner-Canham, *Harriet Brooks: Pioneer Nuclear Scientist* (Montreal: McGill-Queen's University Press, 1992); Robert Rosner and Brigitte Strohmaier, *Marietta Blau: Sterne der Zertrümmerung* (Wien: Böhlau Verlag, 2003); Elizabeth Róna, *How it Came About: Radioactivity, Nuclear Physics, Atomic Energy* (Oak Ridge: Oak Ridge Associated Universities, 1978).

[37] See e.g. Lawrence Badash, "Radioactivity before the Curies," *American Journal of Physics* **33** (1965), 128-135; Lawrence Badash, "'Chance favors the prepared mind': Henri Becquerel and the discovery of radioactivity," *Archives Internationales d'histoire des sciences* **18** (1965), 55-66; Lawrence Badash, "Becquerel's 'Unexposed' Photographic Plates," *Isis* **57** (1966), 267-269; Lawrence Badash, "The Discovery of Thorium's Radioactivity," *Journal of Chemical Education* **43** (1966), 219-220; Lawrence Badash, "How the 'Newer Alchemy' was Received," **215** (1966), 88-95; Lawrence Badash, "Rutherford, Boltwood, and the Age of the Earth: The Origin of Radioactive Dating Techniques," *Proceedings of the American Philosophical Society* **112** (1968), 157-169; Lawrence Badash, "The Suicidal Success of Radiochemistry," *British Journal for the History of Science* **12** (1979), 245-256; Lawrence Badash, "Nuclear Physics in Rutherford's Laboratory," *American Journal of Physics* **51** (1983), 884-889; Lawrence Badash, *Rutherford and Boltwood: Letters on Radioactivity* (New Haven and London: Yale University Press, 1969).

[38] Londa Schiebinger, "The History and Philosophy of Women in Science. A Review Essay," *Signs: Journal of Women in Culture and Society* **12** (1987), 305-332, quote on p. 307.

[39] Margaret W. Rossiter, *Women Scientists in America: Struggles and Stragies to 1940* (Baltimore and London: The John Hopkins University Press, 1982) and Margaret W. Rossiter, *Women Scientists in America: Before Affirmative Action 1940-1972* (Baltimore and London: The John Hokins University Press, 1995).

International Congress of History of Science in Bucharest, leading to the establishment of a new commission; namely the History of Women in Science, Technology and Medicine (today: Commission "Women in Science") under the International Union for History and Philosophy of Science (IUHPS), division of History of Science (DHS). Between 1982 and 2001 the Commission organized around ten sessions under the auspices of IUPHS/DHS as well as separate international conferences, all stimulating comprehension of women in science.[40] Interest in many women in *radioactivity* was stimulated when *A Devotion to Their Science: Pioneer Women of Radioactivity* was published in 1997, as a first collective volume, telling stories of the first generation of women scientists (all born before 1900), including many lesser-known ones.[41] As this volume also contains the above mentioned, well-written essay on Gleditsch, the first article in English on her, Gleditsch's life and position became interesting to an international audience of researchers on women in science. Soraya Boudia and Astrid Schüermann have conducted research on female researchers from Curie's laboratory in Paris, whilst Brigitte Bischof's Master thesis from 2000 and Maria Rentetzi's Ph.D. thesis from 2003 have drawn attention to the women at the Radium Institute in Vienna.[42] In 2003 the conference "Women Scholars and Institutions" had a separate panel on women pioneers in radioactivity research, organized by Maria Rentetzi, intending to "place greater importance back on contingencies of time and place, highlight the significance of cultural and political context and at the same time shed light on the interrelation between

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[40] Soňa Štrbáňová, Ida H. Stamhuis, and Kateřina Mojsejová, "Introduction," in: Soňa Štrbáňová, Ida H. Stamhuis and Kateřina Mojsejová, *Women Scholars and Institutions: Proceedings of the International Conference (Prague, June 8-11, 2003)*, Studies in the History of Sciences and Humanitites, vol. 13A, Prague 2004, pp. 9-14.

[41] Rayner-Canham and Rayner-Canham, *A Devotion to Their Science*.

[42] Soraya Boudia, "Les femmes dans la recherche scientifique en France: Le cas du champ de la radioactivité (1898-1934)" in: Raffaella Simili (ed.), *Scienza a due voci* (Florence: Olschki, 2005) [in press]; Astrid Schüermann, "Promoting International Women's Research on Radioactivity: Marie Curie and her Laboratory," in: Štrbáňová, Stamhuis, and Mojsejová (eds.), *Women Scholars and Institutions,* vol. 13B, pp. 591-609; Astrid Schüerman and Ruth Lewin Sime, "Gender and 'race' in Paris and Berlin: From the discovery of radioactivity to World War II," *Osiris* **8** (2005) [in press]; Brigitte Bischof, *Frauen am Wiener Institut für Radiumforschung* (Diplomarbeit Universität Wien, 2000) [to be published in the near future]; Maria Rentetzi, *Gender Politics, and Radioactivity Research in Vienna, 1910-1938* (Ph.D. thesis, Virginia Tech., 2003) [to be published in 2006]; Maria Rentetzi, "Gender, Politics, and Radioactivity Research in Interwar Vienna," *Isis* **95** (2004), 359-393.

scientific practices and gender" in the history of science.[43] The proceedings is the only collective work on women in radioactivity after the Rayner-Canhams' work from 1997. In addition several biographies of women in the field have been published.[44] My project on Ellen Gleditsch must be added to this growing knowledge of the many women in radioactivity.

History of science in Norway is a new discipline, however in recent years milieus in Oslo and Trondheim have emerged; the most recent is the Forum for the History of Knowledge which was established at NTNU in Trondheim in 2003, encouraging new research on various cultures of knowledge, how they emerged, how and why they continued, which of them developed into something new, and what characterized them.[45] The Forum for University History, established by the University board of the University of Oslo in 1993, has another perspective; in 2011 the University of Oslo will celebrate its 200 years anniversary, and this Forum's aim is to develop greater competency and interest in university history as

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43 Maria Rentetzi, "Introduction," in: Štrbáňová, Stamhuis, and Mojsejová (eds.), *Women Scholars and Institutions,* vol. 13B, pp. 581-589, on p. 583. The session on women in radioactivity also includes the following papers: Astrid Schüermann, "Promoting International Women's Research on Radioactivity: Marie Curie and Her Laboratory;" Maria Rentetzi, "Gender and Radioactivity Research in Interwar Vienna: The Case of the Institute for Radium Research;" Brigitte Bischof, "The 'Marie Curie Syndrome,' The Role of Mentors and Romanticism or Why Were There So Many women in Radioactivity Research in Vienna?;" Emilie Těšínská, "Women in Czech Radiology: The Case of Physical Chemist and Radiobiologist Jarmila Petrová;" Annette Lykknes, Lise Kvittingen and Anne Kristine Børresen, "Struggles and Achievements. Ellen Gleditsch (1879-1968): Norwegian Female Radiochemist."

44 For biographies of Marie Curie, see footnote 36, as well as Rosalynd Pfaum, *Grand Obsession: Madame Curie and her World* (New York: Doubleday, 1989); Helena Pycior, "Marie Curie's Anti-Natural Path: Time only for Science and Family," in: Pnina Abir-Am and Dorinda Outram (eds.), *Uneasy Careers and Intimate Lives: Women in Science 1789-1979* (New Brunswick: Rutgers University Press, 1989); Helena Pycior, "Reaping the Benefits of Collaboration While Avoiding its Pitfalls; Marie Curie's Rise to Scientific Prominence," *Social Studies in Science* **23** (1993), 301-323; Sime, *Lise Meitner*; Charlotte Kurner, *Lise, Atomphysikerin: Die Lebengeschichte der Lise Meitner* (Weinheim: Beltz &Gelberg, 1998); Patricia Rife, *Lise Meitner and the Dawn of the Nuclear Age* (Boston: Birkhäuser, 1999); Loriot Noëlle, *Irène Joliot-Curie* (Paris: Presses de la Renaissance, 1991); Rayner-Canham and Rayner-Canham, *Harriet Brooks*; Rosner and Strohmaier, *Marietta Blau*; Peter Galison, "Marietta Blau: Between Nazis and Nuclei," in: Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: The University of Chicago Press, 1997); Ruth Lewin Sime, "Twice Removed: The Emigration of Lise Meitner and Marietta Blau," in: Friedrich Stahler (ed.), *Österreichs Umgang mit dem Nationalsozialismus: Die Folgen für die naturwissenschaftlische und humanistische Lehre* (Wien. Springer Verlag, 2004), pp. 153-170; Maria Alzira B. Almoster Moura Ferreira, "Branca Edmée Marques (1899-1986)," in: *Memórias de Professores Cientistas* (Faculdade de Ciências Universidade de Lisboa, 2001), pp. 50-57.

45 Forum for the History of Knowledge's publications include proceedings from its opening conference in November 2003; Anne Kristine Børresen (ed.), *Science, Crafts and Ignorance: Perspectives on the History of Knowledge* (Tapir Akademisk Forlag, 2004), Publication 1/2004 from Forum for the History of Knowledge.

well as to produce a major work on the entire history of the University.[46] Several permanent and temporary researchers' studies will add to the knowledge on cultures and contexts involved in a modern university development, and on the broader historical impact of these institutions; already a series of projects have been completed.[47] These will, together with on-going projects, hopefully provide new knowledge on a university in the periphery, its role in nation building, as well as the specific traditions cultivated due to the university's small size and relatively short history.[48]

Internationally there are several examples of how research gradually became an integrated part of European and American universities.[49] The studies however look at the university as an institution. My perspective is different; I have directed my gaze on the fundament; to a university scientist's every day life and research practices. The sources I have used from the Chemistry Department and Faculty of Science and Mathematics provide answers to some questions, there are also studies in other disciplines from the same period,

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[46] Robert Marc Friedman, "University History in Norway," *Uppsala Newsletter* no. 28 (2000), 1-3.

[47] Some examples of the theses or publications emerging from the Forum for University History project, are Tore Grønningsæter, *Christopher Hansteen og framveksten av norsk astronomi i begynnelsen av det 19. århundre* (Forum for Universitetshistorie, hovedoppgaveserie 1/2001); Anne Vaalund, *Botanikk og folkeskikk: Botanikkprofessor Nordal Wille –institusjonsbygger, folkeopplyser og filantrop i perioden 1893-1924* (Forum for Universitetshistorie, hovedoppgaveserie 3/2001); Ole Anders Røberg, *Vitenskap i krig og fred: Astrofysikeren Svein Rosseland i norsk forskningspolitikk 1945-1965* (Forum for Universitetshistorie, hovedoppgaveserie 4/2001); Jorunn Sem Fure (ed.), *Studenter under hakekorset: Fra 60-årsmarkeringen av Universitetets stenging i 1943* (Forum for Universitetshistorie 4/2004); Jon Røyne Kyllingstad; *Kortskaller og langskaller: Fysisk antropologi i Norge og striden om det nordiske herremennesket* (Spartacus forlag, 2004). A short history of the University of Oslo has already appeared; John Peter Collett, *Historien om Universitetet i Oslo* (Universitetsforlaget, 1999).

[48] For example, can its peripheral position explain why Norwegian universities were more socially open and egalitarian than other universities in continental Europe and even in Scandinavia? Also, according to Friedman, the culture of outdoor life in Norway might explain why disciplines like the geophysical and earth sciences were more strongly supported than the traditional physics and chemistry (Friedman, "University History in Norway." See also Robert Marc Friedman, *Integration and visibility: Historiographic challenges to university history* (Forum for University History, 2000), Occasional papers 1/2000).

[49] See e.g. Laurence R. Veysey, *The Emergence of the American University* (Chicago and London: The University of Chicago Press, 1970); R. Steven Turner, "The Growth of Professorial Research in Prussia, 1818 to 1848 – Causes and Context," *Historical Studies in the Physical Sciences* **3** (1971), 137-182; Björn Wittrock, "Dinosaurs or Dolphins? Rise and Resurgence of the Research-Oriented University," in: Björn Wittrock and Aant Elzinga, *The University Research System: The Public Policies of the Home of Scientists* (Stockholm: Almqvist & Wiksell International, 1985), pp. 13-37; and essays in Sheldon Rothblatt and Björn Wittrock, *The European and American university since 1800: Historical and sociological essays* (Cambridge: Cambridge University Press, 1993).

but few deal with science as practice.[50] My work is one of many pieces in this overall mozaic. Furthermore, both in the Forum for University History's projects and in the Forum for the History of Knowledge there are no studies of the Chemistry Department or any chemist. My project on Ellen Gleditsch will therefore contribute to this new history of the University of Oslo, to one of its departments, as well as to the general body of women scholars.[51]

Note on Sources

This project is based on a variety of sources. The first group, the *archival sources,* consists firstly of letters, in particular Gleditsch's correspondence with Marie Curie. It is a large collection, placed in the Curie archive at the Musée Curie, in the *Bibliothèque nationale* in Paris, and the manuscript section of the National Library in Oslo. The collection in Oslo also contains her correspondence with several other scientists and a few friends. There are also letters in archives in New Haven, Cambridge (USA), Cambridge (UK), Berlin, Vienna, Stockholm, and Trondheim. In addition to Gleditsch's letters, I have studied parts of correspondence from some of Gleditsch's Norwegian colleagues, such as Odd Hassel, Victor

[50] Examples of biographical work on Norwegian scientists include, apart from the theses mentioned in footnote 47, Geir Hestmark, *Vitenskap og nasjon: Waldemar Christopher Brøgger 1851-1905* (Oslo: Aschehoug, 1999); Arild Stubhaug and Bente Geving, *Det var mine tankers djervhet: matematikeren Sophus Lie* (Oslo: Aschehoug, 2000); Arild Stubhaug og Åsta Brenna, *Et foranskutt lyn: Niels Henrik Abel og hans tid* (Oslo: Aschehoug, 2004); Arild Stubhaug, *Skjulte kodar: Niels Henrik Abel: ein biografi* (Oslo: Samlaget, 2004); Elisabeth Lønnå, *Helga Eng: Psykolog og pedagog i barnets århundre* (Universitetsforlaget, 2002); Lucy Jago, *The Northern Lights* (New York: Alfred A. Knopf, 2001) [biography of Kristian Birkeland]; Åse Kathrine Lauritzen, *Vitenskapsmannen som teknolog: Kristian Birkeland 1901-1908* (Master thesis in history, University of Oslo, 2000); Brian Mason, *Victor Moritz Goldschmidt: Father of Modern Geochemistry* (Texas: The Geochemical Society, 1992), Special publication no. 4; Anne Kristine Børresen, on-going work on the geologist Johan Herman Lie Vogt; Arve Monsen, on-going work on Kristine Bonnevie; see also Robert Marc Friedman, *Appropriating the weather: Vilhelm Bjerknes and the Bergen school of metorology* (Ithaca, N.Y.: Cornell University Press, 1989) and Robert Marc Friedman, "Civilization and National Honour: The Rise of Norwegian Geophysical and Cosmic Science," in: John Peter Collett and Arne Gundersen (eds.), *Making Sense of Space: The History of Norwegian Space Activities* (Scandinavian University Press, 1995), pp. 3-39.

[51] Early work on chemistry in Norway includes: Helge Kragh, "Out of the shadow of medicine, themes in the development of chemistry in Denmark and Norway," in: David Knight and Helge Kragh (eds.), *The Making of the Chemist: The Social History of Chemistry in Europe, 1789-1914* (Cambridge: Cambridge University Press, 1998), pp. 235-263; Olav Helge Angell Nordeng, *Universitet – forskning – samfunn: En studie av Kjemisk Institutt ved Universitetet i Oslo* (Master thesis in sociology, University of Oslo, 1973); Ellen Gard and Bjørn Pedersen, *Kjemisk Institutt, Universitetet i Oslo: En presentasjon…*(University of Oslo, 1981); also, biographies of chemists have been published by professors of chemistry and pharmacy, Bjørn Pedersen and Ragnar Bye, e.g. in the Norwegian chemistry journal, *Kjemi*.

Goldschmidt, Sem Sæland, and Eyvind Bødtker, in order to get a broader view on the scientific community in which she worked, and to understand how they perceived Gleditsch. Gleditsch's letters shed light on scientific practice and what constituted Gleditsch's career; who did Gleditsch keep in touch with, order equipment from, to where did she travel, and sometimes I got a glimpse of the person Gleditsch, how she managed her teaching load, or to which extent she supported e.g. grieving friends. New archive sources in different countries have appeared during the process, partly as I searched new places, partly due to advice from other researchers in the field.

The public archives of the department, faculty and university are scattered, and only thanks to experienced archivists have I obtained some of them. The Department of Chemistry's archives have been transferred to the Public Record Office, whereas the protocols from faculty meetings are kept at the Faculty of Science and Mathematics. Some files are in the cellar of the Central Administration at the university campus, Blindern, in Oslo. The University board's protocols, together with the archives of the Norwegian Academy of Science, different funds, and the Ministry of Church and Education all belong to the collections of the Public Record Office. These public records give an insight to the administration and bureaucracy, how the university system was organized, and to some extent about what characterized this particular culture, e.g. through reading reports of meetings, or applications, I learnt about argumentation for grants, positions, instruments, lab-space and rooms in general, but also which position Gleditsch held in her department and faculty.

Newspaper reports have been another valuable source, and supplemented by other sources they give information on the public figure Ellen Gleditsch. Especially around her professor appointment there was a great interest in her. I have worked my way through every single edition of three important Norwegian newspapers (Aftenposten, Dagbladet, Morgenbladet) for three months in 1929 and indeed they revealed the media's interest in the case. Other newpaper reports were results of specific searches, whilst some I simply stumbled over. For newspaper reports Kronen and Pappas' biography also provided a useful starting point for interviews with Gleditsch, as at the time the book was published clipping archives of newspapers existed. Ironically two months before I was to submit my thesis, I talked for the first time to the grand-daughter of one of Gleditsch's brothers, who had kept Gleditsch's own scrap book, which she kindly lent me. In it were newspaper reports and interviews complementing my already large collection, and they confirmed, not surprisingly, that Gleditsch was a public person.

A third important source has been Gleditsch's own *publications*. Fortunately, most of them were listed in her letter collection in Oslo. However to get hold of other contemporary scientists' publications, in order to track the scientific debates, was not straight-forward, as authors did not always cite their contemporaries' and predecessors' work, and, if they did, these references were often incomplete. To understand what happened after Gleditsch's work appeared was even more challenging. Sometimes contemporary textbooks were helpful, secondary treatises such as Badash's on the history of radioactivity also gave clues, and finally sometimes I obtained a paper with a complete reference list and my project moved on at an unprecedented rate. For debates that continued until the 1950s (the work on ^{40}K) on-line search resources have also been valuable, the results of which helped me to find which journals to look through for more publications. In some cases I had to rely on advice from experts in the field in order to progress. I believe that I have obtained most of the relevant sources and thus that the scientific debates as they are presented in this dissertation (paper 1 and 3), are representative for the discussions at the time.

Finding information on Gleditsch's students and collaborators was sometimes also difficult. In Norway we are fortunate to have directories written by every student for the 25- and 50-years anniversaries of their matriculation exam, which summarize what the students have achieved since their exam.[52] However, to find these sources I needed to know the year of their matriculation, which there are no short-curts to. Some of them I found in the catalogues of Norwegian scientists, pharmacists and engineers,[53] some by ploughing through the lists of students in the annual reports of the university. Having found the directories, these were not always complete, and I had to search for additional information elsewhere. A few of Gleditsch's students later became professors and articles about them could be found in biographical encyclopedia, or e.g. in publications honouring their anniversaries, for others oral sources provided helpful starting points.

Among *oral history* sources are radio interviews or obituaries of Gleditsch from the archives at NRK (Norwegian Broadcasting Corporation), video interviews with Gleditsch and two representatives of the next generation of chemists, her own student Ivan Rosenqvist and Hassel's student, Otto Bastiansen, which like written obituaries and newspaper interviews shed some light on the persons behind the names. My impression of Gleditsch has been further substantiated by talks with relatives (a niece, a nephew as well as more distant relatives), students (Master and Undergraduate students) and colleagues, however their memories are naturally limited to the last thirty years of her life. Some talked heartedly about their family and lives and also provided pictures, some shared their experiences with Gleditsch as a teacher and supervisor, and many emphasized her warmth, although she was well known not to play along with anybody. Also the second generation students of Gleditsch have given information and helped me with difficult scientific questions and identified persons in photos. With most of them I talked at least twice, sometimes on the phone, sometimes in their homes or offices, and many of them gave additional information by e-mail or regular mail.

[52] These are called *Studentene fra [eksamensår]* (The students from [year of matriculation]).
[53] *Norges Realister 1907-1962* (Norges Teknisk-Naturvitenskapelige Forskningsråd, 1963); Bjarne Bassøe (ed.), *Ingeniørmatrikkelen: Norske Sivilingeniører 1901-55 med tillegg* (Oslo: Teknisk Ukeblad, 1961); Christian van der Lagen (ed.), *Norges Apotekere og Farmaceutiske Kandidater* (Oslo: A. M. Hanches forlag, 1933).

Oral sources, such as interviews and conversations, are valuable because they give personal reflections which are difficult to obtain otherwise, they sometimes indicate new sources, give unexpected perspectives, and add information that does not exist in written form. Only persons who knew Ellen Gleditsch well can provide information on her personality, priorities, caring, and interests, but of course these stories are subjective and must be treated as such.[54] The main objection against oral sources in history writing as discussed in the 1960s and 1970s, is of course still relevant; namely, that informants often tell about events which took place many years ago. Memory does not only fade with time, memory is also influenced by new information, culture and experiences that come afterwards, which might adjust the actual episodes, consciously or unconsciously. Historians, as any other researchers using interviews, must be aware of the fact that an interview or conversation may "create" certain answers, or stories, however at the same time what is said will be reflections of what actually happened. In my work conversations have been utilized to supplement biographical information about Gleditsch or her students, to get an impression on how the students saw Gleditsch, and, in some cases, her relationship with her colleagues. The commemorative radio program about Gleditsch by Ivan Rosenqvist, for example, provides an interesting view on her field and methods, seen from the perspective of one of her students and later colleagues.

Newspaper reports (as well as personal letters) are of course also colored by the author's subjective opinion or the board's policy and political preferences, I therefore consulted three newspapers from different traditions; the liberal *Dagbladet*, and the conservative *Aftenposten* and *Morgenbladet* in my 1929 investigations. Newspaper interviews of Gleditsch are used as biographical information, to understand her motivation for entering

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[54] In 1967 the Oral History Association (OHA) was founded, through their website and publications, users of oral history sources can get information and guidelines, see http://omega.dickinson.edu/organizations/oha/pub_eg.html See also Paul Thomson, *The Voice of the Past: Oral History* (Oxford and New York: Oxford University Press, 1988); David Henige, *Oral Historiography* (London: Longman, 1982); Dagfinn Slettan, *Minner og kulturhistorie: Teoretiske perspektiver* (Universitetet i Trondheim, Historisk Institutt, 1994), Skriftserie fra Historisk Institutt, no. 4.

science, her thoughts on how she was received as a woman, and to illustrate the attention around the professor appointment.

Final Comments

Ellen Gleditsch was an international scientist. She was not only trained in the centers of radiochemistry, but returned there frequently during her career to do research and breathe the air of a scientific institute in her field. The international aspect was an important part of her life, and her congenial networks of women in radioactivity and in the International Federation of University Women in many ways distinguish her story from that of other contemporary scientists. Yet most of her career she lived in Oslo, as professor, radiochemist and mentor at the Chemistry Department of the University. By dealing with certain aspects of her scientific career I have hopefully contributed to an enhanced understanding of what it could be like to be a researcher on the scientific periphery of Europe. As will be treated in the following papers, to Gleditsch this meant e.g. pioneering work abroad, for which she gained international reputation, network building, and seeding of what was to be harvested as a Norwegian center for nuclear chemistry research a decade after her retirement. Happy reading!

Archives

Archives Marie Curie, Historical Archives of the Curie Laboratory (AMC), Musée Curie, Paris

Archives Irène Joliot-Curie, AMC

Archives Frédéric Joliot-Curie, AMC

Archives Irène and Frédéric Joliot-Curie, AMC

Marie Curie letter collection, no. 18450, Bibliothèque nationale de Paris (BN)

Marie Curie micro film collections, no. 2669, 2671, BN

Ellen Gleditsch letter collection, no. 456, National Library of Norway, manuscript section (NBM)

Letters from Ellen Gleditsch, collections no. 48, 253, 304, 347, 386, 435, 537, 585, Ms. 4° 2985:3, NBM

Ellen Gleditsch manuscripts, collection no. Ms. 4° 2437: 2-19, NBM

Eivind Bødtker letter collection, no. 359, NBM

Letters from Victor Moritz Goldschmidt, letter collections no. 102, Ms. fol. 1924: $14d_3$, Ms. fol. 3861: 8, NBM

Odd Hassel material, unsorted, boxes 1-5, NBM

Correspondence between Sem Sæland and Vilhelm Bjerknes, letter collection no. 469B, NBM

Bertram Boltwood collection, manuscripts and archives of Yale University Library, New Haven (YUL)

T. W. Richards papers, HUG 1743.1.8, Box 3, Harvard University Archives, Cambridge, Massachusetts

Ernest Rutherford papers, MS.ADD. 7653, Cambridge University Library, Department of manuscripts, Cambridge

Lise Meitner papers, MTNR 5/9, 5/15, Churchill College Archives (CCA), Cambridge

Ellen Gleditsch correspondence, Archives of the Austrian Academy of Sciences, Institute for Radium Research (AÖAW), Boxes 12, 32, 41, 68, Vienna

Ellen Gleditsch-Friedrich Paneth correspondence, Historical Archives of the Max Planck Institute, Berlin-Dahlem (MPG), III. Abt., Rep. 45, No. 39, Berlin

Ellen Gleditsch correspondence, The Royal Swedish Academy of Sciences, (KVS) Center for History of Science, Stockholm

Victor Moritz Goldschmidt correspondence, Niels Bohr Archive, Copenhagen

Victor Moritz Goldschmidt Archive, Archives of the State Laboratory for Raw Materials, the Regional State Archive in Trondheim, Boxes H-06, H-08, H-09

Honorary Degree Files: Ellen Gleditsch, Smith College Archives, Northampton, Massachusetts

Warren Weaver Diary 1933, Rockefeller Record Group 12.1, Rockefeller Archive Center, New York

Archive of the Faculty of Science and Mathematics, University of Oslo (AMNF)

Central Archive, Files of the Faculty of Science and Mathematics, University of Oslo (SAO)

Archive of the Ministry of Church and Education, Public Record Office (RARK)

Archive of the University board, University of Oslo, RARK

Archive of the Chemistry Department, University of Oslo, RARK

Archive of the Norwegian Academy of Science, RARK

Oral history

Official material

Interview with Ivan Rosenqvist, video tape in possession of Forum for University History, University of Oslo

Interview with Otto Bastiansen, video tape in possession of Forum for University History, University of Oslo

Interview with Ellen Gleditsch in NRK, video tape in possession of Chris Koch

Interview with Ellen Gleditsch in NRK radio, no. 3790

Radio Obituary of Ellen Gleditsch by Ivan Rosenqvist and Anna Rosenqvist, NRK radio, no. 51577

Ellen Gleditsch's own memoirs in NRK radio, no. 684, 51506

Ellen Gleditsch's lecture about Marie Curie in NRK radio, no. 51912

Ellen Gleditsch and Irène Joliot-Curie about atomic energy, NRK radio, no. Gram-4764

Family

Conversations with Chris Koch, April 2002 and May 2004 + correspondence

Conversations with Nils Petter Gleditsch, September 2001, February 2004 + correspondence

Conversations with Bernard Ragvin, October 2003 + correspondence

(as well as conversations and correspondence with Dagmar Gleditsch, Lars Edmund Gleditsch, Mette Janson, Dag Gleditsch, Esther Gleditsch, Susanne Øverli)

Students/colleagues/second generation students

Conversation with Alexis C. Pappas, October 2001

Conversations with Paul Thrane Cappelen, January 2003, October 2004

Conversations with Terkel Rosenqvist, January 2003, March 2005

Conversations with Ellen Rosenqvist, January 2003, October 2004

Conversation with Gerd Borgen, January 2003

Conversations with Jorolf Alstad, January 2003 and repeatedly through my work

Conversation with Geirr Sletten, June 2004

<u>Others</u>

Conversation with Hélène Langevin-Joliot, June 2001

Paper 1

Annette Lykknes, Helge Kragh, and Lise Kvittingen,

”Ellen Gleditsch: Pioneer Woman in Radiochemistry,”

Physics in Perspective **6** (2004), 126-155

Paper 1 is not included due to copyright

Paper 2

Annette Lykknes, Lise Kvittingen, and Anne Kristine Børresen,

”Appreciated Abroad, Depreciated at Home.
The Career of a Radiochemist in Norway:
Ellen Gleditsch (1879-1968),”

Isis 2004, 95:576-609

Appreciated Abroad, Depreciated at Home

The Career of a Radiochemist in Norway: Ellen Gleditsch (1879–1968)

By Annette Lykknes,* Lise Kvittingen,** and Anne Kristine Børresen***

ABSTRACT

Ellen Gleditsch (1879–1968) became Norway's first authority on radioactivity and the country's second female full professor. From her many years abroad—in Marie Curie's laboratory in Paris and at Yale University in New Haven with Bertram Boltram—she became internationally acknowledged and developed an extensive personal and scientific network. In the Norwegian scientific community she was, however, less appreciated, and her appointment as a professor in 1929 caused controversy. Despite the recommendation of the expert committee, her predecessor and his allies spread the view that Gleditsch was a diligent but outdated researcher with little scientific promise—a view that apparently persists in the Norwegian chemical community today. In addition to her scientific work, Gleditsch acquired political influence by joining the International Federation of University Women in 1920; she later became the president of both the Norwegian section and the worldwide organization. She worked in particular to establish scholarships enabling women to go abroad.

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> I once worked with a learned man who was reputed to hate women. On one occasion he stated that the new collaborator was a rare exception. When he was asked why he said, "She does not scream." I heard this several months later and have kept it as a great compliment; yes—the biggest in my scientific career.
>
> —Ellen Gleditsch

DESCRIPTIONS OF THE EARLY HISTORY OF RADIOACTIVITY often confine themselves to the contributions of well-known researchers such as Ernest Rutherford, Bertram B. Boltwood, Otto Hahn, and Stefan Meyer, on the male side, and to Marie Curie and Lise Meitner among the women. Thanks to collected biographies, such as Marelene and Geoffrey Rayner-Canham's edited volume *A Devotion to Their Science,* attention has been drawn to some of the other women in the field, who, like women in science more generally, have previously received scant attention in the historical literature. Many, many women got caught in all the dead ends that make up the history of women in science; they belonged to the second, or even the third, rank of physical scientists, and they are in fact more representative of women scientists—in radioactivity and other fields—than were exceptional figures like Curie and Meitner.[1] In this essay we hope to provide further justification for learning more about women scientists at this next level.

Curie attracted women from a number of countries; the Norwegian chemist Ellen Gleditsch, who arrived in Paris in 1907, was the first woman to work in her laboratory for a prolonged period.[2] Gleditsch's acquaintances from this time formed the basis of her scientific network throughout her career. Later Gleditsch had a sojourn in New Haven, Connecticut, where she worked for Boltwood, and eventually she established a career in her native country.

Like many of her female colleagues, and despite the comparatively large proportion of women within radioactivity, Gleditsch encountered prejudice and hostility from the men she worked with. The quotation that opens this essay illustrates one man's—probably Boltwood's—attitude at the time of her arrival in the United States in the fall of 1913. In Norway she met misogyny of a more unpleasant sort, particularly when she applied for a full professorship in 1929. Both the rector of the university and Gleditsch's predecessor tried to prevent her appointment, even though the majority of the expert committee found her the best candidate.

Gleditsch functioned in a society pervaded by the traditional pattern of sex roles, both ideologically and in everyday life. Women were subordinate to men; and while men's work and activities largely took place in the public arena, women directed their efforts toward home and family. As Evelyn Fox Keller notes, it was generally accepted that women could not and should not be scientists; they were held to lack the strength, rigor, and clarity of

[1] Marelene F. Rayner-Canham and Geoffrey W. Rayner-Canham, eds., *A Devotion to Their Science: Pioneer Women of Radioactivity* (Philadelphia: Chemical Heritage Foundation, 1997) (hereafter cited as **Rayner-Canham and Rayner-Canham, eds., *Devotion to Their Science***). See also Margaret Rossiter, "A Twisted Tale: Women in the Physical Sciences in the Nineteenth and Twentieth Centuries," in David C. Lindberg and Ronald L. Numbers, eds., *The Cambridge History of Science,* Vol. 5: *The Modern Physical and Mathematical Sciences,* ed. Mary Jo Nye (Cambridge: Cambridge Univ. Press, 2003), pp. 54–71. The epigraph is quoted from an interview with Ellen Gleditsch published in a local newspaper in Norway: "Mannen som kollega: Hvad professor Ellen Gleditsch mener," *Adresseavisen,* 10 May 1930 (here and throughout the essay, translations into English are our own unless otherwise indicated).

[2] Liste du personnel du laboratoire Curie 1904–1934, Historical Archives of the Curie Laboratory, Archives Musée Curie (hereafter cited as **AMC**).

mind for an occupation that properly belonged to men.[3] Through her choice of career and by virtue of being one of the first female professors in Norway—and even in Europe—Ellen Gleditsch challenged common perceptions about what jobs were suitable for women and what women could achieve. Her position gave her the opportunity to specialize within a field, to lecture at the university level, to travel, and to develop as a person in an unprecedented way. But she did meet obstacles, and many of them were connected to her gender. Science was an area created by men and permeated by masculine values; this essay will make it clear that, even though Gleditsch was not a total outsider to science, she was by no means an insider.

The story of Ellen Gleditsch could be written from several perspectives. Torleiv Kronen, a French teacher, became aware of Gleditsch's correspondence with Curie while doing research on Norwegian academics in France. He and Alexis C. Pappas, a professor of nuclear chemistry who was Gleditsch's student, successor, and friend, wrote a biography that pays tribute to Gleditsch as a scientist and humanist.[4] It is a valuable overview, rich in useful information on Gleditsch's life and career, but it does not present detailed discussions of and critical reflections on the scientific debates and the broader institutional context in which she participated or on her fight to become a full professor. This essay will focus on Gleditsch's experiences as a female researcher both abroad and, especially, in Norway, where she spent most of her career as a university fellow, associate professor, and, finally, full professor.

Like many female academics, Gleditsch had problems finding acceptance among her colleagues at her home university; in contrast to many others, however, she was fortunate to be part of a congenial international network. As we shall see, this network included scientists, in particular female scientists, who worked in radioactivity and also members of the International Federation of University Women. These people would be her supporters and friends throughout her career, compensating for the chilly atmosphere she met in Norway. Gleditsch is thus an example of an internationally recognized scientist who was disparaged when she returned to the small chemical community in her native country but was sustained both scientifically and personally by an extensive international network. We have included a brief summary of her background, education, and entrance into science and a discussion of some of her main scientific contributions in order to present a broader picture of Gleditsch as a scientist and as a person. To contextualize, we begin with a short introduction to the history of women's participation in Norwegian academia.

WOMEN IN NORWEGIAN ACADEMIA: FORMAL RIGHTS IN GLEDITSCH'S TIME

Secondary Schools and Matriculation

When Gleditch passed her matriculation exam in 1905, three years after completing her degree in pharmacy, Norwegian women had been permitted to sit this examination for twenty-three years; the secondary school examination had been open to them for twenty-nine years.[5] The opening of what had been boys' secondary schools to women had been

[3] Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven, Conn.: Yale Univ. Press, 1985), p. 77.

[4] Torleiv Kronen and Alexis C. Pappas, *Ellen Gleditsch: Et liv i forskning og medmenneskelighet* (Oslo: Aventura, 1987). A well-written account, based largely on the biography by Kronen and Pappas, is Anne Marie Weidler Kubanek and Grete P. Grzegorek, "Ellen Gleditsch: Professor and Humanist," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 51–75.

[5] The matriculation exam, *Examen artium,* corresponded to today's high school graduation exam, after which the pupils were given the title "students." It was also a requirement for university acceptance. Until 1923 this

a gradual process, initiated by women who needed educational certificates that girls' primary schools did not supply. The first girl to take the secondary school exam with the permission of the Ministry of Church and Education was Ingeborg Poulsson, whose father raised the issue on her behalf. It was determined that no change of law was needed to enable girls to take the exam, and an administrative addition to the existing statutes, dated 26 April 1876, accomplished the purpose.[6]

In Sweden and Denmark, matriculation and most university degrees were opened to women in 1870 and 1875, respectively. In 1880 (Ida) Cecilie Thoresen asked her father whether she had the same opportunities in Norway.[7] He directed the question to the Ministry of Church and Education. The Faculty of Law, speaking on behalf of the university, concluded that a change of law would be required: the matriculation exam was held to be a maturity test for men only. After a debate in Parliament, only one of the 114 members voted against changing the law. Although the Ministry of Church and Education continued to express doubts as to whether women should be permitted to take the exam, the new law was formally approved on 15 June 1882. A few weeks later Cecilie Thoresen was finally able to matriculate.

The cases of Cecilie Thoresen and Ingeborg Poulsson show that Norwegian women from resourceful families could fulfill their unorthodox wishes if a man—often the father—was willing to articulate them.[8] Their ambitions were put forward in a period of general social and political change, and from the 1880s onward a sympathy for women's liberation developed in Norway. This gradually changed women's legal position and paved the way for them to achieve full rights throughout society.[9]

University Degrees for Women

Although the university had been opened to women as a result of their right to matriculate, women were still not permitted to complete degrees. They were not allowed to participate in seminar groups within some faculties; this would, after all, be useless to them, as they had no right to hold any academic position. Nevertheless, Thoresen and others attended courses and lectures as so-called auditors.[10] Thoresen never completed a degree in science, as she thought that this would be incompatible with her future life when she married in 1887. Like most people, she regarded it as improper for a woman to continue her education or to work after marriage. From that point, nearly everyone believed, a woman's energy should be directed toward her home, husband, and children.

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exam was not compulsory for pharmacy studies, however. This explains why Gleditsch did not pass the exam before she started her chemistry studies at the university in 1905. See Bjørn Johannesen, "Norsk Farmaceutisk Selskap gjennom 75 år," *Cygnus,* 1999, no. 3, pp. 5–10.

[6] Anna Caspari Agerholt, *Den norske kvinnebevegelses historie,* 2nd ed. (Oslo: Gyldendal Norsk, 1973), p. 56; and Agnes Frølich, "Kvinner får adgang til høyere utdanning," in Ingeborg Astrid Klepp *et al., Jubileumsskrift: Kvinner ved Universitetet i 100 år—Hvor langt har vi nådd?* (Bergen: Univ. Bergen, 1982), pp. 1–8, on p. 2.

[7] Anna Caspari Agerholt, "Kampen om adgang til høiere utdannelse," in *Kvinnelige Studenter 1882–1932,* published by Norske Kvinnelige Akademikeres Landsforbund (Oslo: Gyldendal Norsk, 1932), pp. 41–78, on p. 53; and Agerholt, *Den norske kvinnebevegelses historie,* p. 59.

[8] A similar initiative was taken by a group of thirty mothers in Switzerland in 1872. See Natalia Tikhonov, "Le rôle des parents dans l'accès de jeunes filles à l'enseignement supérieur en Suisse à la fin du XIXe siècle," in *Lorsque l'enfant grandit: Entre dépendence et autonomie,* ed. Jean-Pierre Bardet, Jean-Noël Luc, Isabelle Robin-Rouiero, and Catherine Rollet (Paris: Presses de la Sorbonne, 2002), pp. 505–520.

[9] Gro Hagemann, "Det moderne gjennombrudd 1870–1905," in *Aschehougs Norgeshistorie,* 12 vols., Vol. 9 (Oslo: Aschehoug, 1997), p. 118.

[10] Agerholt, *Den norske kvinnebevegelses historie* (cit. n. 6), p. 62.

From the 1880s, women's insistence that they should be allowed to complete university degrees increased. The demands began with the medical degree. Even some men regarded the idea of female physicians as inoffensive, believing that a woman was entitled to treatment by one of her own kind. The medical authorities were, however, opposed to training female doctors. One argument was that a woman who studied medicine would become "something abnormal," that "her intelligence would develop at the expense of her emotional life."[11] In 1884 H. E. Berner, the member of Parliament who had proposed the law that allowed women to matriculate, proposed that women should be granted full rights at the university—not only the right to pursue medical degrees. This new law, like the matriculation law, passed with only one vote in opposition and was sanctioned on 14 June 1884, two years after the matriculation law was changed and four years after Cecilie Thoresen had started her fight. This new law did not admit women as public servants, however, and this would become the next battleground. The movement to change the law regarding public service brings us to the case of the first female professor in Norway, Kristine Bonnevie.

Norway's First Female Full Professor

Norway was comparatively late in opening school exams and university degrees to women, but 1912 saw the appointment of Kristine Bonnevie as the first female full professor at the university in Oslo.[12] After completing her studies she worked as a curator in the Department of Zoology, where her duties included teaching. According to her memoirs, she also administered the department and was responsible for student excursions. In brief, she stated, "During the first decade after my appointment I had in reality a professor's full work and responsibility, but with respect to title and salary I was still 'curator.'"[13] Not until she applied and was recommended for a lectureship—equivalent to a professorship—at the Bergen Museum in 1910 did Robert Collett and Georg Ossian Sars, the professors in the department in Oslo, act to avoid losing her—and thus having to take over her duties. They proposed that Bonnevie be given a full professorship at the university. But the law that would allow women to hold positions as public servants had not yet been passed.[14]

[11] Unanimous statement from the university medical faculty, quoted *ibid.,* pp. 62–63.

[12] At this time there was only one university in Norway, the Royal Frederik University in Kristiania, founded in 1811. Norway was a part of Denmark-Norway until 1814, and before 1811 Norwegians studied in Copenhagen. Beginning in 1624, the capital of Norway was called Christiania (spelled "Kristiania" from 1877), after the Danish-Norwegian king Christian IV (1577–1648). In 1925 the original name, Oslo, was restored. In 1939, in anticipation of the founding of another Norwegian university, the University of Bergen (which was established in 1946), the Royal Frederik University was renamed the University of Oslo. For simplicity, we will refer throughout this essay to "Oslo" and the "University of Oslo," even for periods when the name was actually otherwise. It should be noted, furthermore, that Norway also had other important research institutions: e.g., the Norwegian Institute of Technology, founded in 1910, which is now part of the Norwegian University of Science and Technology in Trondheim.

[13] Aadne Ore and Ove Arbo Høeg, "Det Matematisk-Naturvitenskapelige Fakultet," in *Universitetet i Oslo 1911–1961,* 2 vols. (Oslo: Universitetsforlaget, 1961), Vol. 1, pp. 475–699, on p. 597; and Kristine Bonnevie, "Fra 30 års virksomhet som Universitetslærer," in *Kvinnelige Studenter 1882–1932* (cit. n. 7), pp. 92–101, on p. 96 (quotation). For information on Bonnevie see Arne Semb-Johansson, "Kristine Bonnevie, vår første kvinnelige professor," *Forskningspolitikk,* 1999, no. 4, http://fagbladet.nifustep.no/fagbladet/innhold/redaksjonsarkiv/nr_4_1999/kristine_bonnevie_v_r_f_rste_kvinnelige_professor; and Bjørn Føyn, "Minnetale over Professor Kristine Bonnevie," in *Det Norske Videnskaps-Akademi: Årbok* (Oslo: Det Norske Videnskaps-Akademi, 1949), pp. 71–79. A note on Bonnevie appears in Marilyn Ogilvie and Joy Harvey, eds., *The Biographical Dictionary of Women in Science* (New York: Routledge, 2000), Vol. 1, pp. 157–158. See also Bonnevie's own memoirs in Elga Kern, *Führende Frauen Europas* (Munich: Ernst Reinhardt, 1928), pp. 187–198.

[14] Public servants *(embetsmenn)* were all those who held final university degrees and had been appointed by the king to their posts, including full professors. Bergen Museum, founded in 1825, was a semipublic institution

By 1902 360 women had matriculated, and their meager job rights became the next focus in the fight for equality. In 1904, in a move without precedence in Europe, the government proposed women's admission to public service positions, with some exceptions. Action on this proposition was postponed in 1904 and 1905, and it was not put forward again until 1911, by which time the issue was less contentious. Some argued that women had already demonstrated their abilities in public positions and even that they were better qualified than men for certain jobs. As Parliament had been open to women since 1907, it seemed unreasonable not to allow them to hold other positions in public service.[15] Shortly after the law was sanctioned in 1912, Kristine Bonnevie was appointed to a (extraordinary) full professorship in zoology (full professor from 1919). She was one of the first women to become a full professor at a state institution in Europe: the first female full professor in what is now the Czech Republic was appointed in 1945, while the first in Germany was named in the late 1950s, in Sweden in 1937, and in Denmark in 1946.[16] Four years after Bonnevie's appointment, Ellen Gleditsch became the first female associate professor at the university in Oslo, and in 1929 she was named the second woman full professor in Norway. The third was Helga Kristine Eng, who became a professor of pedagogy in 1938. Only three more women were appointed full professors in Norway (one in 1939 and two in 1948) until the 1960s, and all were in the humanities.[17]

ELLEN GLEDITSCH: NORWEGIAN RADIOCHEMIST AND NETWORK BUILDER

Family Background and Scientific Training

Ellen Gleditsch was born in 1878 into a middle-class family in the south of Norway, the first of eleven children who arrived in rapid succession. Both parents were politically involved, and her mother was a suffragist. Her father, a teacher with a special interest in the natural sciences, eagerly took his family to the mountains, the forest, and the sea.

for natural history, archaeology, and cultural history, financed mainly by the state and the local community. Bergen Museum became the University of Bergen in 1946. See Anders Haaland, "Bergen Museums historie 1825–1945," in Astri Forland and Haaland, *Universitetet i Bergens historie* (Oslo: Akademisk Publisering, 1996), Vol. 1, pp. 93–110.

[15] Agerholt, *Den norske kvinnebevegelses historie* (cit. n. 6), pp. 232–238.

[16] For an account of women's admission to German universities see Patricia M. Mazón, *Gender and the Modern Research University: The Admission to German Higher Education, 1865–1914* (Stanford, Calif.: Stanford Univ. Press, 2003). The first female professor in Europe was the Russian mathematician Sofia Kovalevskaia, appointed in 1899 at Stockholm's Högskola (later the University of Stockholm), a private institution not subject to the same laws as state universities. Similarly, Lise Meitner became a professor at the private Kaiser Wilhelm Institute for Physics in Berlin in 1919 but was not allowed to teach at German universities. Later, in 1926, she became the first female professor at a German university, although she held the rank of extraordinary professor *(ausserordentlicher Professor)* rather than full professor *(ordentlicher Professor).* No woman was entitled to a full professorship until the 1950s: Annette Vogt, private communication, 8 July 2003. See also Ann Hibner Koblitz, *A Convergence of Lives: Sofia Kovalevskaia: Scientist, Writer, Revolutionary* (New Brunswick, N.J.: Rutgers Univ. Press, 1983); Ruth Sime, *Lise Meitner: A Life in Physics* (Berkeley: Univ. California Press, 1996); Rossiter, "Twisted Tale" (cit. n. 1); Soňa Štrbáňová, "The Institutional Position of Czech Women in Bohemia, 1860–1938," in *Women Scholars and Institutions: Proceedings of the International Conference (Prague, June 8–11, 2003),* ed. Štrbáňová, Ida Stamhuis and Kateřina Mojsejová (Studies in the History of Sciences and Humanitities, 13) (Prague, 2004), pp. 69–97; and Vogt, "Women Scholars at German Universities; or, Why Did This Story Start So Late?" *ibid.,* pp. 159–186.

[17] *Universitetet i Oslo 1911–1961,* Vol. 2, p. 266 (Gleditsch); and "Alfabetisk oversikt over vitenskapelige ansatte ved UiO 1811–1984" (list of professors at the University of Oslo, 1811–1984), prepared by the Forum for University History, University of Oslo, available at http://www.hf.uio.no/hi/prosjekter/univhist/FaktaUiO/databaser/dokumentasjon.html.

Gleditsch recalled her father's special interest in botany and that they collected plants on family trips.[18] Thus the children adopted their parents' fondness for nature at an early age.

When Ellen was nine years old the family moved to Tromsø, in the north of Norway, and there, at eighteen, she started an apprenticeship in pharmacy. She chose this subject, in consultation with her parents, partly because the courses included many natural sciences that interested her (botany, zoology, physics, chemistry, mineralogy) and partly because this profession would allow her to become economically independent within a reasonably short time. Gleditsch's parents wanted their children, boys and girls, to get an education and to become useful, independent, and economically responsible citizens. After some years as an apprentice, she passed the two exams necessary to become a pharmacist in 1900 and 1902. After taking her examinations the twenty-three-year-old Gleditsch became interested in chemistry and decided to continue her studies. She supported herself by coaching freshman students of pharmacy. In 1903 she began to receive funding from the Pharmaceutical Funds and started an assistantship in chemistry (see Figure 1), but she had to continue with the coaching as well.[19] These experiences gave her teaching practice and

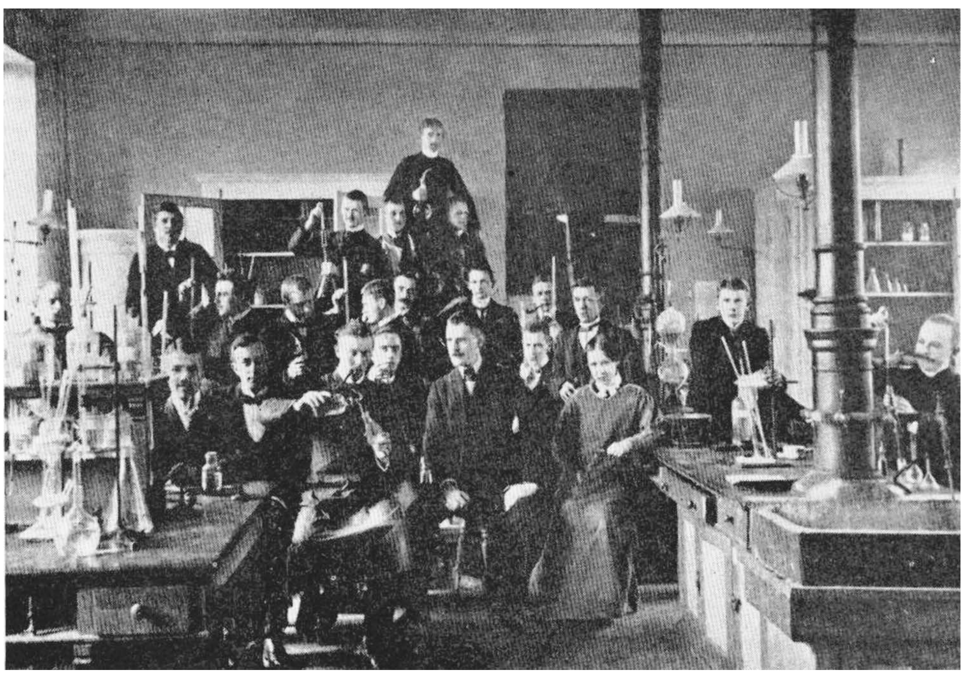

Figure 1. *Ellen Gleditsch as an assistant in the Chemistry Laboratory at the University of Oslo, together with her supervisor Eyvind Bødtker and some other students in spring 1903. (From* Universitetet i Oslo 1911–1961, *Vol. 1, p. 546.)*

[18] Ellen Gleditsch, "Et liv i vitenskapens tjeneste," radio memoir, 1 Sept. 1966, NRK (Norwegian Broadcasting Corporation) Radio Archives, no. 51506.

[19] *Ibid.;* "Ellen Gleditsch" [interview], *Urd,* 14 Jan. 1911, pp. 13–14; and Ore and Høeg, "Det Matematisk-Naturvitenskapelige Fakultet" (cit. n. 13), p. 538. See also Gleditsch's application for Queen Dowager Josephine's Scholarship for Women's Education, 27 Feb. 1905, Archives of the Ministry of Church and Education (Kirke- og Utdanningsdepartementet), 1. skolekontor D, 1898–1938: Enkedronning Josephine's legat for kvinnelig utdannelse, 1904–1905, Søknader, Utdelinger, Ed-218, Public Record Office (Riksarkivet) (hereafter cited as **RARK**).

enabled her to develop her laboratory skills and insights, assets that were to prove important when she approached Marie Curie four years later.

After some years as an assistant, Gleditsch managed to get to Paris to work in radioactivity. Her interest in the new phenomena of X-rays and radioactivity had grown considerably over the preceding decade. The liberal newspaper *Verdens Gang* had published an article entitled "Photographing Through the Wall" only two months after Wilhelm Conrad Röntgen discovered X-rays in late 1895. Soon the conservative newspaper *Morgenbladet* advertised "Lectures and Experiments on X-rays" by university fellow Kristian Birkeland, advising the audience to bring their opera glasses. And when Birkeland also displayed X-ray pictures of the skeleton, explaining the medical use of these new rays, many Norwegians were excited. With Henri Becquerel's discovery of radioactivity in 1896 and Marie and Pierre Curie's discovery of polonium and radium two years later, the general enthusiasm was further enhanced. Gleditsch was fascinated by the fact that "rays one could not see nonetheless worked." In a 1907 essay on radium she reflected on how swiftly this purely scientific discovery had disseminated into the general public, concluding that "the properties of radium are so new and peculiar and in so many ways shatter the theories we have regarded as quite certain for years."[20]

According to the Rayner-Canhams, astronomy, crystallography, and atomic science (which included radioactivity) were the fields within the physical sciences that particularly appealed to women at the time. Brigitte Bischof has shown that radioactivity was presented as a "romantic endeavor" in the Viennese media and that women, in particular, were attracted to the field and to Marie Curie as a person, although she never specifically promoted women researchers. The Curies, together with Becquerel, had been awarded the Nobel Prize in Physics in 1903 for their discovery of radioactivity and research on radiation phenomena, and even in the early years students from around the world wanted to work in their laboratory. The first woman to study there, the Canadian Harriet Brooks, came in 1906 and worked for a year under Marie Curie, who took charge of the laboratory after Pierre's tragic death and ensured that it retained its leading position within the field. During Gleditsch's first five years in Paris there were between two and five women and between eleven and twenty-two scientists in all in the laboratory. With her second Nobel Prize in 1911, this time in chemistry, Curie's fame increased; but during the same period the refusal of the French Academy of Science to elect her to membership and the rumors of her involvement with Paul Langevin may have affected her popularity. In any case, the number of workers at and publications from her laboratory decreased for a time. After the war, and with the inauguration of her new radium institute, the number of laboratory workers rose once again. Curie was aware of her "celebrity effect" and rejected students she suspected of wanting to work with her only to be able to brag about it later.[21]

[20] *Verdens Gang,* 14 Jan. 1896; *Morgenbladet,* 22 Mar. 1896; and Tor Brustad, "Radiologiens inntog i Norge," *Forskningspolitikk,* 2000, no. 1, pp. 6–7, 10. Gleditsch confirmed the general enthusiasm for radioactivity in an NRK television interview in 1965 (videotape in possession of Chris Koch, Gleditsch's niece). For the quotations see Ellen Gleditsch, "Et liv i vitenskapens tjeneste" (cit. n. 18); and Gleditsch, "Radium," *For Kirke og Kultur,* 1907, pp. 211–224.

[21] Rayner-Canham and Rayner-Canham, eds., *Devotion to Their Science,* p. 13; and Brigitte Bischof, "'The Marie Curie Syndrome,' the Role of Mentors, and Romanticism; or, Why Were There So Many Women in Radioactivity Research in Vienna?" in *Women Scholars and Institutions,* ed. Štrbáňová, Stamhuis and Mojsejová (cit. n. 16), pp. 639–658. For the figures on laboratory workers during Gleditsch's time with Curie see J. L. Davis, "The Research School of Marie Curie in the Paris Faculty, 1907–14," *Annals of Science,* 1995, *52:*321–355; and Liste du personnel, Historical Archives of the Curie Laboratory, AMC. On the academy's refusal to elect Curie to membership and on the Langevin *affaire* see Susan Quinn, *Marie Curie: A Life* (London: Heinemann, 1995); regarding the "celebrity effect" see *ibid.,* p. 402.

Women at the turn of the century generally had to create their own "feminine" jobs or study "feminine" subjects such as home economics, botany, or child psychology in order to enter the world of science. The passive, routine work often associated with astronomy, crystallography, and atomic science has been suggested as a reason why many women had a chance to enter these fields. Because they were also willing to accept low pay and jobs as assistants, they were able to carve out "niches" within otherwise masculine research fields. James Chadwick, visiting Meyer's laboratory in Vienna in 1927, observed that women did the scintillation counting. He reasoned that they were able to concentrate on this tedious work more intensely than men because they had so little on their minds. Supportive supervisors were of course also crucial in enabling women to enter into radioactivity research, and Rutherford and Meyer were renowned for providing collaborative and positive working environments for their women researchers. Even Gleditsch, who never worked with Rutherford, wrote to him in 1915 about her work on the half-life of radium: "I hope you will forgive me for writing you about my work. As you will understand you yourself gave me the courage in Washington [to pursue it]."[22]

Going abroad for research and training was considered a necessity for Norwegian students and scientists. Researchers in a peripheral country like Norway, with its small university and even smaller research units, needed sojourns at well-equipped and topic-specific laboratories if their work was to progress. Gleditsch was well aware of this; she wrote that "the demand for instruments and apparatus is now high, and progress in a specific field of science is often connected to the development of the finest and best apparatus." The laboratory in Oslo where Gleditsch did her work in chemistry was not adequately equipped, particularly not for radioactivity research, and its deficiencies were reported repeatedly over the years. As early as 1903 the budget was exhausted on chemical consumables for everyday use, making new investments in instruments, chemicals, and specimens impossible to consider.[23]

Norwegian scientists' travels abroad were thus common. Not only did they need better laboratory facilities and the chance to participate in a strong research group: by visiting highly regarded professors, groups, and institutions, Norwegian scientists sought to link their own research projects to these persons and places and at the same time establish a professional network that they could rely on after they returned home.[24] Gleditsch certainly understood this dynamic, though in spending more than seven years abroad she might, paradoxically, have gone beyond what was advantageous to her future career in Oslo.

[22] Lawrence Badash, "Nuclear Physics in Rutherford's Laboratory before the Discovery of the Neutron," *American Journal of Physics,* 1983, *51:*884–889 (Chadwick's view); and Ellen Gleditsch to Ernest Rutherford, 1 Nov. 1915, Ernest Rutherford Papers, MS ADD 7653:G.99, Department of Manuscripts, Cambridge University Library. On women's "niches" within masculine research fields see Margaret W. Rossiter, *Women Scientists in America: Struggles and Strategies to 1940* (Baltimore: Johns Hopkins Univ. Press, 1982), pp. 51–72, 313–316; and Rayner-Canham and Rayner-Canham, eds., *Devotion to Their Science,* pp. 17–18. On the supportiveness of Rutherford and Meyer see *ibid.,* pp. 20, 24.

[23] Ellen Gleditsch, "Kvinnelige Akademikere—Utenlandsopphold og stipendier," in *Kvinnelige Studenter 1882–1932* (cit. n. 7), pp. 244–248, on p. 244. At this time the Chemical Laboratory, situated in Fredriksgate 3—which also hosted the metallurgical laboratory—comprised two laboratories, one for the pharmacy students and the other for the science students. When the metallurgists moved out in 1912, their laboratory was taken over. As early as 1918, however, the sites were described as being too small. Gleditsch's first radiochemistry laboratory was a room in the basement of the building, which was specially equipped for this purpose in 1920/1921. The ongoing deficiencies are noted in the annual reports from the Chemical Laboratory that appeared in *Universitetet i Oslo: Årsberetninger,* the annual report of the university; for the first such complaint see *ibid.,* 1902/1903, pp. 88–89.

[24] Sven Widmalm, *Det öppna laboratoriet: Uppsalafysiken och dets nätverk 1853–1910* (Stockholm: Atlantis, 2001), pp. 34–77; and Anne Kristine Børresen, "Johan H. L. Vogt—naturforsker, rådgiver og nasjonsbygger," in *Historiske fabrikasjonar,* ed. Ola Svein Stugu (Fabrikken, 2001), pp. 87–116, on p. 95.

For many scientists Germany was the natural place to go to at the end of the nineteenth century, gradually replacing France as the chief center for science in Europe. However, with the work of Louis Pasteur on microorganisms and the founding of the Institut Pasteur in 1888, Paris remained a center for chemical-biological research. The discoveries of Becquerel and the Curies in the 1890s made the city a center for physical-chemical science as well.[25]

Gleditsch might have been influenced by her supervisor, Eyvind Bødtker, who himself went to Paris in 1906 to work in organic chemistry. He remained her supporter throughout her career, from encouraging her to begin her studies in chemistry to supporting her application to become a full professor. He established the first contact between Gleditsch and Curie in Paris; he even dictated her first letter in French to Curie. Gleditsch's wish to go to Paris was due to a combination of factors; in addition to Bødtker's influence, she had great ambitions and career plans and was eager to work with an important scientist such as Marie Curie.

Bødtker called on Curie to request a place for Gleditsch in her laboratory. Curie originally declined the inquiry, citing a lack of space, until Bødtker desperately exclaimed: "But Gleditsch is so small, she doesn't need much space!" It is likely that Gleditsch's skills as a chemist changed Curie's mind, as she needed another chemist to perform crystallizations. Isolating radium from uranium minerals was laborious and meticulous work: a ton of mineral rich in uranium yielded only 0.2 grams of radium chloride.[26] One step in the procedure was the separation of barium from radium. As these elements have similar chemical properties, repeated fractional crystallizations were necessary. Performing crystallizations is itself considered something of an art in chemistry. Fractional crystallizations are even more challenging, demanding an intimate chemical understanding of the compounds to be separated and thorough and practiced chemical dexterity, as well as patience and perseverance—this was one of Gleditsch's main tasks during her years in Paris.

Gleditsch stayed in Paris for five years, from 1907 to 1912, and was soon promoted from student to Marie Curie's personal assistant. During these years she also studied at the Sorbonne and completed the *Licenciée ès sciences* degree (equivalent to a B.S.). Gleditsch was not supported financially by Curie during all these years, but she did not have to pay the laboratory fee because of the crystallizations she did for Curie. According to her niece, Chris Koch, Gleditsch was frugal and might have been able to live on her savings during her first year of study. Her repeated applications for various scholarships, some of which were granted, indicate that she must have felt the need for additional economic support. From 1908 until 1911, Gleditsch received a substantial scholarship from the University of Oslo. In 1911 she became a university fellow; during the first year of the fel-

[25] On Germany as a scientific center in the late nineteenth century see John Peter Collett, "Tysk innflytelse på norsk vitenskap og høyere utdannelse," in *Tyskland-Norge: Den lange historien,* ed. Jarle Simensen (Oslo: Tano Aschehoug, 1999), pp. 49–60 (this volume has been translated into German as *Deutschland-Norwegen: Die lange Geschichte* [Oslo: Tano Aschehoug, 1999]); Børresen, "Johan H. L. Vogt"; Håkon With Andersen, "Germany and the Education of Norwegian Engineers, with Some Reflections on the Role of the Engineers as a Social Group," in *Bürgentum und Bürokratie im 19. Jahrhundert: Technologie, Innovation, Technologietransfer* (Oslo: Norges Allemenvitenskapelige Forskningsråd/Stifterverband für die Deutsche Wissenschaft, 1988), pp. 104–109; and Torleiv Kronen, *Ut over grensene: Norske vitenskapsmenn i Frankrike 1150–1940* (Oslo: Aventura, 1985), pp. 93, 146–147. On the attractions of Paris see *ibid.,* pp. 146–147; and Kronen and Pappas, *Ellen Gleditsch* (cit. n. 4), p. 22.

[26] Gleditsch reported Bødtker's remark in a television interview (cit. n. 20). On the yield of radium chloride see Ellen Gleditsch, "Om radioaktive mineraler og om radiums utvinding," *Teknisk Ukeblad,* 22 Sept. 1911, pp. 461–464, 515–517.

lowship she was exempted from her teaching duties so that she could finish her education in Paris. For the academic year 1909/1910 she also received a Curie-Carnegie Fellowship, endowed by the American millionaire Andrew Carnegie.[27]

Networks of Women

Between 1900 and 1910, about thirty women throughout Europe were working in radioactivity, many of them at the Laboratoire Curie in Paris. In one year researchers from seventeen countries worked in this laboratory, and during Curie's lifetime no fewer than twenty-five nations were represented there. Curie's laboratory thus became an ideal place to foster international relations. Ellen Gleditsch enjoyed the cosmopolitan atmosphere thoroughly and later corresponded with many of her coworkers. In the book *Kvinnelige Studenter 1882–1932* [Female Students, 1882–1932], published by the Norwegian section of the International Federation of University Women, she wrote: "You return from such a stay [abroad] greatly enriched, not exactly in gold, but in noble goods: an understanding of your science, knowledge of another country's people and culture, and an extended acquaintance with representatives of still many other countries and people." When Gleditsch arrived in Paris in 1907 she was the only woman in the laboratory apart from Curie. In succeeding years more women came, among them the Englishwoman May Sybil Leslie (1909–1911) and the Swede Eva Ramstedt (1910–1911), with both of whom Gleditsch kept in touch for years.[28] Her frequent references to Ramstedt in her letters to Curie testify to the special relationship that started in Paris. Later the two coauthored a book and met several times—at least twice with Leslie, who later came to work with Rutherford in Manchester. Leslie wrote to Arthur Smithalls, her professor at Leeds, while in Paris: "There are only two ladies beside myself, Norwegian Mlle. Gleditsch, and French, Mlle. Blanquies. Of the French lady I see very little because she does not spend all her time here, but of Mlle. Gleditsch I see much since she lives in the same *pension.* She has been exceedingly good to me and has prevented me from feeling lonely."[29]

[27] For more details about her stay in Paris see Annette Lykknes, Helge Kragh, and Lise Kvittingen, "Ellen Gleditsch: Woman Pioneer in Radiochemistry," *Physics in Perspective,* 2004, *6:*126–155. For an account of the Curie laboratory see Soraya Boudia, *Marie Curie et son laboratoire* (Paris: Editions des Archives Contemporaires, 2001). Regarding Gleditsch's efforts to win scholarship support see her applications for Queen Dowager Josephine's Scholarship and the Houen Fund, 1905–1910, Archives of the Ministry of Church and Education, 1. skolekontor D, 1898–1938, Ed-218–221, Ed-305–307, RARK. Her scholarships from the university are recorded in *Universitetet i Oslo: Årsberetning: Matrikulen,* 1907/1908, 1908/1909, 1909/1910, 1910/1911. The Curie-Carnegie Fellowship is noted in Liste du personnel, Historical Archives of the Curie Laboratory, AMC; see also Robert Reid, *Marie Curie* (New York: Dutton, 1974), p. 160.

[28] Ellen Gleditsch, "Maria Sklodowska Curie," *Nordisk Tidsskrift,* 1959, pp. 417–434 (twenty-five nations) (hereafter cited as **Gleditsch, "Maria Sklodowska Curie" [1959]**); and Gleditsch, "Kvinnelige Akademikere—Utenlandsopphold og stipendier" (cit. n. 23), p. 246. Leslie's and Ramstedt's dates are taken from Liste du personnel, Historical Archives of the Curie Laboratory, AMC. For brief accounts of their lives and work see Marelene F. Rayner-Canham and Geoffrey W. Rayner-Canham, "May Sybil Leslie: From Radioactivity to Industrial Chemistry," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner Canham, pp. 76–81; and Rayner-Canham and Rayner-Canham, ". . . And Some Other Women of the French Group" [including Ramstedt], *ibid.,* pp. 125–126.

[29] May Sybil Leslie to Arthur Smithalls, 30 Nov. 1909, Arthur Smithalls Collection, Leeds University Library; quoted in Rayner-Canham and Rayner-Canham, "May Sybil Leslie," p. 77. The coauthored book is Ellen Gleditsch and Eva Ramstedt, *Radium og de radioaktive prosesser* (Oslo: Aschehoug, 1917). Later meetings are noted in Gleditsch to Marie Curie, 10 Nov. 1915, Marie Curie Archives, letter 785, AMC; postcard from Gleditsch, Ramstedt, and Leslie to Curie, 12 June 1920, Letter Collection 18450, Bibliothèque Nationale, Paris; Gleditsch to Lise Meitner, 7 July 1926, Collection MTMR 5/15, Churchill College Archives, Cambridge (hereafter cited as **CCA**); postcard from Gleditsch and Ramstedt to Curie, 12 July 1932, Letter Collection 18450, Bibliothèque Nationale; and Gleditsch to Irène Joliot-Curie, 26 Feb. 1947, Irène Joliot-Curie Archives, AMC.

Since some of her colleagues in Paris later went to work in other laboratories, Gleditsch was able to maintain contact with scientists in many places. For this reason she has been described as the central figure linking the three main groups in radioactivity: the French (in Paris under Curie), the British (in Manchester under Rutherford), and the Austro-German (in Vienna under Meyer and in Berlin under Hahn). Gleditsch and Ramstedt were also so-called honorary correspondents of the Austro-German group. Among her colleagues from Paris—apart from Ramstedt and Leslie—were the Polish-Russian Jadwiga Schmidt and the Pole Alicja Dorabialska. The latter welcomed Gleditsch's former assistant Ruth Bakken as her assistant at the University of Lwow in the 1930s.[30]

But Gleditsch also cultivated bonds and friendships with scientists who never worked in Paris. During World War II she offered positions in her laboratory in Oslo to the scientist-refugees Marietta Blau, an Austrian, and the Hungarian Elizabeth Rona, both of whom had worked in Stefan Meyer's Institute for Radium Research in Vienna. Rona recalled: "My close friend Ellen Gleditsch . . . had invited me to replace a staff member who was on a leave of absence."[31]

Although they never worked together, Gleditsch took the initiative in 1926 to ask for a meeting with Lise Meitner in Berlin, since she would pass through on her way to Warsaw: "I do wish to make your acquaintance; we have radioactivity in common."[32] This was the beginning of a friendship that would last for the rest of their careers. Gleditsch also recommended her students and assistants to Meitner, both for short meetings and for longer stays.

But it was with Curie, her mentor and friend, that Gleditsch maintained her closest contacts. After examining the thirty-nine volumes of the Curie correspondence in the Bibliothèque Nationale in Paris, Gleditsch biographers Torleiv Kronen and Alexis Pappas say that there was no one closer to Curie, apart from her immediate family, than Gleditch. Some students in Curie's laboratory described her as dismissive and reserved, but Gleditsch, who knew her better, considered Curie a caring advisor with a particular interest in each student. She observed that Curie was "immensely shy" and opened her mind only to her family and close friends, in which group Gleditsch was included. Gleditsch was a regular guest in Curie's home on Sundays and also grew close to her daughter, Irène Joliot-Curie. They spent the summer of 1953 hiking together in the Norwegian mountains, and their correspondence continued until Irène's death in 1956.[33]

[30] On Gleditsch's "centrality" see Marelene F. Rayner-Canham and Geoffrey W. Rayner-Canham, "Pioneer Women of Radioactivity," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 12–28, on p. 27; Gleditsch and Ramstedt are mentioned as "honorary correspondents" on p. 26. On Schmidt see Rutherford to Bertram Boltwood, 20 June 1914, in Lawrence Badash, *Rutherford and Boltwood: Letters on Radioactivity* (New Haven, Conn.: Yale Univ. Press, 1969), p. 294; on Dorabialska see Stephanie Weinsberg-Tekel, "Alicja Dorabialska: Polish Chemist," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 92–96.

[31] Elizabeth Rona, *How It Came About: Radioactivity, Nuclear Physics, Atomic Energy* (Oak Ridge, Tenn.: Oak Ridge Associated Univ. Press, 1978), pp. 42–43. For accounts of Blau's life and work see Peter L. Galison, "Marietta Blau: Between Nazis and Nuclei," *Physics Today,* 1997, *50:*42–48; Galison, "Marietta Blau: Between Nazis and Nuclei," in *Image and Logic: A Material Culture of Microphysics* (Chicago: Univ. Chicago Press, 1997), pp. 146–160; and Leopold E. Halpern, "Marietta Blau: Discoverer of the Cosmic Ray 'Stars,'" in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 196–204. On Rona see Marelene F. Rayner-Canham and Geoffrey W. Rayner-Canham, "Elizabeth Róna: The Polonium Woman," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 209–216.

[32] Gleditsch to Meitner, 16 June 1926, Collection MTNR 5/15, CCA.

[33] Gleditsch's close relationship with the Curies is noted in Kronen and Pappas, *Ellen Gleditsch,* p. 125. On Curie's purported reserve see Gleditsch, "Marie Sklodowska Curie" (1959), p. 429; and Quinn, *Marie Curie* (cit.

As we have seen, Gleditsch kept in touch with so many of the women in radioactivity that she became a central figure in the network of women in this field. From 1920 on, she also participated in formal networks of women, not least during her many years in the International Federation of University Women. We will return to this group after a look at her initial years as a researcher in Norway.

Fellowship at the University of Oslo

At the turn of the century the University of Oslo was still quite small. In his speech marking the centenary of the university in 1911, Rector Waldemar Christopher Brøgger announced that a staff of 102 professors and university fellows was insufficient. If Oslo was to retain its standing compared to other universities and ensure recruitment for the future, Brøgger insisted, at least 130 professors and university fellows would be necessary. His hopes for such an expansion were not fulfilled, although a substantial increase did take place, from 80 professors in 1911 to 116 in 1922.[34]

Gleditsch applied for a fellowship *(adjunktstipend)* from the university in 1910 but was turned down, despite a faculty recommendation in her favor. She had already received money to continue her studies in Paris, and the university board was unwilling to support a candidate who was already holding a scholarship. However, the next year, when she reapplied, she was awarded a five-year grant as a university fellow, a position that offered the holder financial support and the opportunity to do research and teaching and helped the university build a pool of talent from which the professors of the future could be drawn.[35]

With some economic security, then, Gleditsch completed her studies in Paris and a year later returned to Oslo, where she began lectures on "Radium and the Radioactive Substances" for an audience of ten to twenty students. The spring of 1913 was a devastating time in Gleditsch's personal life: she attended the deathbeds of her mother, her twenty-five-year-old brother, and her father, all within two months. Diligently she kept on teaching until 17 April, but at this point, two days before her father died, she had to give in. As the eldest child and, hence, the natural center of the family, Ellen had to organize the funerals and see to the creation of a new home. She shared a home with her brother Adler for the rest of her life. The youngest brother, Kristian, was only twelve years old when his parents died. Characteristically, Ellen provided both emotional and financial support for many years. Kristian's daughter, Chris Koch, recalls that Ellen paid for part of her education and offered economic support whenever she had some extra money. Her care also extended to Chris's children, for whom she was like a grandmother—supplying them with hand-knitted sweaters, for example.[36] Gleditsch's concern to take care of her family was partly due to her being the eldest of the siblings, but these tasks also seemed natural to her as a woman

n. 21), p. 403. For Gleditsch's own view see Ellen Gleditsch, "Discours de Mlle. Gleditsch," in *Cinquantenaire du premier cours de la Marie Curie à la Sorbonne* (Cahors: Couelant, 1957), pp. 36–37; Gleditsch, "Marie Sklodowska Curie" (1959), p. 429; and Gleditsch, "Marie Sklodowska Curie," *Naturen,* 1934, pp. 289–294, on p. 294. The Sunday visits are noted in Gleditsch, "Marie Sklodowska Curie" (1959), p. 428; hiking with Irène is mentioned in Gleditsch, "Irène og Frédéric Joliot-Curie," *Samtiden,* 1959, *68:*172–181.

[34] John Peter Collett, *Historien om Universitetet i Oslo* (Oslo: Universitetsforlaget, 1999), pp. 117–121; the increase to 116 is noted on p. 115.

[35] For the initial refusal see reports from the faculty board meetings, 6 Oct. 1910, 20 Oct. 1910, Reports 1899–1927, Archives of the Faculty of Science and Mathematics, University of Oslo (Arkiv fra det Matematisk-Naturvitenskapelige Fakultet) (hereafter cited as **AMNF**). The five-year grant is noted in *Universitetet i Oslo: Årsberetninger,* 1914/1915, pp. 195–196.

[36] Conversation with Chris Koch, Copenhagen, Apr. 2002.

of her time. In living with her brothers and having responsibility for Chris during the war (see Figure 2), Gleditsch, who never married, had the chance to express the nurturing part of herself and to combine her career at the university with the pleasures of having a home and a family. On the other hand, because she had to run a household, she was not able to dedicate herself entirely to her research, as the majority of her male colleagues could do.

Gleditsch felt isolated at the University of Oslo, as there was no one else there with much experience in radioactivity. She therefore corresponded extensively with her colleagues from her Paris period and returned there frequently.[37] During her first years as a university fellow her time was divided between the demanding task of establishing a laboratory in radioactivity, which included purchasing chemicals and instruments, applying to various funds for project support and travel grants, teaching students, and doing research. To get a break from her busy schedule—and seeking new stimuli—she applied for a fellowship from the American-Scandinavian Foundation that would enable her to go to the United States. In America Gleditsch would benefit from exposure to other scientists and new methods. As in Paris, she met colleagues with whom she kept in touch for the rest of her career.

When she was awarded the fellowship she wrote to ask both Boltwood at Yale and Theodore Lyman at Harvard if she could work with them for a year. Lyman simply answered that no woman had ever set foot inside a physics laboratory at Harvard, whereas Boltwood hesitatingly welcomed her. In a letter written to Rutherford in September 1913

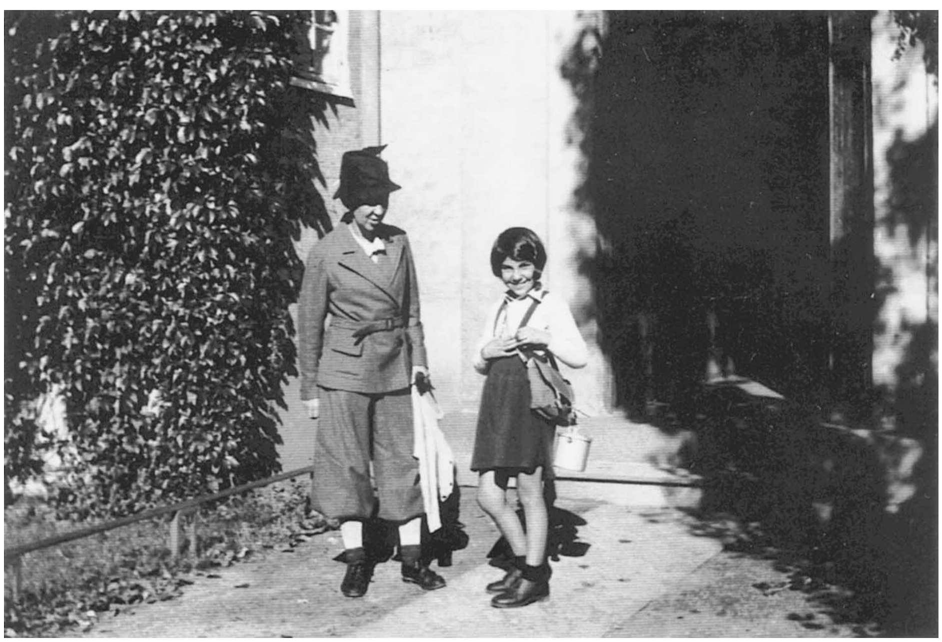

Figure 2. *Ellen Gleditsch with her niece Chris Koch (b. 1931) in 1942. (Courtesy of Chris Koch.)*

[37] E.g., in the fall of 1916 Gleditsch ran the radium factory outside of Paris, where she had worked previously, because Curie needed more radium to treat those wounded in the war. In July 1920 Curie left her laboratory in Gleditsch's hands when she had to travel. See Curie to Gleditsch, 22 June 1916, 7 July 1920, Letter Collection 456, National Library of Norway, Oslo (Nasjonalbiblioteket, manuskriptsamling) (herafter cited as **NBM**).

it appears that Gleditsch was well known to both of them but that Boltwood was nonetheless skeptical:

> Mlle. Gleditsch has written that she has a fellowship of the American Scandinavian Foundation (I never heard of it before!), and wishes to come and work with me in New Haven!! What do you think of that? I have written to her and tried to ward her off, but as the letter was necessarily delayed in forwarding to me, I am afraid she will be in New York before I get there. Tell Mrs. Rutherford that a silver fruit dish will make a very nice wedding present!!!

Boltwood, still a bachelor, was known for his misogynistic attitudes—for example, toward Marie Curie, whom he rarely and reluctantly credited for her work—and though the tone of his letter is humorous he evidently had difficulties in imagining a female scientist. In Boltwood's world women belonged to other parts of society; they were potential wives, not colleagues. Marelene and Geoffrey Rayner-Canham state that attitudes toward women in American academic circles were colder than those in Europe and suggest that this might have led to a decline in the numbers of women working in radioactivity after World War I, when the United States became increasingly interesting for promising students in the field.[38]

Probably in jest, Rutherford's wife Mary wrote to Boltwood in October 1913, wondering, "Are you engaged to the charmer yet, I forgot who she was"—obviously in reference to Gleditsch. Despite his initial suspicion, Boltwood soon accepted Gleditsch as a colleague and coworker, and their cooperation resulted in two papers on the half-life of radium, published by Gleditsch in 1915 and 1916. Even Lyman relented and invited her to work with him, if only as a guest. Nevertheless, Gleditsch did not forget the hostility she met with in the United States. In a newspaper interview in 1930 she made a point of mentioning that a man "who was reputed to hate women"—probably Boltwood—thought she was "a rare exception" among womankind because she did not scream.[39]

Boltwood learned to appreciate Gleditsch's scientific and intellectual abilities; both her work on the half-life of radium and her facility in the English language impressed him. During her year in New Haven she also lectured on radioactivity at the Women's Colleges of Massachusetts and New York, and in June 1914 she was awarded an honorary doctorate at Smith College in Northampton, Massachusetts. During the presentation Professor Gardiner described Gleditsch as someone "who for exceptional intellectual attainments was selected as the first woman fellow of the American-Scandinavian Foundation, and whose investigations and original contributions to the field of radio-activity have placed her among the acknowledged experts in this new and important science."[40] Bolstered by an

[38] Boltwood to Rutherford, 12 Sept. 1913, in Badash, *Rutherford and Boltwood* (cit. n. 30), pp. 285–286. Regarding Curie see, e.g., Boltwood to Rutherford, 11 Oct. 1908, *ibid.,* pp. 195–196. On American attitudes see Marelene Rayner-Canham and Geoffrey Rayner-Canham, *Women in Chemistry: Their Changing Roles from Alchemical Times to the Mid-Twentieth Century* (Philadelphia: Chemical Heritage Foundation, 1998), p. 133.

[39] Mary Rutherford to Boltwood, 6 Oct. 1913, in Badash, *Rutherford and Boltwood,* p. 286. For the publications see Ellen Gleditsch, "Om radiums levetid og om dets aktivitetskonstant," *Archiv for Mathematik og Naturvidenskab,* 1915, *34:*3–19; and Gleditsch, "The Life of Radium," *American Journal of Science,* 1916, *41:*112–124. Lyman's invitation is reported in "Lolita: Kjernekjemisk Gratie" [interview with Gleditsch], *Dagbladet,* 13 June 1964; the story about the man "who was reputed to hate women" comes from the interview "Mannen som kollega: Hvad professor Ellen Gleditsch mener" (cit. n. 1).

[40] Gardiner is quoted in the *Springfield Republican,* 17 June 1914; the clipping is in Honorary Degree Files: Ellen Gleditsch, Smith College Archives, Northampton, Massachusetts. Boltwood's appreciation is expressed in Boltwood to Gleditsch, 28 June 1915, Letter Collection 456, NBM. Gleditsch's lectures in Massachusetts and New York are reported in *Universitetet i Oslo: Årsberetninger,* 1913/1914, pp. 94–95.

honorary doctorate of science, Gleditsch was even more encouraged to continue her experiments and studies of radioactivity on her return to Oslo.

Scientific Work in Paris, America, and Oslo

Gleditsch's first publication, on the tertiary derivatives of amyl benzene, would be her only paper in organic chemistry. It appeared while she was an assistant at the Chemistry Laboratory in Oslo. During her Paris period Gleditsch authored several papers, in both French and Norwegian. Her work in French contributed in particular to discussions pertaining to the alleged transformation of copper into lithium and the radium-uranium ratio. Eager to present evidence for Rutherford and Frederick Soddy's transformation theory of 1902, the Nobel laureate William Ramsay and Alexander Thomas Cameron reported the detection of lithium in copper solutions treated with radium emanation (radon, $_{86}Rn^{222}$) in a paper published in 1907. Because the new phenomenon of radioactivity had opened several black boxes within the atomic sciences, it also lent itself to speculation and sensationalism, and Ramsay and Cameron's findings resulted in press notices in France speculating about the transmutation of silver into gold. Curie and her coworker, assistant professor André Debierne, were skeptical, however, and Gleditsch and Curie investigated Ramsay and Cameron's claims and found that the traces of lithium in their copper solutions probably originated from the glass container.[41]

Gleditsch also published on her own on the lithium controversy. Her investigation of the lithium content in minerals containing both copper and radium led her to claim that copper did not transform into lithium under the influence of radiation. These results are mentioned in the major contemporary English, French, and German textbooks on radioactivity, an indication of their importance.[42] In her own work and in collaboration with Curie, she had therefore disproved claims about the transmutation of metals. Further speculative experiments on silver and gold were thus avoided, and the old alchemical dream remained just that.

Another topic of interest to Gleditsch during her time in France was the ratio of radium ($_{88}Ra^{226}$) to uranium ($_{92}U^{238}$), the Ra-U ratio, in minerals. This too was a response to the transformation theory of Rutherford and Soddy. Finding the Ra-U ratio would indicate whether uranium was radium's parent and would be important for mapping radioactive decay. Boltwood had worked on the Ra-U ratio in minerals and his results showed a constant ratio, indicating that there was a genetic relationship between the two elements in the radioactive decay series. Gleditsch's results, however, indicated that the ratio varied from mineral to mineral.[43] This perturbed scientists, as it seemed to indicate that uranium

[41] Ellen Gleditsch, "Sur quelques derivés d'amylbenzène tertiaire," *Bulletin de la Société Chimique de France,* 1906, pp. 1094–1097; André Debierne to Gleditsch, 16 Sept. 1908, Letter Collection 456, NBM; and Marie Curie and Gleditsch, "Sur le lithium dans les minéraux radioactifs," *Comptes Rendus de l'Acadèmie des Sciences,* 1908, *147:*345–349. For a more detailed discussion of Gleditsch's scientific work in Paris and in America see Lykknes *et al.,* "Ellen Gleditsch" (cit. n. 27).

[42] Ernest Rutherford, *Radioactive Substances and Their Radiations* (Cambridge: Cambridge Univ. Press, 1913), pp. 320–322; Marie Curie, *Traité de radioactivité,* 2 vols., Vol. 2 (Paris: Gauthier-Villars, 1910), p. 262; and Stefan Meyer and Egon R. Schweidler, *Radioaktivität* (Leipzig: Teubner, 1916), p. 13. For Gleditsch's work on the lithium controversy see Ellen Gleditsch, "Sur le lithium contenu dans les minéraux radioactifs," *Compt. Rend. Acad. Sci.,* 1907, *145:*1148; Gleditsch, "Sur le lithium dans les minerais radioactifs," *ibid.,* 1908, *146:*331–333; and Gleditsch, "Sur le lithium dans les minéraux radioactifs," *Radium,* 1908, *5:*33–34.

[43] Ellen Gleditsch, "Sur le radium et l'uranium contenus dans les minéraux radioactifs," *Compt. Rend. Acad. Sci.,* 1909, *148:*1451–1453; Gleditsch, "Sur le radium et l'uranium contenus dans les minéraux radioactifs," *Radium,* 1909, *6:*165–166; Gleditsch, "Om forholdet mellom uran og radium i de radioaktive mineraler," *Arch. Math. Naturvidenskab,* 1909, *30:*3–11; Gleditsch, "Sur le rapport entre l'uranium et le radium dans les minéraux actifs," *Radium,* 1911, *8:*256–273; and Gleditsch, "Om forholdet mellom uran og radium i de radioaktive mineraler," *Tidsskrift for Kjemi, Farmasi og Terapi,* 1911, *8:*369–379.

was not the ancestor of radium. Gleditsch, however, emphasized that her findings did not disprove anything; she urged caution, noting that the relationship had not been demonstrated experimentally in any direct way.

Since experiments had indicated that radium was not formed as a direct decay product of uranium, Boltwood began looking for an intermediate radioactive element. In 1907 he discovered such an element and named it "ionium" for its ionizing action. Otto Hahn and Willy Marckwald in Berlin discovered ionium independently at about the same time.

Ionium, later recognized as the thorium isotope ${}_{90}Th^{230}$, explained why the Ra-U ratio was not always constant. Gleditsch argued that if the half-life of ionium was assumed to be 10^5 years (it is now established to be 7.54×10^4 years), this would explain why older minerals had a constant Ra-U ratio while younger ones did not: radioactive equilibrium had not yet been reached in the latter. This work, too, found a place in the most important contemporary textbooks on radioactivity.[44]

When Gleditsch came to the United States in 1913 her research addressed the half-life of radium (${}_{88}Ra^{226}$). Boltwood had estimated this half-life as 2,000 years by comparing the amount of radium produced by ionium (${}_{90}Th^{230}$) to the amount in equilibrium with ionium in uranium minerals. Rutherford and Hans Geiger, however, had calculated the half-life as 1,690 years by counting the number of alpha particles emitted by a salt with a known amount of radium. Boltwood asked Gleditsch to look for the reason for the discrepancy. She improved on Boltwood's method by ensuring the complete isolation of ionium from the uranium minerals, a challenging chemical task, and determined the half-life of radium to be between 1,642 and 1,674 years. These values agreed well with Rutherford and Geiger's results. Today the accepted value is 1,605 years.[45]

The determination of the half-life of radium is one of Gleditsch's most celebrated achievements: all of the expert evaluations pertaining to her application for a full professorship in 1929 highlighted this work. The half-life of radium was an important constant, since radium was regarded as the standard substance in this research field. It was also necessary for the estimation of the half-life of uranium. Direct measurement of the half-life of uranium was impossible because of its large magnitude, but it could be deduced from the half-life of radium and the Ra-U ratio. Even though Gleditsch's figure for the half-life of radium was later revised, Lawrence Badash argues that her work "had developed assurance that future changes would be small."[46] The half-life of radium and the Ra-U ratio also formed the basis for geological age determinations using the ratio of lead to uranium (the Pb-U ratio), a topic in which Gleditsch soon became interested.

After World War I Gleditsch continued to work on radioactive isotopes and the age of minerals. In 1916 she had isolated lead from the Norwegian mineral bröggerite, a thorium-rich uraninite (UO_2) named after the Norwegian geologist (and university rector) Waldemar Christopher Brøgger. The internationally acknowledged expert on atomic weights, Theodore W. Richards at Harvard, had determined that the atomic weight of the lead from

[44] Rutherford, *Radioactive Substances and Their Radiations* (cit. n. 42), p. 463; Curie, *Traité de radioactivité* (cit. n. 42), Vol. 2, pp. 440–441; and Meyer and Schweidler, *Radioaktivität* (cit. n. 42), p. 314.

[45] Gleditsch, "Om radiums levetid og om dets aktivitetskonstant" (cit. n. 39); and Gleditsch, "Life of Radium" (cit. n. 39). On the value accepted today see M. J. Woods and S. M. Collins, "Half-Life Data: Critical Review of TECDOC-619 Update," *Applied Radiation and Isotopes,* 2004, *60:*257–262.

[46] Lawrence Badash, *Radioactivity in America: Growth and Decay of a Science* (Baltimore/London: Johns Hopkins Univ. Press, 1979), pp. 153, 92, 158 (quotation). For the expert opinions see Central Archive, Files of the Faculty of Science and Mathematics, 1929, University of Oslo (Sentralarkiv, Mapper fra Det Matematisk-Naturvitenskapelig Fakultet 1929, Universitetet i Oslo) (hereafter cited as **SAO**).

Gleditsch's bröggerite samples differed from that of common lead. Gleditsch therefore assumed that the lead in bröggerite was a mixture of three different isotopes: RaG ($_{82}Pb^{206}$), the end product of the uranium series; ThD ($_{82}Pb^{208}$), the end product of the thorium series; and the common lead present since the formation of the earth.[47] Determining the age of bröggerite required calculation of the ratio of RaG to uranium, which led Gleditsch to investigate the isotopic composition of lead in the samples of bröggerite. This, in turn, led her to atomic weight determinations for chlorine and lead.[48] Together with Bjarne Samdahl (later professor of pharmaceutical chemistry at Oslo) and her sister Liv, Gleditsch found that the average atomic weight (and thus the isotopic composition) of chlorine did not vary with the mineral source.[49] In sum, her work confirmed that the ratios of the isotopes of elements—with the exception of lead—had not changed measurably since the formation of the earth. Since the isotopes of lead are the end products of the radioactive decay series, they are constantly being produced; thus the isotopic composition of lead depends on the age of the mineral.

In the 1930s, the relationship between the radioactive decay series of uranium and of actinium was an unsolved problem. Analysis showed that the amounts of actinium and uranium present in uranium minerals were interdependent, which indicated a genetic relationship between the two series. It was initially assumed that actinium was a branch product of $_{92}U^{238}$. After Francis Aston's 1929 discovery of the lead isotope $_{82}Pb^{207}$, assumed to be the end product of the actinium-decay series, it seemed more likely that actinium originated from a third uranium isotope, actinouranium (AcU, $_{92}U^{235}$). Gleditsch and her coworker Ernst Føyn (later professor of chemical oceanography at Oslo) measured the ratio of actinium to uranium in rare earths. They then calculated the amount of AcU in natural uranium and confirmed that it is the ancestor of the actinium-decay series, just as

[47] Regarding the work with Gleditsch's brøggerite samples see T. W. Richards to Gleditsch, 29 Mar. 1916, T. W. Richards Papers, HUG 1743.1.8, Box 3, Harvard University Archives, Cambridge, Massachusetts; and T. W. Richards and C. Wadsworth, "Further Study of the Atomic Weight of Lead of Radioactive Origin," *Journal of the American Chemical Society,* 1916, *38:*2613–2622. Today natural lead is known to consist of $_{82}Pb^{204}$ (1.4 percent), $_{82}Pb^{206}$ (24.1 percent), $_{82}Pb^{207}$ (22.1 percent), and $_{82}Pb^{208}$ (52.4 percent): G. Pfennig, H. Klewe-Nebenius, and W. Seelman-Eggebert, *Karlsruher Nuklidkarte* (Karlsruhe: Forschungszentrum Karlsruhe GmbH, Technik und Umwelt, 1995). For Gleditsch's publications after World War I see, e.g., Ellen Gleditsch, "Études sur les minéraux radioactifs, I: La broeggerite," *Arch. Math. Naturvidenskab,* 1919, *36:*3–84; Gleditsch, "Studier over brøggerit, et radioaktivt mineral, og en bestemmelse af dets alder," *Fysisk Tidsskrift,* 1919, *17:*101–120; and Gleditsch, "L'age des minéraux d'après la théorie de la radioactivité," *Bull. Soc. Chim. France,* 1922, *31:*351–372.

[48] See, e.g., Ellen Gleditsch, "Om atomvegtsbestemmelser av grundstoffer av forskjellig oprindelse," *Naturen,* 1923, pp. 118–129; E. Gleditsch and Bjarne Samdahl, "The Atomic Weight of Chlorine in an Old Mineral Apatite from Bamle," *Arch. Math. Naturvidenskab,* 1923, *38:*3–10; E. Gleditsch, "Sur les poids atomique du chlore," *ibid.,* 1924, *39:*3–8; E. Gleditsch, "Sur le poids atomique du chlore," *Journal de Chimie Physique,* 1924, *21:*456–460; E. Gleditsch, Margot Dorenfeldt Holtan, and O.-W. Berg, "Determination du poids atomique du mélange isotopique de plomb de la clévеïte de Aust-Agder, Norvège," *ibid.,* 1925, *22:*253–263; and E. Gleditsch and Liv Gleditsch, "Contribution a l'étude des isotopes, sur le poids atomique du chlore dans les sels de potasse d'Alsace," *Journal de Chimie Physique et de Physico-Chimie Biologique,* 1927, *24:*238–244.

[49] Marelene and Geoffrey Rayner-Canham have also discussed this; see Marelene F. Rayner-Canham and Geoffrey W. Rayner-Canham, "Stefanie Horovitz, Ellen Gleditsch, Ada Hitchins, and the Discovery of Isotopes," *Bulletin for the History of Chemistry,* 2000, *25:*103–108. See also Irène Curie, "Sur le poids atomique dans quelques minéreaux," *Compt. Rend. Acad. Sci.,* 1921, *172:*1025–1028. Liv Gleditsch, the first female master's candidate in chemistry at the University of Oslo (1923), earned her living as a high school teacher. Ellen probably invited her to join in some of her research projects because she needed help—and maybe partly to include her sister in the exciting world of science. Liv Gleditsch also participated in Ellen's investigations into the electrical conductivity of radon solutions at the end of the 1920s. See Ellen Gleditsch and Liv Gleditsch, "Elektrisk ledningsevne av radonoppløsninger," *Arch. Math. Naturvidenskab,* 1927, *40:*3–8; and E. Gleditsch and L. Gleditsch, "La conductivité électrique des solutions aqueuses de radon," *J. Chim. Phys.,* 1928, *25:*290–293.

uranium I ($_{92}U^{238}$) is the ancestor of the uranium-decay series and thorium ($_{90}Th^{232}$) is the ancestor of the thorium-decay series.[50]

In the fall of 1939 Gleditsch helped the Hungarian refugee scientist Tibor Graf to come to Oslo. He was an expert on Geiger-Müller counters and constructed several for Gleditsch and Lars Vegard, a professor of physics. Vegard used his Geiger-Müller counters primarily to study cosmic rays, while Gleditsch used hers to study the radioactivity of rocks, a field she termed “radiogeology.”

The radioactive potassium isotope $_{19}K^{40}$, which was identified by Georg von Hevesy in 1935, has a half-life of 1.3×10^9 years and thus became important in determinations of geological age. During their investigations of this isotope, Gleditsch and Graf discovered that it emitted gamma rays with far greater intensity than had been reported previously. They found, in fact, that the heat produced by the radioactive decay of $_{19}K^{40}$ corresponded to 20 percent of the total heat produced in acidic igneous rocks. This discovery prompted a reevaluation of the past and present heat balance of the earth.[51]

Gleditsch retired in 1946, and her contributions to international publications in the field ceased to appear. However, her keen interest in chemistry, and especially radiochemistry, did not abate: for example, she attended the weekly Saturday seminars in nuclear chemistry in the 1960s and wrote essays on the history of chemistry. Given her affection for France, it is not surprising that many of her biographical studies, including a monograph on Lavoisier, treated French chemists. Yet she also found time for Scandinavian scientists. She completed her last manuscript, on the great Swedish chemist Carl Wilhelm Scheele, just before her death at the age of eighty-eight.[52]

The International Federation of University Women

In addition to her research, teaching, and dissemination of science, Gleditsch was actively engaged in the International Federation of University Women, at both the local and the international levels, during the 1920s. This organization helped her to extend her international network beyond radiochemistry and was a resource and support throughout her life.

In 1918 three women—Virginia Gildersleeve, dean of Barnard College in New York, Professor Caroline Spurgeon of the University of London, and Rose Sidgwick, a lecturer at the University of Birmingham—launched the idea of a worldwide organization uniting university women. Spurgeon and Sidgwick were, at the time, the female members of the

[50] On the origin of actinium see Ernest Rutherford, “Origin of Actinium and Age of the Earth,” *Nature,* 1929, *123:*313–314; and Badash, *Radioactivity in America* (cit. n. 46), p. 209. For Gleditsch’s investigations with Føyn see Ellen Gleditsch and Ernst Føyn, “Dosage de l’actinium dans les minerais d’urane,” *Compt. Rend. Acad. Sci.,* 1932, *194:*1571–1572; and Gleditsch and Føyn, “Sur le rapport actinium-uranium dans les minéraux radioactifs,” *ibid.,* 1934, *199:*412–414.

[51] On $_{19}K^{40}$ see Helge Kragh, “Isotopkjemi,” in *J. N. Brønsted—en dansk kemiker,* ed. Børge Riis Larsen (Copenhagen: Dansk Selskab for Historisk Kemi, 1997), pp. 59–69, on p. 66. For Gleditsch and Graf’s work see Ellen Gleditsch and Tibor Graf, “Dosage rapide du potassium par la mesure de son rayonnement radioactif,” *Arch. Math. Naturvidenskab,* 1941, *44:*63–72; Gleditsch and Graf, “Sur la radioactivité des sels de potassium,” *ibid.,* pp. 145–157; Gleditsch and Graf, “On the Gamma-Rays of K40,” *Physical Review,* 1947, *72:*640; and Gleditsch and Graf, “Significance of the Radioactivity of Potassium in Geophysics,” *ibid.,* p. 641. For the reevaluation the discovery prompted see Alexis Pappas, “100 år siden professor Ellen Gleditsch ble født,” *Kjemi,* 1980, *40:*53–56.

[52] On Gleditsch’s regular attendance at the Saturday seminars see Ernst Føyn and Alexis C. Pappas, “Ellen Gleditsch 85 år,” *Aftenposten,* 28 Dec. 1964 (morning ed.); and Jorolf Alstad, private communication, 14 Apr. 2004. For the biographies see Ellen Gleditsch, *Antoine Laurent Lavoisier* (Oslo: Gyldendal, 1956); and Gleditsch, “Carl Wilhelm Scheele,” *Naturen,* 1968, no. 6, pp. 353–374.

British Universities Mission, a committee appointed by the government to develop closer relations with universities on the other side of the Atlantic. The mission toured the United States and Canada in October 1918; during their frequent returns to New York the English women met Gildersleeve and discussed their experiences and plans. Gildersleeve particularly recalls one event:

> One evening, as I sat on a steamer trunk in Miss Spurgeon's room at the old Women's University Club on East Fifty-second Street in New York, we three talked about the terrible war which had just ended. "We should have," said Miss Spurgeon, "an international association of university women, so that we at least shall have done all we can to prevent another such catastrophe."
>
> Miss Sidgwick and I looked at each other. "Then I guess I must rally the Association of Collegiate Alumnae [an association of women college graduates]," I said. Rose Sidgwick added, "And we must go back and talk with the British Federation of University Women." That was for me the birth of the International Federation of University Women.

These women were convinced that, by fostering friendship and understanding, women graduates could help prevent another catastrophe such as the recent war; helping female teachers and students to work abroad would be one way of achieving this. They had no desire to set up a "separatist, ultra-feminine movement" but felt that some organized effort was necessary to give women a chance to participate in international educational activities.[53]

In 1919 university women from the United States, Great Britain, and Canada met in London to found the International Federation of University Women (IFUW), and the following year the first IFUW conference was convened in London, with delegates from organized groups in Canada, Czechoslovakia, France, Great Britain, Italy, the Netherlands, Spain, and the United States, as well as representatives from incipient groups from Belgium, Denmark, India, Norway, South Africa, and Sweden.[54]

In November 1920 the Norwegian group, the Norske Kvinnelige Akademikeres Landsforbund (NKAL), was founded, with Kristine Bonnevie as its first leader. The next year the organization was formally included in the IFUW, and Gleditsch joined the board (see Figure 3). Here she could use her social and linguistic skills in a context that had always been of interest to her. From her mother, the suffragist, she had inherited a preoccupation with women's rights, and naturally Gleditsch turned her attention to academia. "It is completely indifferent to me if work has been conducted by a small lady in Bulgaria or a big man in America, as long as it is well done. And this is what we have to do, work so well that nobody dares say: It is good work for a woman; but that everybody says: It is good work," she insisted in a speech to the NKAL in 1929.[55] This was the same year in which she found her scientific contributions belittled in the course of her fight to become a full professor; at least some of the dismissiveness she faced during that battle was attributable to her gender. The importance of an organization like the IFUW was no doubt particularly evident to her.

Gleditsch succeeded Bonnevie as head of the NKAL in 1924 and became vice president of the IFUW the same year. As the leader of the NKAL, in cooperation with the other

[53] Virginia Gildersleeve, *Many a Good Crusade* (New York: MacMillan, 1954), pp. 129, 138.

[54] *Ibid.,* pp. 130–133; and Web site of the IFUW: http://www.ifuw.org/.

[55] Gleditsch's speech is quoted in *Dagbladet,* 7 Oct. 1929. On the founding of the Norwegian group see Lilli Skonhoft, "Norske Kvinnelige Akademikeres Landsforbund," in *Kvinnelige Studenter 1882–1932* (cit. n. 7), pp. 249–263, on p. 251.

Figure 3. *Three members of the Norwegian section of the International Federation of University Women: Ellen Gleditsch, Kristine Bonnevie, and Lilli Skonhoft. (From* Kvinnelige Studenter 1882–1932, *p. 255.)*

Scandinavian groups and the organization in Finland, she helped to organize the third congress of the IFUW, held in Oslo in 1924. Two years later she was elected president of the International Federation, a position she held until 1929. This post suited her well, as a firm adherent of intellectual cooperation across borders, independent of sex, race, and politics. Her cosmopolitan and polyglot background, the fruit of her years in various laboratories in Europe and the United States, was certainly helpful as well. In her first speech as president of the international organization she emphasized that women should prove their ability as researchers, not only as teachers: “For years women have been teaching on all levels in society, most of them in lower positions, where less research is required. . . . They never had the chance to develop as researchers.” She suggested that the federation should help women to go abroad, to work in specialist laboratories where they could develop knowledge and skills and gain experience: “Women who have had such opportunities will come home to their country with the most valuable of all gifts, a decision to continue their research, . . . and, . . . not the least important, a stimulating acquaintance with colleagues in other countries.”[56]

As a leader of the organization Gleditsch initiated the establishment of scholarships for university women. At the congress in Oslo in 1924 the first contribution came from Mayor Sofus Arctander, representing the students of 1863, who had already established a fund for women in 1913. By 1928, the IFUW had collected enough money to fund one scholarship per year. Today the organization awards between fifteen and twenty-five scholarships every second year. In 1964, shortly after Gleditsch was awarded honorary lifetime membership in the NKAL, Martha Moldung, a degree candidate in pharmacy from Bergen, undertook to establish a fund in her name. It was intended to reflect the NKAL’s gratitude to the international organization for all the scholarships that had been given to Norwegian

[56] Gleditsch’s speech, delivered at the fourth congress of the IFUW in Amsterdam, is quoted in Kronen and Pappas, *Ellen Gleditsch* (cit. n. 4), pp. 111, 113.

women in science. Today the Ellen Gleditsch Fellowship is given to a woman doing independent research at the postgraduate/doctoral level.[57]

A SECOND FEMALE PROFESSOR IN NORWAY? NEW CHALLENGES

Though Gleditsch was a successful researcher with formal and informal networks around the world, she was not thought of as a star within her own university. In contrast to Bonnevie's appointment in 1912, Gleditsch's advancement to a full professorship in 1929 did not proceed smoothly. In particular, Heinrich Goldschmidt, the retiring professor, left no doubt that he preferred Odd Hassel as his successor. Moreover, the rector of the university, Sem Sæland, used his position to influence the board against electing Gleditsch.

It will be useful to present the "prehistory" to Gleditsch's 1929 candidacy. In 1914, two years after she returned to Oslo from Paris, four professors (Thorstein Hallager Hiortdahl, Oscar Emil Schiøtz, Paul Edvard Poulsson, and Kristian Birkeland) had proposed to the Faculty of Science and Mathematics that an associate professorship *(docentur)* in radiochemistry should be established for Ellen Gleditsch, then a university fellow. They emphasized that she was the only radiochemist in the country, apart from the geologist Victor Moritz Goldschmidt (the son of the most important opponent to Gleditsch in 1929) and insisted that "it will be of great importance to make her associated with the university, especially as our country offers a rich area for research in radioactivity." As Gleditsch had been offered attractive positions abroad, these colleagues recognized that they would have to make an effort if they were to keep her competence at the University of Oslo. Their proposal was favorably received by the faculty board and then the university board, and in a meeting in April 1916 the Parliament granted a salary for a position in radiochemistry. As expected, only Gleditsch applied. A few months later she was employed as an associate professor.[58]

Her promotion to full professor, however, would be more difficult for the Norwegian scientific community to accept. This was not the first time the appointment of a professor at the university had caused controversy, of course.[59] There were few positions, and professorships were much coveted. Those who were turned down for such posts often had to remain in the lower ranks for the rest of their lives, so a lot was at stake. Between 1914 and 1929, Birkeland, Hiortdahl, and Schiøtz had retired and Poulsson had died. Gleditsch was surrounded by colleagues whose agendas did not include her.

The professorship of inorganic chemistry became vacant in 1927, when Heinrich Goldschmidt retired after twenty-six years. Goldschmidt, born in Prague, came to Norway from a position in Heidelberg. He did research over the years in both inorganic and physical chemistry, but he was best known for his use of the methods of physical chemistry in organic chemistry. He reluctantly kept his professorship for an extra year because a decision as to his successor had not been made.[60] Originally there were five applicants, but

[57] On Arctander's contribution see Gleditsch, "Kvinnelige Akademikere—Utenlandsopphold og stipendier" (cit. n. 23), p. 247; on Moldung's initiative see Kronen and Pappas, *Ellen Gleditsch,* p. 199. On the various scholarships now awarded see the Web site of the IFUW (cit. n. 54).

[58] Stortingsproposisjon (Parliament proposition), 1-1916, Pt. 5, Ch. 3, pp. 26–27 (quotation); and *Universitetet i Oslo: Årsberetninger,* 1915/1916, pp. 3, 21.

[59] One of the more famous examples is the 1903 appointment of a professor in theology. See Vidar L. Haanes, *"Hvad skal da dette blive for prester?"* (Trondheim: Tapir, 1998), pp. 409–422.

[60] On Goldschmidt's work see Ore and Høeg, "Det Matematisk-Naturvitenskapelige Fakultet" (cit. n. 13); Marit Trætteberg, "Heinrich Jacob Goldschmidt," in *Norsk Biografisk Leksikon,* ed. Jon Gunnar Arntzen and Knut Helle (Oslo: Kunnskapsforlaget, 1999–), Vol. 3, pp. 327–328; and Ragnar Bye, "Heinrich Goldschmidt,"

two of them, associate professor Ludvig Johannes Lindeman and university fellow Gulbrand Lunde, withdrew when they were offered other positions. The remaining candidates were Ellen Gleditsch (see Figure 4), Odd Hassel, and Endre Berner.

Berner, an associate professor at the Norwegian Institute of Technology in Trondheim, had been awarded a doctorate in science in 1926. His application included recommendations from V. M. Goldschmidt and Claus Nissen Riiber, as well as from Richard Willstätter, under whom he had studied organic chemistry in Munich. Hassel received a doctorate from Berlin in 1924 and was appointed associate professor of physical chemistry and electrochemistry at the University of Oslo two years later. After he graduated in 1920 Hassel went to Paris, where he worked for some months under Paul Langevin, then turned to Munich to join Professor Kasimir Fajans. In 1923 he went to the Kaiser Wilhelm Institut für Faserstoffchemie in Berlin, where he began investigations with X-ray crystallography; this would become his favored technique for molecular structure elucidations.[61] Both Ber-

Figure 4. *Ellen Gleditsch in 1927. (Courtesy of Chris Koch.)*

Kjemi, 2003, pp. 18–19 (this was a special issue entitled *Store nordiske kjemikere*). On Goldschmidt's extra year see correspondence between the faculty board, the university board, and Heinrich Goldschmidt, Mar.–July 1927, Files of the Faculty of Science and Mathematics, 1929, SAO.

[61] Berner's application for the professorship, Files of the Faculty of Science and Mathematics, 1929, SAO; on his background see Ore and Høeg, "Det Matematisk-Naturvitenskapelige Fakultet," pp. 549–550. Hassel's background is discussed in *ibid.,* pp. 553–554; and in Tor Dahl, "Odd Hassel," in *Norsk Biografisk Leksikon,* ed. Arntzen and Helle, Vol. 4, pp. 131–132.

ner and Hassel were much younger, by fifteen to twenty years, than Gleditsch, who was fifty in 1929.

In her application Gleditsch summed up her education: her pharmacy studies and then the courses at the Chemistry Laboratory under Eyvind Bødtker's supervision; she noted that the courses in mineral analysis, based in analytical chemistry, had "partly been decisive for the scientific tasks I started later." Both in Paris and later in Oslo, she continued with mineral analysis. Gleditsch also emphasized her broad lecturing experience: over the years she had treated physical chemistry, radioactivity, thermochemistry, reaction rates and chemical equilibrium, and molecules and atoms, as well as radioactivity and modern atomic theory, elements, and isotopes. Friendly to students and supportive of their efforts—and with the ambition to build up a research laboratory akin to the one she had worked at in Paris—she allowed her students to do radioactivity measurements themselves insofar as laboratory space allowed.[62]

Gleditsch also noted her many trips abroad, especially as an invited speaker, to the United States, Budapest, Sofia, Bucharest, and Glasgow, and she emphasized her work at the radium factory in Nogent-sur-Marne, outside Paris: "These stays [in Nogent-sur-Marne] have been very useful to me. They have extended my knowledge of radioactive minerals and the problems that arise during extraction of the radioactive substances within these, and they have furthermore put me in contact with industrial chemistry." She concluded by listing her awards and distinctions: she was a member of the Norwegian Academy of Science in Oslo, had won a prize from the Nansen Fund for her article "Études sur les minéraux actifs" (1920), had been awarded an honorary doctorate by Smith College (1914), and was named Officier de l'Instruction publique in France (1924).[63]

Expert opinions on the applicants were obtained from Johannes Nicolaus Brønsted in Copenhagen, Georg von Hevesy in Freiburg, and Wilhelm Palmær in Stockholm. Brønsted, professor and head of the Department of Physics and Chemistry at the Polytechnical College, was already internationally recognized for his work on chemical affinity. In 1923 he put forward new definitions of acids and bases that are still in use today. Hevesy, professor of physical chemistry at the University of Freiburg in Breslau, was the radiochemist among the three experts. He had studied under Rutherford in Manchester (1910–1913) and had worked with Friedrich Paneth at the Vienna Institute for Radium Research (1913–1915) and at Niels Bohr's Institute for Theoretical Physics in Copenhagen (1920–1926). He was an authority on radiochemistry and especially well known for his isotopic tracer techniques. Palmær, the professor of general chemistry—which included theoretical chemistry and electrochemistry (earlier in his career he had been responsible for inorganic chemistry as well)—at the Royal Institute of Technology, was renowned for his research in electrochemistry. All three experts also spoke Scandinavian languages, a necessary asset as some of the candidates' publications were in Norwegian.[64]

Both Brønsted and Palmær regarded Gleditsch as the best candidate, whereas Hevesy

[62] Gleditsch's application for the professorship, Files of the Faculty of Science and Mathematics, 1929, SAO.

[63] *Ibid.* For more information on her work in the radium factory see Lykknes *et al.,* "Ellen Gleditsch" (cit. n. 27).

[64] On Brønsted see Stig Veibel, "Johannes Nicolaus Brønsted," in *Dansk Biografisk Leksikon,* ed. Sv. Cedergreen Bech, 3rd ed. (Copenhagen: Gyldendal, 1979), Vol. 3, pp. 40–42; on Hevesy see http://www.nobel.se/chemistry/laureates/1943/hevesy-bio.html; and on Palmær see Anders Lundgren, "Knut Wilhelm Palmær," in *Svenskt Biografiskt Lexikon,* ed. Göra Nilzén (Stockholm: Bonnier, 1992–1994), Vol. 28, pp. 584–588. It was common—through not invariable—practice to use experts who spoke a Scandinavian language. See *Universitetet i Oslo: Årsberetninger,* e.g., 1927/1928, pp. 11–28, 1928/1929, p. 15, 1933/1934, pp. 17–59.

preferred Berner but deemed all three able. He reckoned Gleditsch's work in radiochemistry extremely valuable and a testimony to her "comprehensive knowledge of the field. She is to be regarded as one of the best connoisseurs of radioactivity." All three experts emphasized Gleditsch's determinations of the Ra-U ratio, the half-life of radium, the age of minerals, and the atomic weights of lead and chlorine. Hevesy claimed, however, that her investigations were limited to the field of radioactivity and did not cover inorganic chemistry in its entirety. This view was not shared by the other experts. Palmær, who had written a twelve-page evaluation report, opined that Gleditsch's wide range of experimental work would be a benefit to a professor of inorganic chemistry. She was familiar not only with methods of physical investigation, specific weight determinations, and X-ray spectroscopy but had also conducted preparative chemical work, difficult chemical analyses, atomic weight determinations, and investigations of the chemical character of elements. He concluded that "her work is almost exclusively in the field of the professorship, inorganic chemistry, and touches its most central parts."[65] Brønsted ranked both Gleditsch and Berner above Hassel as prospective professors of inorganic chemistry. He felt that Hassel was not yet an independent researcher and that his work was too narrow.

Two of the three outside experts therefore preferred Gleditsch, while one favored Berner. In addition to these international experts, the two professors of chemistry in Oslo (Goldschmidt and Bødtker) were asked to give oral evaluations of the candidates to the faculty board. This was not a very common practice, but it was chosen as a time-saving expedient because the matter of the appointment had already been long delayed. For various reasons, some faculty members, Dean Sæland among them, found this informal approach unsatisfactory.[66]

Goldschmidt claimed that Palmær's assessment of Gleditsch's merits was exaggerated and that the young and promising Hassel was the candidate to be preferred. Bødtker, Gleditsch's former supervisor, supported her. Now three of the five experts recommended appointing Gleditsch, and the matter could have been settled. Two of the professors on the faculty board, which met on 14 March, asked for written evaluations so that all of the faculty board members could read the Norwegian experts' statements. But this proposal was rejected, and Gleditsch was elected with ten of the thirteen votes. Hassel got the rest, so Berner was eliminated from the competition. At this point, however, Rector Sem Sæland—who was also dean of the faculty—entered the faculty board meeting for its discussion of this case only. He suggested a supplement to the report from the meeting stating that a Norwegian committee as well as the international one should be consulted, as had been the case in the recent appointment of a professor in astronomy and would be again with an upcoming appointment in applied mathematics. The university board, meeting on 14 April, returned the case to the faculty board, as "doubt had arisen whether the faculty's recommendation was made on a completely satisfactory basis." The university board ob-

[65] Hevesy's expert opinion, Files of the Faculty of Science and Mathematics, 1929, SAO; and Palmær's expert opinion, Files of the Faculty of Science and Mathematics, 1929, SAO.

[66] Sem Sæland, "Besettelsen av professoratet i kjemi ved universitetet," *Tidsskrift for Kjemi og Bergvesen,* 1929, no. 9, pp. 102–103 (Sæland was responding to the editor's commentary on the delays in this case). Soliciting the views of the candidates' predecessor might seem strange from today's perspective, but at the time Goldschmidt was one of only two professors of chemistry at the university. And there was a precedent: when Bødtker—the only candidate—applied for his professorship in 1918, his predecessor Thorstein Hallager Hiortdahl offered an opinion as to his qualifications. See Archives of the Ministry of Church and Education, 1. skolekontor D, 1898–1938, professorembeter 1913–1918, Eea-441, professoratet i kjemi 1918, RARK.

jected that the Norwegian professors' statements should have been presented in written form.[67]

By this point the affair had reached the media. The public was impatient with the duration of the process, and some suspected that the points at issue were not exclusively scientific. On 16 April, a month after Gleditsch had won the first faculty vote, the liberal newspaper *Dagbladet* asked: "Why has the case come to a stop? The appointment of Gleditsch as professor is met with broad interest." *Dagbladet* also pointed out that in returning the case from the university board to the faculty board Sæland had essentially returned it to himself, as he was dean of the Faculty of Science and Mathematics as well as university rector. Defending his decision to return the case to the faculty, Sæland observed to *Morgenbladet* that "the appointment of a professor is a serious matter." As the matter dragged on, Sæland's many roles were also lampooned in a student newspaper, *Fikenbladet* [The Fig Leaf], in an article that reveals the students' views about the ongoing case and Gleditsch's situation:

> Can Little Ellen Become Professor?
>
> The Rector of the University, Sem Sæland, finds that associate professor Ellen Gleditsch should not become full professor of chemistry. He has returned the recommendation to the university board.
>
> The president of the university board, Professor Sem Sæland, declared that he agrees with the rector of the university. The case is transferred to the Faculty of Science and Mathematics.
>
> The dean of the Faculty of Science and Mathematics has, in agreement with the above, uttered that Miss Ellen Gleditsch cannot be considered mature enough for a professorship of chemistry.—The dean is Sem Sæland.

Sæland's role in prolonging the dispute—and his preference of Hassel over Gleditsch—is also clear from a report in the conservative newspaper *Aftenposten* on 6 June: "One of the prominent university authorities has wished to appoint another applicant, and this has led to a reopening of the case."[68]

No doubt Gleditsch had spent more time building an international network than cultivating professional bonds with her colleagues at the university in Oslo. Now, however, she needed all the support she could muster. One colleague who supported Gleditsch and resented the way she was treated was Kristine Bonnevie, who at the time was pro-dean. Was she one of those who encouraged Gleditsch to ask Curie for support? Gleditch had not enclosed a recommendation from her mentor in her application, as Berner had. Perhaps she had felt reluctant to bother Curie, but at this point her back was to the wall. When she visited Curie in May 1929, after a trip to the United States for the International Federation of University Women, she described the debate that raged at home. Curie willingly supported her former coworker and wrote a letter that detailed her many excellent research projects, as well as noting her contributions and devotion to science.[69]

[67] Reports of faculty board meetings, 14 Mar. 1929 (initial vote), 25 Apr. 1929 (case returned from university board), Reports 1918–1930, AMNF. It is worth noting that no expert evaluation was sought at the time of Sæland's own appointment to a professorship in physics in 1922; only a personal reference to his former job as professor at the Norwegian Institute of Technology was attached. See Archives of the Ministry of Church and Education, 1. skolekontor D, 1898–1938, professorembeter 1922–1924, Eea-443, professoratet i fysikk 1922, RARK.

[68] *Dagbladet,* 16 Apr. 1929; "Det ubesatte professorat i kemi," *Morgenbladet,* 16 Apr. 1929 (*Morgenbladet* reported on the case three days running); *Fikenbladet,* 17 May 1929; and *Aftenposten,* 15 Apr. 1929. Sæland seems to have added to the turmoil by announcing his preference for a candidate from Trondheim—C. N. Riiber—who never applied for the professorship. See *ibid.; Morgenbladet,* 16 Apr. 1929; and *Dagbladet,* 17 Apr. 1929.

[69] Curie to Kristine Bonnevie, 11 May 1929, Marie Curie Archives, letter 1506, AMC.

Curie's recommendation was addressed to Bonnevie. The choice of recipient was not accidental; this was a personal letter, and it had to be received by someone with both the ability and the inclination to make use of it if it was to have any effect. At this point in the proceedings nothing more would have been added to the official dossier—especially since Sæland, who was in charge of the deliberations, was one of Gleditsch's opponents. In acknowledging receipt of Curie's letter, Bonnevie outlined where things stood: "One of our professors of Chemistry, H. Goldschmidt, who is now resigning, is very hard against her, while the other, E. Bødtker, together with the foreign scientists who have been asked their opinion, seems to appreciate her work very much."[70] Curie's recommendation of Gleditsch was, of course, impossible to discount. Goldschmidt's views had no comparable authority in the scientific community.

In the faculty meeting following the return of the case from the university board, on 25 April, Bonnevie pointed out that only a formal error in the handling of the case warranted reopening it. The matter was postponed until the next meeting, on 2 May, and, as a compromise, Goldschmidt and Bødtker were asked to submit their statements in written form. When the faculty eventually received these statements, at the end of May, Gleditsch was elected unanimously. The newspapers that had written about this case continually since Gleditsch was first recommended for the professorship in the beginning of April announced early in June that the faculty had finally decided on Gleditsch and that she would probably be appointed.[71] About a week later, on 15 June, she was the subject of an in-depth story, running over six columns, in *Dagbladet.*

The appointment attracted attention from media across the political spectrum. The liberal magazine *Tidens Tegn* interviewed Gleditsch on the day of her formal appointment, 21 June 1929. The story reported her response to congratulations: "'No, I don't believe that [I have been appointed yet]; I heard that the appointment will not occur until next week.' But we did the cross-my-heart sign and then she had to believe us." Gleditsch emphasized the good working conditions that she would now enjoy, and "of course I am glad," she exclaimed.[72]

The Opposition: A Closer Look

In the very small university milieu in Oslo, the matter of the appointment in physics must have been a topic of daily discussion and controversy. The division between Gleditsch's adherents and opponents apparently ran quite deep. Eyvind Bødtker, as we have seen, belonged to the first group. He wrote a three-page expert statement, devoting one page to each candidate. He discussed the international experts' opinions and added his own views on the applicants. Bødtker agreed that Berner's work was well executed and admired by his peers, even though his research findings were not numerous at this point. He also noted Berner's skills as a teacher and judged him an able candidate.

Bødtker largely agreed with Brønsted that Hassel's work was narrow and within a field closer to physics than to chemistry, though he believed that Hassel was "a clever and hard-working researcher, with a true need to do research." He added that "Associate Professor Hassel is moreover not suited to giving lectures in inorganic experimental chemistry, be-

[70] Bonnevie to Curie, 25 May 1929, Marie Curie Archives, letter 1507, AMC.

[71] The unanimous vote is recorded in report of faculty board meeting, 6 June 1929, Reports 1918–1930, AMNF. For newspaper accounts see *Dagbladet,* 7 June 1979; and *Aftenposten,* 10 June 1929.

[72] Interview with Gleditsch, *Tidens Tegn,* 21 June 1929.

cause he speaks less well, and particularly because he, unfortunately, does not see well [he had albinism]."[73]

Bødtker agreed with Palmær's evaluation of Gleditsch's research and noted that he and Goldschmidt had found her qualified to be a professor in 1925: they had proposed a professorship for her in physical chemistry. And "since then Dr. Gleditsch has published several articles, showing that despite her many assignments there has still been no decline in her scientific work." Bødtker emphasized that the international experts were able to evaluate only the candidates' scientific skills, not their ability to teach, adding, "It should be well known to the faculty that Associate Professor Gleditsch possesses quite extraordinary skills as a lecturer." That she had held so many positions—assistant, university fellow, and associate professor—had given her wide experience as a teacher, "adding to inborn skills as such."[74]

As we have seen, Goldschmidt was not in favor of Gleditsch's appointment. But this is not to say that he was wholly opposed to her as a scientist and researcher. The fact that, with Bødtker, he had proposed a professorship in physical chemistry for Gleditsch in 1925 testifies to this, although his main motivation at that point was probably to relieve himself from his many teaching duties in both inorganic and physical chemistry. Over the years Goldschmidt acted both for and against Gleditsch. In 1910, when she applied for a university fellowship, Goldschmidt had voted against her—something that Professor Kristian Birkeland (famous, among other things, for his work on the northern lights) found so unfair that he wrote to the university board, asking for an international expert evaluation.[75] But in 1917 Goldschmidt recommended Gleditsch to the Norwegian Society for Science and Letters in Christiania, and she became the second female member (after Bonnevie, who was elected in 1911).[76]

Even if Goldschmidt had favored Gleditsch in earlier years and had even helped her career to advance, he was not at all pleased with the idea of her as his successor. Goldschmidt had great expectations for his own student, Hassel, and therefore emphasized his qualifications while downplaying Gleditsch's. In his six-page evaluation report, two treated Hassel and Berner and the last four focused on Gleditsch. A closer comparative look at the way Goldschmidt described Gleditsch and Hassel is revealing, offering the opportunity not only to examine the contrasting evaluations of their qualifications but to analyze the particular words he chose to characterize their work.

Goldschmidt agreed with the experts' opinion that Gleditsch's emphasis on using RaG instead of all lead isotopes in age determinations was important, even "her best achievement," but he added that her methods were developed by others. He also observed that the composition of lead isotopes in bröggerite had recently been reevaluated by Francis

[73] Bødtker's expert opinion, Files of the Faculty of Science and Mathematics, 1929, SAO; see also Ragnar Bye, "Norske Nobelpristakere i kjemi VI: 1969: Odd Hassel," *Kjemi,* 2003, pp. 39–41 (special issue entitled *Store nordiske kjemikere*).

[74] Bødtker's expert opinion, Files of the Faculty of Science and Mathematics, 1929, SAO.

[75] Proposal from Bødtker and Goldschmidt to the Faculty of Science and Mathematics, Files of the Faculty of Science and Mathematics, 1929, SAO. Goldschmidt's vote in opposition to a fellowship for Gleditsch is noted in report of the faculty board meeting, 6 Oct. 1910, AMNF; Birkeland's protest is noted in report of the university board meeting, 22 Oct. 1910, Archives of the University of Oslo, University board, A-0026, Forhandlingsprotokoll 1908–1911, RARK.

[76] Leiv Amundsen, *Det Norske Videnskabs-Akademi i Oslo 1857–1957* (Oslo: Aschehoug, 1957), Vol. 2, pp. 18, 116. The Norwegian Society for Science and Letters changed its name to Norwegian Academy of Science and Letters when the capital reverted to its original name—Oslo—on 1 Jan. 1925. The addition of "in Oslo" was to avoid confusion with the Royal Society of Science and Letters, which was the oldest such organization and was located in Trondheim: *ibid.,* p. 317.

Aston and that the new results diverged from those Gleditsch published about ten years earlier. In 1929 Aston had used his new mass spectrograph, for which he was awarded the Nobel Prize in 1922, to identify the third lead isotope, ${}_{82}Pb^{207}$, work that contributed to finding the genesis of the actinium-decay series. Goldschmidt suggested that Gleditsch should have allowed for the possibility that this isotope was present when performing her calculations in 1919—despite the fact that it was not identified until ten years later. The most positive phrases Goldschmidt used to characterize the rest of Gleditsch's publications were "very diligent," describing her work on the Ra-U ratio, and "very carefully conducted investigations," about her 1925 publication *Contribution to the Study of Isotopes.* He added, however, that her results were contradictory—a fact "that had not been discussed"—and that most of this work was a "compilation of results already published earlier." Furthermore, he claimed that her uranium analyses were much inferior to those of William F. Hillebrand; she analyzed few elements, failed to separate them according to element or group of elements, and omitted the evaluation of important parameters. He described her joint work with Erling Botolfsen from 1925, published as "Les specters des rayons X du praséodyme, du néodyme et du samarium," as "completely useless and without meaning." In conclusion, he wrote:

> When you look at Dr. Gleditsch's collected work, you obtain respect for the diligence with which her early work, particularly, has been conducted. But what you miss is original approaches to problems. All of her works that have given important results—the Ra-U ratio, the half-life of radium, the age of uranium minerals—are continuations of work, whose ideas and methods are shaped by others, and one cannot deny that some of her later works do not measure up to the previous ones. To her advantage must be counted her great ability to make difficult topics clear, as is revealed in her numerous review treatises.[77]

Goldschmidt's condescending description of Gleditsch was in contrast to his statements on Hassel, whom he repeatedly praised for doing difficult experiments that had earned him the respect of all his colleagues in the field. Goldschmidt furthermore described Hassel as an excellent researcher whose investigations would stand as "classic works." He opined that Hassel was an excellent associate professor who had the ability to present difficult topics in a comprehensible fashion. Goldschmidt concluded: "Dr. Hassel is unconditionally the first with respect to scientific originality, productivity, and production. Under his leadership the Chemistry Laboratory will most likely take a leading position in atomic research." Surprisingly, Goldschmidt had ranked Berner above Gleditsch in his oral statement. His written report devoted less than a page to Berner, referring to his experiments as "precisely conducted." Berner was not as modern in his techniques as Hassel, Goldschmidt pointed out, but his techniques nonetheless gave him high rank in the competition for the professorship. The advantage of Gleditsch, in Goldschmidt's opinion, was that she would bring "glory to the university for her fame, which she rightly deserved already long ago."[78]

[77] Goldschmidt's evaluation report, Files of the Faculty of Science and Mathematics, 1929, SAO. Goldschmidt's positive remark about the 1925 publication is in reference to Ellen Gleditsch, *Contributions to the Study of Isotopes* (Oslo: Det Norske Videnskaps-Akademi i Oslo, 1925). The paper he described as "completely useless and without meaning" is Gleditsch and Erling Botolfsen, "Les specters des rayons X du praséodyme, du néodyme et du samarium," *Compt. Rend. Acad. Sci.,* 1925, *180:*1653–1655.

[78] Goldschmidt's evaluation report, Files of the Faculty of Science and Mathematics, 1929, SAO. The oral statement ranking Berner above Gleditsch is recorded in report of faculty board meeting, 14 Mar. 1929, Reports 1918–1930, AMNF.

One reason for Goldschmidt's opposition to Gleditsch, clearly, was his preference for Hassel, a former student with whom he had worked closely for several years. Since his arrival as professor in Oslo in 1901, Goldschmidt had built up the Chemistry Laboratory. It is understandable that, as he approached retirement, he wanted to secure his life's work by leaving it in the hands of the best possible researcher within his field. Hassel, who was evidently very competent, was not only Goldschmidt's closest colleague in Norway but the only one of the three candidates whose work was firmly within physical chemistry. He and Goldschmidt also had their German cultural background in common. In contrast, Gleditsch's scientific roots were in France and the United States, and her extended network included colleagues from the United Kingdom and Central Europe as well.

Many looked on Hassel as a coming man, with his appetite for hard work, analytical abilities, and already promising results, and indeed forty years later he would be awarded the Nobel Prize. Goldschmidt knew that Bødtker would retire in four years; no doubt he envisioned that Gleditsch would succeed Bødtker and found it natural that Hassel should have his own position. Hassel, however, had little teaching experience, and Bødtker emphasized that he had no pedagogical gifts. Gleditsch, with her considerable teaching experience, was renowned for her natural abilities and for evoking enthusiasm for chemistry amongst the students. Goldschmidt quite likely knew this as well; but he made no mention of it in his evaluation of her. He also contentiously downplayed Gleditsch's long research experience and international renown, as well as her important place within the worldwide network of radiation researchers. In appointing a new professor, he maintained, the university should emphasize research promise rather than earlier achievements. In this respect—at least according to Goldschmidt—Gleditsch had already passed her prime and could not compete with Hassel. On the other hand, the international committee did not recognize the same potential in him. The committee appreciated Hassel's papers but regarded him, as we have seen, as an immature scientist of uncertain promise.

Although radiochemistry had brought much new knowledge to atomic science, at the end of the 1920s it had reached a saturation point, having become what Lawrence Badash describes as "suicidally successful."[79] The disintegration theory and the concept of isotopy were accepted, and most radioelements were identified and located in a decay series. What more could the field offer? History shows that in the 1930s things started to move again, as the discovery of the neutron and artificial radioactivity laid the groundwork for today's nuclear chemistry. But at the end of the 1920s, none of this could be anticipated. However, this apparent dead end in what had come to be Gledtisch's primary research field was not explicitly noted by Goldschmidt or any other faculty member, and it is uncertain whether this argument influenced their decision.

Is it possible that Goldschmidt felt uneasy with the idea of a woman as his successor? His description of Gleditsch as a researcher who depended on the ideas of others but was an able disseminator and a diligent foot soldier is condescending and certainly reveals a misogynistic bias. Interestingly, the words Goldschmidt chose to describe Gleditsch's scientific papers were essentially ones that could be perceived as appealing feminine characteristics: "diligence," "exactness," "dependence." He resolutely ignored the other expert opinions, forcefully presenting his own view of Gleditsch as an old-fashioned and outdated researcher whose most impressive abilities were in teaching. No doubt he was very displeased by the outcome of the final vote. Goldschmidt's son, the geologist Victor Moritz

[79] Lawrence Badash, "The Suicidal Success of Radiochemistry," *British Journal for the History of Science,* 1979, *12:*245–256.

Goldschmidt, immediately resigned his own position and accepted a guest professorship in Göttingen; Hassel's defeat was supposedly the last straw.[80]

The Aftermath

Over the next few years, things turned out well for Hassel and Berner as well. In the same meeting at which Gleditsch was elected, Haakon Hasberg Gran, one of the members of the faculty board who had supported Hassel's bid to replace Goldschmidt, proposed establishing a new professorship in physical chemistry for which Hassel could apply. The proposal was passed unanimously, but it was impossible actually to establish the post before the Chemistry Laboratory moved to the new campus at Blindern, where more rooms and laboratories were available, in 1934. In December 1933, with Bødtker's resignation, Endre Berner became professor of organic chemistry—a field closer to his research interests than the position Gleditsch won. This resignation, in fact, provided the final impetus for establishing the professorship in physical chemistry. Both Berner and Hassel—as well as two other candidates—applied for Bødtker's position. Since both men were qualified, the experts—among whom Gleditsch was included—recommended that the university find professorships for both of them. By that time, moreover, the increased use of physical methods in chemistry had made a professorship in physical chemistry seem increasingly desirable. By 1934, then, just five years after the battle to fill Goldschmidt's position, all three candidates had become professors in Oslo—an exceptional outcome.[81]

As we have seen, Gleditsch's appointment generated intense media interest. If the general public was so involved, certainly those more directly affected were even more taken up with the matter. Goldschmidt's views and statements about Gleditsch were of course not born and bred in isolation, and it doesn't take much imagination to divine that the atmosphere at the department, faculty, and university where Gleditsch, Hassel, and the younger Goldschmidt—who returned to Oslo in 1935—all worked was not particularly collegial. Former students of Hassel and Gleditsch, who wish to remain anonymous, have said that they were like cat and dog and that he did not respect her.[82] Some also report that Gleditsch's reputation as a teacher was much better than her reputation as a researcher. Goldschmidt's characterization of her—though inconsistent with her international standing—and the conflict associated with her appointment in all likelihood led to the lack of respect she experienced in the department after her appointment and are probably to some extent responsible for her apparent lack of recognition in the chemical community and academia in Norway today.

[80] Brian Mason, *Victor Moritz Goldschmidt: Father of Modern Geochemistry* (San Antonio, Tex.: Geochemical Society, 1992), p. 54. The Goldschmidts' correspondence with Hassel reveals their concern for his future in Oslo. Victor suggested that he should teach organic chemistry in 1933 in order to increase his chances for a professorship: V. M. Goldschmidt to Hassel, 28 Dec. 1932, unsorted material, Box 2, Letter Collection, NBM; Heinrich wrote after Gleditsch had been appointed that "I hope your prospects of a professorship in physical chemistry are not so dark as you may assume. Who will become Farup's successor at the Pharmaceutical Department? Could not Ellen [Gleditsch] take over, so my whole professorship will become available for you?" H. Goldschmidt to Hassel, 7 Dec. 1931, unsorted material, Box 2, Letter Collection, NBM.

[81] The initial proposal to establish a professorship in physical chemistry is recorded in report of faculty board meeting, 6 June 1929, Reports 1918–1930, AMNF; the experts' recommendation about finding two professorships appears in *Universitetet i Oslo: Årsberetninger,* 1933/1934, pp. 17–59. On the increasing importance of physical methods in chemistry see Ore and Høeg, "Det Matematisk-Naturvitenskapelige Fakultet" (cit. n. 13), p. 553.

[82] Hassel was known to be disrespectful to the many people he disliked; see Bye, "Norske Nobelpristakere i kjemi VI: 1969: Odd Hassel" (cit. n. 73). Bye notes that this was well known to everybody in the chemical community at the University of Oslo at the time.

It must have been difficult for Gleditsch to face opposition almost daily; perhaps she was also excluded from some of the formal and informal discussions that make up scientific life in the university setting.[83] The rumors that were spread about her inferior scientific qualifications in the aftermath of Goldschmidt's campaign against her appointment were not in the open and therefore were hard to fight. Even though she obtained the professorship and the power and privileges that it entailed, her closest colleagues were still abroad, in the United States and on the continent. In meeting with them she could collect moral support and express her frustrations as well as her enthusiasm for her work. These experiences were also important in leading her to become one of the driving forces in creating arenas for female academics, abroad as well as at home.

FINAL COMMENTS: ELLEN GLEDITSCH AND THE HISTORY OF WOMEN IN SCIENCE

Ellen Gleditsch was a scientist with an international reputation, as her many distinctions testify. In 1914 she was awarded an honorary doctorate from Smith College. She became an honorary member of the Société Chimique de Strasbourg (1920), the U.S. honor society for women in chemistry Iota Sigma Pi (1929), the Association Française des Femmes Diplomées des Universités, Paris (this was the French section of the IFUW) (1929), and the Société Chimique de France (1946), and she was inducted into the French Legion of Honor in 1938. In 1957 she became an honorary citizen of Paris, and, most important, she was awarded honorary doctoral degrees by both the University of Strasbourg (1948) and the Sorbonne (1962) (see Figure 5); at the latter she was the first woman to be so honored.

During her lifetime in academia, although she faced no laws barring women's participation or advancement, she regularly experienced the condescending attitudes of her male colleagues. Her initial reception in the United States and the opposition she met when applying for a full professorship in 1929 are particular examples. The latter likely damaged her reputation in Norway at the time, and the disrespect she endured in her home university stood in stark contrast to the reputation she enjoyed abroad.

Gleditsch remarked in an interview in 1930: "I have often worked as the sole woman in a laboratory without any reason to complain. However, I have learned to respect their [men's] 'weaknesses'—and that has been a reasonable thing to do." In accordance with her upbringing and academic background, Gleditch never complained publicly about her situation or made arguments on behalf of her gender. She would also have discouraged any analysis of her work from a gender perspective and, probably, any interest in explorations of her career as a female academic. Gender was an irrelevant parameter of explanation in science; like many of her female colleagues, Ellen Gleditsch practiced rather than preached feminism.[84] Her role as a central figure in the network of women in radioactivity and her position in the International Federation of University Women nonetheless demonstrate that she was preoccupied with women's opportunities. So too does her membership on the editorial board of the women's magazine *Kvinnen og Tiden,* which aimed to broaden social and political attitudes, in the 1940s and her membership in the Norwegian Association for the Rights of Women (Norsk Kvimesaksforening) from 1936. Although Gleditsch was a prolific letter writer, those letters that we have had access to do not reveal

[83] Barbara Reskin, "Sex Differentiation and Social Organization of Science," in *Sociology of Science,* ed. Jerry Gaston (San Francisco: Jossey-Bass, 1978), pp. 6–37.

[84] "Mannen som kollega: Hvad professor Ellen Gleditsch mener" (cit. n. 1). Similar thoughts are reflected in her manuscript "Women in Science, Norway," Letter Collection, MS 4° 2437:18, NBM. The phrase about practicing rather than preaching feminism comes from Pnina Abir-Am and Dorinda Outram, *Uneasy Careers and Intimate Lives: Women in Science, 1789–1979* (New Brunswick, N.J.: Rutgers Univ. Press, 1987), p. 13.

Figure 5. *Ellen Gleditsch as honorary doctor of the Sorbonne, Paris, 1962. (Courtesy of the National Library of Norway, Letter Collection 456, Ellen Gleditsch.)*

what she thought and felt at various crossroads in her life and career—quite probably because she never wished to make those views a topic of discussion.[85]

Gleditsch was not the only female Norwegian academic who endured biased attitudes. Helga Eng, whose field was pedagogy, was rejected twice before her appointment as the third female professor at Oslo in 1938. Although she was regarded as scientifically well qualified when she applied for appointments in both 1921 and 1922, she was declared unsuitable for a leadership position. Furthermore, her research was in the "wrong" area—pedagogical psychology—and she lacked relevant teaching experience. In 1922 one of the two experts who evaluated the applicants regarded Eng as the best candidate, but the Ministry of Church and Education probably considered her background as too "academic" for this position; in the end, the candidate ranked third by both experts, who had extensive experience at a teaching college, was appointed. The contemporary women's movement has left no doubt that at the time of the first appointment Eng's gender was the cause of her rejection. Eng then faced economic problems, which drove her—like many women in the United States—into test administration and applied psychology, a field distinguished by its small salaries and low status. Eng, however, founded her own institution, the Institute

[85] Gleditsch's brother Adler destroyed many of her letters, some of which might have told us more about her true feelings and what it was like to be a woman in her situation. Gleditsch's biographers Kronen and Pappas (and, following them, Kubanek and Grzegorek) mention a missing diary, which of course would have been interesting for historians. However, their source is a letter from Gleditsch asking Curie to return her *cahier,* which she had left behind in the laboratory. A *cahier* is a notebook or journal; this letter, then, offers no evidence that a diary ever existed.

for Psycho-technique, which she directed until 1938, when she finally became a full professor.[86]

In 1915 Eva Ramstedt, Gleditsch's Swedish colleague, was the first woman to be appointed an associate professor in Sweden, at the private Stockholm Högskola (later the University of Stockholm). She had already worked at the Nobel Institute for four years, one of them as an assistant professor under Svante Arrhenius. A full professorship at a state university was not an option for a woman at the time, nor does she seem to have been considered for such a position at the Stockholm Högskola; Ramstedt continued as a lecturer at the Teacher's College in Stockholm until she retired in 1945.[87] Like Gleditsch, she joined the International Federation of University Women in her home country and at the international level.

Stories about scientists and academics like Gleditsch, Eng, and Ramstedt are tiny parts of the multifaceted history of women in science. All three are examples of women who worked within a community of biased scholars—or at least in societies that restricted their opportunities for promotion within their fields. This was a fate they shared with many contemporary female scientists, both exceptional and ordinary.[88] Gleditsch's struggle for a leading position, we believe, was typical for a female scientist—although many would argue that men were not exempt from the same difficulties and perhaps that Gleditsch herself was partly to blame for her problems because she failed to cultivate colleagues and supporters at home.[89] However, her international contacts supported her promotion and provided a network that helped her survive the cold atmosphere in Norway; this international network distinguishes her story.

[86] Elisabeth Lønnå, *Helga Eng: Psykolog og pedagog i barnets århundre* (Oslo: Fagbokforlaget, 2002), pp. 108–111, 112–115, 116.

[87] Hjördis Levin, "Eva Julia Augusta Ramstedt," in *Svenskt Biografiskt Lexikon,* ed. Nilzen (cit. n. 64), Vol. 29, pp. 647–649.

[88] For accounts of other women scientists see, e.g., Rayner-Canham and Rayner-Canham, eds., *Devotion to Their Science;* Abir-Am and Outram, *Uneasy Careers and Intimate Lives* (cit. n. 84); and biographical dictionaries such as Ogilvie and Harvey, eds., *Biographical Dictionary of Women in Science* (cit. n. 13).

[89] Today only 14.3 percent of full professors in Norway are women, although it has been the case for a number of years that more than half of the students are female. So there is still a long way to go before women reach full equality in academia. See Stortingsmelding (Parliament report) 35 (2001–2002), Ch. 8.1: "Rekruttering av kvinner," Utdannings- og Forskningsdepartementet (Ministry for Education and Research).

Paper 3

Annette Lykknes, Lise Kvittingen, and Anne Kristine Børresen,

"From Fertile Centers to Seeding the Periphery.
Ellen Gleditsch: Duty and Responsibility
in a Research and Teaching Career, 1916-1946,"

(manuscript)
The article shown here is the published version of the manuskript

ANNETTE LYKKNES, LISE KVITTINGEN, AND ANNE KRISTINE BØRRESEN*

Ellen Gleditsch: Duty and responsibility in a research and teaching career, 1916-1946

> Many of the young students who entered the University of Oslo during the 1920s and 1930s wanted to become servants of the chemical arts. Among these were a handful who gathered around their inspiring Professor Ellen Gleditsch—our beloved "tante Ellen." She had been one of the pioneers and one of the first assistants to Mme Curie and also her closest friend. She told us about fantastic and marvelous ventures, in a thrilling way and with enthusiasm that aroused our curiosity.[1]

ELLEN GLEDITSCH (1879-1968) trained as a pharmacist, studied radioactivity at the Sorbonne and worked in Marie Curie's laboratory in Paris between 1907 and 1912 (figure 1). After a stay in Bertram Boltwood's laboratory at Yale University, in 1913/14 Gleditsch returned to the University of Oslo where she became

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The following abbreviations are used: AAW, Archiv der Österreichischen Akademie der Wissenschaften, Institut für Radiumforschung; Åb, Universitetet i Oslo: Årsberetninger; AMC, Archives Musée Curie; AMNF, Archives of the Faculty of Science and Mathematics, University of Oslo (Arkiv fra det Matematisk-Naturvitenskapelige Fakultet); BN, Bibliothèque Nationale de Paris; Forelesn, *Det Kongelige Frederiks Universitet Oslo: Forelesninger;* NBM, Nasjonalbiblioteket i Oslo, håndskriftsamlingen; CCA, Churchill College Archives, Cambridge; *CR, Comptes rendus*; *PR, Physical review*; RARK, Public Record Office, Riksarkivet; SAO, Files of the Faculty of Science and Mathematics 1929, Central Archive, University of Oslo; YUL, Yale University Library.

1. Alexis C. Pappas (student of Gleditsch and the first professor of nuclear chemistry at Oslo), "Epilogue," in Einar Hagebø and Brit Salbu, eds., *Aspects of nuclear science: In honour of Professor Alexis C. Pappas: Proceedings symposium. Aspects of nuclear science*

HSPS, Volume 36, Part 1, pages 131-188. ISSN 0890-9997.

FIG 1 Young Ellen Gleditsch. *Source:* Courtesy of Lars Edmund Gleditsch.

university fellow (1911), associate professor (1916), and finally full professor of chemistry (1929). With experience from Paris and Yale she set out to establish a laboratory of radiochemistry at Oslo, a career which included network building, grant applications, travels abroad, committee work, research, teaching, supervision, popularization, war resistance work and participation in intellectual cooperation. This paper concentrates on her formation of a research and teaching laboratory at the small university in Oslo.[2]

The University of Oslo, founded in 1811, was the only university in Norway until the University of Bergen was formed 1946.[3] The Norwegian scientific community was therefore small compared to those in Sweden and Denmark, which had

24th and 25th of October, 1985, Department of Chemistry, University of Oslo (Oslo, 1987), 166-178, on 167.

2. We have previously published on other aspects of Gleditsch's career: Annette Lykknes, Helge Kragh and Lise Kvittingen, "Ellen Gleditsch: Pioneer woman in radiochemistry," *Physics in perspective, 6* (2004), 126-155; Annette Lykknes, Lise Kvittingen and Anne Kristine Børresen, "Appreciated abroad, depreciated at home. The career of a radiochemist in Norway: Ellen Gleditsch (1879-1968)," *Isis, 95* (2004), 576-609. Other accounts of Gleditsch include Torleiv Kronen and Alexis Pappas, *Ellen Gleditsch: Et liv i forskning og medmenneskelighet* (Oslo, 1987) and an article mainly based on this book; Anne-Marie Weidler Kubanek and Grete P. Grzegorek, "Ellen Gleditsch: Professor and humanist," in Marelene F. Rayner-Canham and Geoffrey W. Rayner-Canham, *A devotion to their science: Pioneer women of radioactivity* (Montreal, 1997), 51-75.

3. There were however other university-like institutions that offered higher education

harbored university traditions since the 15th century. In 1814, after a union of 400 years with Denmark, Norway became an almost self-governing part of Sweden. It obtained full independence in 1905. The establishment of a Norwegian university was tied to the project of political liberation from Denmark. Many of the university teachers became central in the nation-building during the 19th century.[4]

While Gleditsch worked at Oslo, the university developed towards a research institution. Beginning around 1870 the focus shifted from general *Bildung* to specialized research and the education of employees for the public and private sectors. The university became socially more open and attracted new student groups, for example, farmers' sons and women.[5]

The large philosophical faculty (which co-existed with the faculties of law, theology, and medicine) was divided in 1860 into a faculty of the natural sciences and mathematics and a faculty of humanities. In 1905 the university introduced the master thesis. Museums and collections were gradually replaced by laboratories, required an international network, money, and personnel. Gleditsch was one of the scientists who participated in shaping the new tradition.

Gleditsch's international career makes possible a case-study of the transfer of ideas and knowledge from center to periphery: What were the consequences of her international training, to what extent, if any, did they influence her introduction of new practices at her local university? Gleditsch's struggle to establish a radiochemistry laboratory also makes possible a micro history of a small scientific milieu on the outskirts of Europe the quest for finances, instruments, and students, and the balancing of research and administrative duties.[6]

Gleditsch was a chemist and research was an important part of her career. In order to understand Gleditsch's research career we will therefore present some of her most important scientific contributions and the contemporary scientific context in which they appeared. Through a close look at her scientific achievements we can furthermore understand more of the dynamics between centers and peripheries;

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within science and technology in Norway, e.g., The Agricultural University at Ås from 1897 and The Norwegian Institute of Technology in Trondheim, founded in 1910.

4. Fredrik Thue, "Norge som dannelsesprosjekt. Akademisk kultur, borgerlighet og samfunnsforståelse 1830-1890," in Anne Kristine Børresen and Mikael Hård, eds., *Kunnskap og kultur: Vitenskapens roller i det norske samfunn, 1760-2000* (Trondheim, 2004), 73-112; Ellen Rodvang, "Vitenskap og motkultur i 1800-tallets Norge: Universitetet og målsaken 1880-1900," ibid., 113-135; Anne Kristine Børresen, "Johan H.L. Vogt: Naturforsker og industribygger," ibid., 137-174.

5. John Peter Collett, "Vendepunkter i norsk universitetshistorie," in Anton Fredrik Andresen and Guri Hjeltnes, eds., *Universitet, samfunn of politikk* (Oslo, 1997), Skriftserie no. 2, 91-106; Vilhelm Aubert, et al., "Akademikere i norsk samfunnsstruktur 1800-1950," *Tidsskrift for samfunnsforskning, 1* (1960), 185-204.

6. Ingar Kaldal, *Alltagsgeschichte og mikrohistorie* (Trondheim, 1994), Skriftserie nr 2 fra Historisk Institutt, 42. See also Winifred Schulze, ed., *Sozialgeschichte, Mikro-Historie: Eine Diskussion* (Göttingen, 1994).

Gleditsch conducted research with her students in Oslo, but had also to go abroad to be able to do experiments.

1. FROM FERTILE CENTERS...

In October 1907 28-year old Ellen Gleditsch traveled to Paris to study and work at Marie Curie's laboratory. After completing her pharmacist degree in 1902 she had continued to study chemistry at the University of Oslo while working as an assistant at the Chemistry Laboratory. Here she assisted in the teaching of pharmacy and medical students in chemistry under assistant professor Eivind Bødtker (1867-1932), an organic chemist originally trained as a pharmacist. Bødtker gave her independent chemistry work so that she could learn to solve scientific problems; this resulted in a paper published in France under her own name.[7] Gleditsch's work was an elaboration of Bødtker's own research, and undoubtedly he helped her in writing it, as her competence in French at the time was limited. He was the link between Gleditsch and Curie and an important supporter throughout her career. He wrote Gleditsch as she prepared for her trip to Paris, "I am pleased to know that you, after so many years of intense work, mostly for others, will at last get out to study under better conditions than here at home. And I am confident that it will turn out that you have chosen the correct branch of chemistry."[8]

In Oslo Gleditsch was used to assisting large laboratory groups conducting basic experiments. In the academic year 1906/7, when she substituted for Bødtker while he was in Paris, there were 223 students at the Chemistry Laboratory (including medical and pharmacy students), all requiring laboratory instruction.[9] The responsible scientific staff totaled one professor and two assistant professors. In her Paris experience, Gleditsch was part of a group of eleven scientific workers in a research laboratory.[10] Several of these workers were women.

Radioactivity was one of the few new fields of science that offered them opportunities. Between 1900 and 1910 about thirty women throughout Europe were working in radioactivity.[11] Supportive mentors or directors of laboratories,

7. Ellen Gleditsch, "Sur quelques dérivés d'amylbenzene tertiaire," Société chimique de France, *Bulletin,* 1906, 1094-1097. Eivind Bødtker, Application for the professorship of chemistry, 1918, Archives of the Ministry of Church and Education, 1. skolekontor D, 1898-1938, University of Oslo, Eea-0441, Professorembeter 1913-18, RARK; See also Åb (annual reports of the University) 1903/4, p. 7.

8. Bødtker to Gleditsch, 9 Jul 1907, letter collection no. 456, NBM; Ellen Gleditsch, "Kvinnelige akademikere –Utenlandsopphold og stipendier," in *Kvinnelige studenter 1882-1932* (Oslo, 1932), 244-248.

9. Åb, 1906/7, 127.

10. Ellen Gleditsch, "Marie Sklodowska Curie," *Nordisk Tidskrift för vetenskap, konst och industri* (1959), 417-434, on 426-427; Liste du personnel 1904-1934, AMC.

11. Rayner-Canham and Rayner-Canham, eds. (ref. 2), 12. Between 1910 and 1934 between 20 and 30 percent of the researchers in Marie Curie's laboratory were women, and between

research practices, novelty, and relative freedom from male hierarchies have been suggested as explanations.[12]

The Curie laboratory where Ellen Gleditsch worked from 1907 to 1912 was situated at 12, rue Cuvier near the Jardin des Plantes. It housed an office, darkroom, small library, a large space with measuring instruments, rooms for Marie Curie and her assistant, André Debierne (1874-1949), and a small pavillion for fractional crystallizations.[13] In 1900, when Pierre Curie was appointed lecturer at the Faculty of Sciences at the Sorbonne (professor from 1904), he and Marie moved from the small premises on rue Vauquelin where they discovered polonium and radium in 1898, to the first Sorbonne annex in rue Cuvier. Here Marie remained until a new laboratory was inaugurated at 11 Rue Pierre Curie in 1914.[14]

When Curie realized that Gleditsch could take care of the crystallizations of radium and barium salts, Curie asked her to do so and exempted her laboratory fee. Isolating radium from uranium minerals was a laborious and meticulous work; one ton of uranium-rich mineral yielded only 0.2 grams of radium chloride.[15] The crystalization work made Gleditsch Curie's personal assistant during the five years she spent in Paris. It gave her an opportunity to familiarize herself with industrial processes, as Curie cooperated with the radium factory outside Paris. Gleditsch ran the factory for six months during the war.[16]

After Pierre Curie died in 1906, Marie turned her attention to the production and study of radioactive substances.[17] She taught her students how to prepare and handle radioactive sources and their radiations. Later she directed work on disintegration constants and the chemical properties of radioelements.[18] The Curie

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16 and 38 percent of the researchers at the Radium Institute in Vienna. See Maria Rentetzi, "Introduction," in Soňa Štrbáňová, Ida H. Stamhuis, and Kateřina Mojsejová, eds., *Women scholars and institutions: Proceedings of the international conference* (Studies in the History of Sciences and Humanities, Vol. 13B, Prague 2004), 581-589; Maria Rentetzi, "Gender and radioactivity research in interwar Vienna: The case of the Institute for Radium Research," in ibid., 611-638; Brigitte Bischof, "The 'Marie Curie syndrome,' the role of mentors and romanticism or why were there so many women in radioactivity research in Vienna?" in ibid., 639-658; and Astrid Schürmann, "Promoting international women's research on radioactivity: Marie Curie and her laboratory," in ibid., 591-609; or Maria Rentetzi, "Gender, politics, and radioactive research in interwar Vienna," *Isis, 95* (2004), 359-393.

12. Rayner-Canham and Rayner-Canham (ref. 2), 17-24; Rentetzi, "Introduction" (ref. 11), 582; Margaret Rossiter, *Women scientists in America* (Baltimore, 1982), 51-72, 313-316.
13. Gleditsch (ref. 10), 426-427.
14. Owing to the war, the new laboratory did not come into use until 1918.
15. Ellen Gleditsch, "Om radioaktive mineraler og om radiums utvinding," *Teknisk ukeblad*, 22 Sep 1911, 461-464, 515-517.
16. Lykknes, Kragh, and Kvittingen (ref. 2).
17. Soraya Boudia, *Marie Curie et son laboratoire* (Paris, 2001), 105.
18. Schürmann (ref. 11), 593.

laboratory was largely dependent on the radium industry, and vice versa, which naturally influenced the research problems in the laboratory.[19] Gleditsch would perform the sort of meticulous analysis she learned in Paris on radioactive minerals native to Norway after her return home.

During her first five years in Paris Gleditsch participated in two major debates on radioactivity. The first concerned claims put forward by William Ramsay about an alleged transformation of copper into lithium. Eager to bring forth evidence of Rutherford and Frederick Soddy's transformation theory, Ramsay and Alexander Thomas Cameron claimed in 1907 to have detected lithium in copper solutions treated with radium emanation (radon, ^{222}Rn). Marie Curie was skeptical, and Gleditsch set out to disprove the claim. She showed that there was no relationship between the amounts of copper and lithium in minerals containing both copper and radium. Together with Curie she explained that traces of lithium found by Ramsay and Cameron probably originated from the glass container.

A longer dispute concerned the ratio of radium (^{226}Ra) to uranium (^{238}U), the Ra/U ratio, in minerals. By finding the Ra/U ratio, and proving it constant in minerals, the genetic relationship between the two elements in the radioactive decay series would be confirmed. Boltwood had demonstrated the constancy, but Gleditsch's results indicated that the ratio varied from mineral to mineral. She showed that the ionium parent of radium (later recognized as the isotope ^{230}Th) had a half-life so long that radioactive equilibrium, and thus a constant Ra/U ratio, could not be achieved in younger minerals. This would be decisive in age determinations in minerals, which Gleditsch, among others, started in Norway. For her study on the Ra/U ratio Gleditsch analyzed twenty-one different uranium minerals from different parts of the world.

Speaking at the 100th anniversary of the University of Oslo in 1911, Rector Waldemar Christopher Brøgger (1851-1940) announced that an increase of 30 percent in the professorial staff (from 102 to 130) would be necessary to ensure recruitment for the future. A substantial increase did take place, from 80 professors in 1911 to 116 in 1922.[20] Acting on this opportunity, Gleditsch applied for a fellowship (adjunktstipend) and received a five-year grant.[21] These fellowships were intended for people who would become university employees, normally supervisors of laboratory work and other practical exercises.[22] Gleditsch's duty was to teach radioactivity or atomic theory one hour per week each semester for an audience of ten to twenty students. During the first years of her fellowship she was exempted from teaching, in 1911/12 when she completed her degree in Paris, in 1913/14 when in the U.S.[23]

19. Boudia (ref. 17), 121-122.
20. John Peter Collett, *Historien om Universitetet i Oslo* (Oslo, 1999), 115, 117-121.
21. Åb, 1914/5, 195-196; see also Lykknes, Kvittingen, and Børresen (ref. 2).
22. *Det Kongelige Frederiks Universitet 1811-1911*. Vol. I, 220-221, 360.
23. Åb; Forelesn (lecture plan for each semester for the Royal Frederik University of Oslo).

FIG 2 Ellen Gleditsch at the University. *Source*: Courtesy of Nils Petter Gleditsch.

Atomic theory caused her some trouble as she had never studied this subject before.[24] Since Oslo lacked facilities and colleagues in radioactivity, Gleditsch applied for a fellowship from the American-Scandinavian Foundation for study abroad. She obtained it and applied to Theodore Lyman (1874-1954) at Harvard University, who declined her request to work with him. Boltwood was more receptive despite his initial skepticism towards women in the laboratory.[25]

The Sloane Physics Laboratory, where Boltwood and later Gleditsch worked, had been inaugurated the year before Gleditsch arrived in September 1913. It was reckoned to be "the best in the country," with ample space for fifteen professors and a number of graduate and undergraduate students.[26] Boltwood was active in many important debates in radiochemistry in its early period, some of which Gleditsch also participated in. Boltwood suggested that she investigate the determination of

24. Gleditsch to Boltwood, 1 Nov 1914, YUL, Bertram Boltwood Papers.
25. Lykknes, Kragh, and Kvittingen (ref. 2) and Lykknes, Kvittingen, and Børresen (ref. 2).
26. Lyman Spitzer Jr., "The division of the sciences," *YAM*, Nov 1948, quoted in Brooks Mather Kelley, *Yale: A history* (New Haven, 1974), 415.

the half-life of radium, as he and Rutherford had obtained diverging results. By improving Boltwood's separation of ionium from the mineral Gleditsch found a value close to Rutherford's. As he had used a different method, her results resolved the puzzle.[27] She continued this work after she returned to Norway.[28]

During her stay at Yale Gleditsch also visited laboratories of chemistry and physics in the Eastern States and lectured on radioactivity at colleges in Massachusetts and New York; she was especially popular in the women's colleges.[29] At one of them, Smith College, Massachusetts, she received an honorary doctorate in June 1914. The same year she had also visited Professor Theodore Richards at Harvard University in order to learn more about atomic weight determinations, a contact that was to become important for her future interests and projects. Gleditsch returned to Oslo intending to create a milieu for radiochemistry research.

2. SEEDING THE PERIPHERY: GLEDITSCH IN PERMANENT POSITIONS

Shortly after Gleditsch returned to Oslo in the summer of 1914, four professors put her forward for a permanent position as associate professor (dosent) of radiochemistry. She received it two years later. Kristian Birkeland (1867-1917), professor of physics and one of the founders of Norsk Hydro, famous also for his research on the northern lights, was one of her supporters. Birkeland went to Africa to study the Zodiacal light in autumn 1913, where he stayed for about four years. From there he wrote several times to Gleditsch about the use of light rays for medical purposes. According to Birkeland, the beneficial effect of the sun, commonly used by sick people in Egypt, could be strengthened by sheets or clothes impregnated with phosphor. After a day in the sun, the phosphor would give off secondary, healing rays for patients suffering from tuberculosis, cancer, etc.[30] Twice he asked Gleditsch to take out a joint patent at his expense: "Now you had better get something out of this, both of us may then earn some money, and a little honor may also fall upon us, if we indeed achieve anything at all."[31] Whether Gleditsch applied for a patent is not known; none was granted.[32] Birkeland had supported Gleditsch's unsuccessful application for a university fellowship in 1910.

27. Ellen Gleditsch, "The life of radium," *American journal of sciecne, 41* (1916), 112-214..
28. Gleditsch to Boltwood, 14 Mar, 4 June, and 21 Oct 1914, YUL.
29. Åb, 1913/14, 94-95.
30. Birkeland to Gleditsch, 12 Nov 1914, Letter collection no. 456, NBM.
31. Birkeland to Gleditsch, 1 Jan 1915, Letter collection no. 456, NBM.
32. Mona Berge, Norwegian Patent Office, private communication, Feb 2005. Neither is this invention mentioned in the list of Birkeland's patents in Åse Katherine Lauritzen, *Vitenskapsmannen som teknolog: Kristian Birkeland 1901-1908* (master's thesis in history, Universitetet i Oslo, 2000).

This he perceived as unfair and asked the University board for an international expert evaluation.[33]

The three other professors who put Gleditsch forward were Oscar Emil Schiøtz (1846-1925) from physics, Poul Edvard Poulsson (1857-1935) from medicine, and Thorstein Hallager Hiortdahl (1839-1925) from chemistry.

The four proposers emphasized Gleditsch's training, international scientific contributions, excellent ability as a lecturer and supervisor, and the importance of establishing her field at the University. The proposal was urgent, since she had been offered favorable positions abroad.[34] Parliament funded the position in 1916 and, as expected, only Gleditsch applied. Her promotion to professor thirteen years later was not so easy. Her predecessor Heinrich Goldschmidt preferred another candidate, ignored the positive expert opinions, and presented her as outdated. The appointment became a public issue, with continuous newspaper coverage. The outcome, a unanimous vote for Gleditsch, was appointment to full professor of inorganic chemistry in June 1929. Nonetheless Goldschmidt's campaign against her had been damaging and probably diminished her influence in the department.

As associate professor Gleditsch was responsible for radiochemistry and atomic theory. As full professor, she ran the entire Inorganic Chemistry Section as well. For a few years she headed the whole department. In 1933, the Chemistry Laboratory moved from downtown Oslo to a new campus (Blindern). The process was time-consuming and challenging, full of opportunities for someone wanting to create a research group.

Associate professor, 1916-29

During her first eight years as associate professor Gleditsch lectured about two hours per week; during the next five years, four hours. Her topics included physical chemistry, atomic theory, radium and radioactivity, constitution of matter, chemical reactions, and isotopes. The audience usually numbered fewer than ten students, although sometimes it reached thirty. When Bødtker fell sick in spring 1921, Gleditsch had to lecture five hours per week and in subjects like organic chemistry, which she had not taught much before. The heavy teaching load almost choked her: "I have an awful time these days. One of the professors of chemistry has fallen sick and I have had to take over all his work. I have hardly time to breathe."[35]

33. Gleditsch lost in the competition although the Faculty recommended her, because she already held a scholarship for study in Paris. Heinrich Goldschmidt (1857-1937), professor of inorganic chemistry and a tenacious opponent of her professorial appointment in 1929, voted against her also in 1910 (Reports from the Faculty board meetings of 6, 20 and 22 Oct 1910, AMNF. Professor of geology, Amund Helland (1846-1918), wrote that the University board had done Gleditsch an injustice: Amund Helland, "Kollegiet og Ellen Gleditsch," clippings in Gleditsch's scrap book, probably from early Feb 1911.

34. Stortingsproposisjon (Parliament proposition) nos. 1-1916, part V, chapt. 3, 26-27.

35. Gleditsch to Charles Stangeland, 9 Feb 1921, Letter collection no. 347, NBM.

FIG 3 The associate professor. *Source:* Courtesy of Nils Petter Gleditsch.

In 1925 she had to lecture on physical chemistry in addition to radioactivity, as the associate professorship of physical chemistry had not been filled.[36] Only twice while associate professor (in 1918 and 1923) did she conduct laboratory courses in radiochemistry: "As the number [of students] was so small it became possible to arrange a practical course for them; which comprised about 20 hours spread over the winter months. The ordinary measurements and investigations of radioactivity were conducted by the students."[37]

36. Åb, 1926/7, 64-65.
37. Åb, 1922/3, 75.

The quarters for chemistry on the old university campus, built between 1841 and 1852, consisted of 800 square meters. Because of fire hazard and unpleasant odors, a new building, situated a certain distance from the library, was opened for chemistry and metallurgy at Fredriksgate. It comprised 2,400 square meters. At the time of its inauguration in January 1875, there were about 100 students, two professors, and one assistant professor.[38] In 1881 the laboratory was split into two sections, one (Section A) for science students, and the other (B) for pharmacy and medical students. Thirty years later, at the centenary of the University, there were two professors, two assistant professors, and one scientific assistant, the number of students remaining almost the same.[39] Gleditsh was the only associate professor at the Chemistry Laboratory in 1916. Four years later an associate professor of physical chemistry and electrochemistry was added.[40]

The new laboratory was well equipped for the time and offered excellent instruction. According to a contemporary description, it was "perfectly adequate to educate chemists and is in every respect on a par with foreign [laboratories], in particular German."[41] The new building opened with optimistic prospects just at the time that industry became increasingly important as an economic factor in Norway. Success soon brought crowding.

Each of the three professors (two in chemistry and one in metallurgy) had an office and laboratory in his own part of the building, in addition to the teaching laboratories. In the attic there was a room for spectral analysis and photometry, and a second lecture hall (the main one being on the first floor); the caretaker and the metallurgists resided in the cellar, which also contained a few rooms for special chemicals or equipment.[42] The structure of the building was already unsound from the start, since it continued to crack as it settled, and provision for gas, water, and ventilation was inadequate.[43]

In 1912 the metallurgists moved to the newly founded Norwegian Institute of Technology (NTH) in Trondheim and their rooms became laboratories for qualita-

38. Ellen Gleditsch, "Universitets kjemiske laboratorium i Fredriksgate 3," *Aftenposten*, 17 June 1966; Åb, 1875, 51-53.

39. Olav Helge Angell Nordeng, *Universitet – forskning – samfunn: En studie av Kjemisk institutt ved Universitetet i Oslo* (master's thesis in sociology, University of Oslo, 1973), 72; Åb, 1910/1, 125-126; 1911/12, 154-155.

40. Aadne Ore and Ove Arbo Høeg, "Det matematisk-naturvitenskapelige fakultet," in *Universitetet i Oslo 1911-1961* (Oslo, 1961), 475-699, on 542; list of professors at the University 1811-1984; see http://www.hf.uio.no/hi/prosjekter/univhist/FaktaUiO/databaser/dokumentasjon.html.

41. "Det kemiske laboratorium i Kristiania," *Skillingsmagazinet*, Dec 1876, in Gleditsch (ref. 38).

42. Åb, 1917/18, 141-144. The authors are grateful to Frode Riise and Bjørn Pedersen for information on people and localities.

43. Bødtker to the University board, 15 Apr 15, 1919?, Archives of the University of Oslo, Department of Chemistry, Sakarkiv ordnet etter emne (1900-1947), Ea-0035, 01 Arbeidshjelp, gasjer ved det kjemiske laboratorium, RARK.

tive analysis, organic synthesis, and physical chemistry as well as a lecture hall.[44] Still, only a few students had lab space, and the professors did not have enough. The professors complained to the Faculty and University boards, and then to the cognizant ministry. Professor Heinrich Goldschmidt and his son, the professor of crystallography, mineralogy, and petrography Victor Moritz Goldschmidt (1888-1947), wrote the minister that the laboratory in many ways was almost useless for teaching and research. V.M. Goldschmidt knew what he was talking about; a long-time association with industry had made him realize how far behind the Chemistry Laboratory had fallen. The building did not have room for the elementary courses, and "the most important national task of a university laboratory, namely to educate chemists, can be pursued only rarely."[45] They urged the building of a new laboratory as soon as possible. They ran into resistance from the newly-established NTH in Trondheim, which also claimed the right to educate (industrial) chemists.[46]

As associate professor Gleditsch was not entitled to a research laboratory of her own, but four years after her appointment she acquired a small, dark, and humid room in the cellar. It did not compare well with the research facilities in Paris, where she had had at her disposal a pavilion for the fractional crystallizations and other rooms for measuring instruments and a general laboratory.[47] And there was no possibility to accept students, a fact the chemists took every opportunity to bring before the University board. In 1919 Bødtker wrote as follows: [48]

> As the honorable University board is aware, the space in the Chemistry Laboratory became quite insufficient long ago. Radiochemistry, physical chemistry, and electrochemistry suffer especially. The associate professor of radiochemistry has apparently obtained enough room for her own research, however, she cannot accept students in her laboratory.

The new associate professor of physical chemistry and electrochemistry, who was to be employed in 1920, would have "absolutely no laboratory space."

44. Ore and Høeg (ref. 40), 541-542; Bjørn Pedersen, *Kjemikere i Norge og norske kjemikere (sett fra UiO)* (Department of Chemistry, University of Oslo, 2002), unpub. booklet written for the 150th anniversary of chemistry in Norway.
45. H. Goldschmidt and V.M. Goldschmidt to the Minister, 12 Apr 1918, Letter collection Ms. fol. 3861:8 (Papers of Vilhelm Bjerknes, New buildings of the University, 1916-18), NBM.
46. *Dagbladet,* 21, 22 and 24 Mar 1922; *Adresseavisa*, 23, 24 and 25 Mar 1922; *Under Dusken*, 25 Mar 1922. Archives of the University of Oslo, Files of the University board, Sakarkiv ordnet etter emne: E-0086 Diverse, Planer for et nytt kjemisk Institutt 1918-24, RARK.
47. Åb, 1920/1, 125; Gleditsch (ref. 10), 427.
48. Bødtker to the University board, 4 Sep 1919, Archives of the University of Oslo, Department of Chemistry (Universitetet i Oslo, Kjemisk Institutt), 1839-1971, Sakarkiv ordnet etter emne (1900-1947), Ea-0036, 08 Kjemisk Institutt—første plan (1926), RARK.

World War I brought scarcity, inflation, and housing shortages to Norway. At the same time, the number of students increased, the funding of instruments and equipment decreased, and, on the few occasions when money appeared, instruments were difficult, if not impossible, to obtain.[49] Plans for new facilities for physics and chemistry were "put on ice."[50] Employees struggled daily to obtain basic chemicals. "It was impossible to get things done."[51]

The annual budget of the Chemistry Department covered small equipment, glassware, lecture slides, electroscopes, and radioactive minerals, but did not suffice.[52] External funding therefore was extremely important. The Fridtjof Nansen Foundation for the promotion of science, founded on private donations in 1897, promoted science by supporting research and publication.[53] Other, smaller funds were disseminated through the University. From such sources Gleditsch received between 250 and 2,400 Norwegian crowns each year (around 700 crowns on average) for instruments, radioactive specimens, assistants, and travel.[54]

In 1918 the University board appointed a planning committee for a new Chemistry Laboratory consisting of professors Goldschmidt and Bødtker, associate professors Gleditsch and Erling Schreiner, and professor Poulsson advising on the teaching of medical students.[55] To Gleditsch, Curie's laboratory in Paris and Boltwood's at Yale were important models. But also Rutherford's laboratory in Cambridge and Frederick Soddy's (1877-1956) in Oxford were of equal interest to her. She therefore traveled to England to see how these well-run centers were built and organized.[56]

In April 1919 the committee decided to organize the Chemistry Department according to student affiliations. Sections were planned for students of science, pharmacy, medicine, veterinary medicine, and research.[57] In the instructions for the architectural competition, which opened in 1925, Gleditsch requested ten rooms for

49. Collett (ref. 20), 126.

50. Robert Marc Friedman, "Civilization and national honor: The rise of Norwegian geophysical and cosmic science," in John Peter Collett, ed., *Making sense of space: The history of Norwegian space activities* (Oslo, 1995), 3-39, on 28.

51. Statement by Gleditsch's colleague, Odd Hassel, quoted in Nordeng (ref. 39), 74.

52. Archives of the University of Oslo, Department of Chemistry, 1893-1971, Da-0001: Anvisningsprotokoller 1881-1899, RARK.

53. Its first donation counted 50,000 N. Kr., and with more collections and a loan the fund reached one million N. Kr. by 1904; see http://www.nansenfondet.no/historie.

54. Åb. A professor's salary was around 10,000 crowns (*Universitetet i Oslo 1911-1961*. Vol. 2, 236-238).

55. Archives of the University of Oslo, Department of Chemistry, 1893-1971, Ea-0036: Sakarkiv uten nøkkel, 1900-1947, 08—Kjemisk Institutt—første plan, 1926, RARK; Åb, 1918/9, 34.

56. Åb, 1919/20, 77-78; Gleditsch to Curie, 29 Jul 1919, Marie Curie Archives, letter no. 841, AMC; Rutherford to Gleditsch, 23 Sep 1919, 9 and 14 June 1920, letter collection no. 456, NBM; Soddy to Gleditsch, 6 May 1920, letter collection no. 456, NBM.

57. Report, 6 Apr 1919, Archives (ref. 55).

radiochemistry, including laboratories, darkroom, an optical room, a weighing room and an office for the associate professor.[58] The professor of physics and member of the physics building committee, Sem Sæland (1874-1940), strove to convince the authorities that the new buildings were absolutely necessary.[59] In 1928, Sæland was appointed rector and two years later leader of the building committee. At this time he opposed Gleditsch's promotion to professor. She ended up with less than half the space she had anticipated.[60]

Full professor, 1929-1946

A year after being appointed professor Gleditsch became a member of the building committee for the new physics and chemistry departments at Blindern.[61] On April 28, 1930 the Parliament agreed to the building, in May the committee was formed; ground was broken in October. Four years later the chemists moved in, followed half a year later by the physicists. Altogether they had 3,680 square-meters at their disposal, fifty percent more than at Fredriksgate.[62] Gleditsch had the honor of inaugurating the lecture hall of the new Department: "This was not by chance. She has struggled perhaps more than anyone else to start building as soon as possible and, furthermore, she is the only woman on the building committee. The Professor is also one of the more excellent lecturers at the Faculty of Science.[63]

By this time the original Chemistry Laboratory had become the Department of Chemistry with the sections for inorganic chemistry, organic chemistry, and physical chemistry, with one professor each. Work on the planning and building committees, occupied hours and days of Gleditsch's schedule for sixteen years. The support she enjoyed at the beginning eroded in the controversy around her professorial appointment and brought her enemies, including Sæland, and her enlarged teaching duties as professor of inorganic chemistry also sapped her strength.

Only twice or thrice in seventeen years did Gleditsch teach radioactivity (as associate professor she did this almost every year), and a few times the history of chemistry. When her associate professorship became vacant, no radiochemist replaced her; instead Georg Dedichen (1870-1942), who had studied organic chemistry under Theodor Curtius (1857-1928) in Kiel, was appointed and to

58. Plans for the architect competition, Archives (ibid.)

59. Sæland to the Minister, undated (1924?), draft, Archives of the University of Oslo, the University board, Sakarkiv ordnet etter emne, E-0086 Diverse, Planer for et nytt kjemisk institutt 1918-1924, RARK.

60. Archives of the University of Oslo, Department of Chemistry, 1839-1971, Ea-0035 Sakarkiv uten nøkkel 1900-1947, 06-Byggekomité fysikk og kjemi, 1934-35, RARK.

61. Åb, 1929/30, 139.

62. Archives (ref. 60). Sakarkiv uten nøkkel 1900-1947, 06-Byggekomité fysikk og kjemi, 1934-35, RARK.

63. G.S., "Et besøk hos professor Gleditsch på universitetet på Blindern," [interview with Gleditsch] *Urd* 1934, 201-203. *Aftenposten*, 17 Sep 1934.

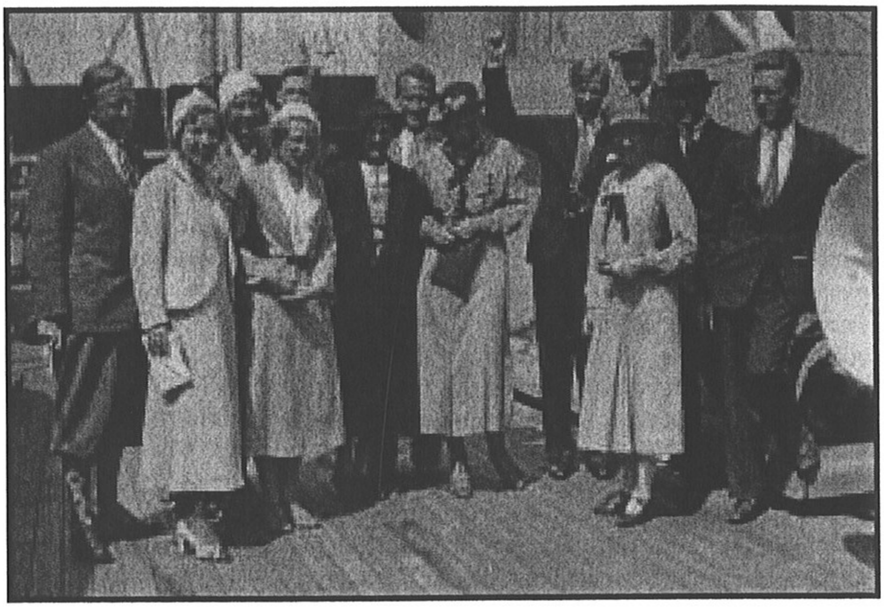

FIG 4 As professor of inorganic chemistry Gleditsch participated in student excursions. This picture is from an excursion to Bergen and Odda in 1933; Gleditsch (to the right) with among others Einar Jensen, Bergliot Qviller Werenskiold, Milda Prytz and Christen Schreuder. *Source:* Courtesy of the Public Record Office, University of Oslo, Department of Chemistry, Sakarkiv ordnet etter emne 1900-1947, Eb-0073: Studenter.

teach chemistry for medical students. In a plan for 1930 radiochemistry had two rooms on the second floor and two in the cellar—much less than Gleditsch had requested.[64] Nevertheless, she supervised candidates in both radiochemistry and inorganic chemistry.

As head of inorganic chemistry she soon reported to the rector the lack of staff, only two assistant professors and one assistant (in addition to her personal scientific assistant) was insufficient, since the section would be responsible for both the qualitative and quantitative analysis courses for scientists and pharmacists. Two assistant professors and four assistants were needed. "Possibly the work can be done with three assistants, but I doubt it; it will naturally depend on the number of students."[65] This was what the section received. Her request for another three as-

64. Archives (ref. 60). Sakarkiv uten nøkkel 1900-1947, 06-Byggekomité fysikk og kjemi, 1934/5, RARK.
65. Gleditsch to Rector, 12 Dec 1930, Archives of the University of Oslo, Department of Chemistry, Ea-0035 Sakarkiv uten nøkkel, Ad arbeidshjelp, gasjer ved kjemisk laboratorium, RARK.

sistants for teaching qualitative analysis for medical students and practical exercises in physical chemistry brought nothing.

The number of students in pharmacy and medicine increased during the 1930s and Gleditsch wrote regularly to the University board about lack of space. The chemistry department was repeatedly asked to take up more pharmacy students (from thirty to fourty). Extra practical courses had to be conducted in borrowed laboratories. To service the many medical students, the practical courses were concentrated within six weeks per semester, which Gleditsch judged to be too short even for clever students. The lecture space was also was inadequate: 350 medical, pharmacy, and science students packed into a lecture hall for 240. The problem was solved by sitting in stairways, standing, or skipping class. In addition to trying to obtain adequate rooms and staff for her own section in the new building, Gleditsch promoted space for school experiments, where future teachers of chemistry could compose simple experiments and explain them to their pupils.[66] Another idea she "put a lot into" was a resting and eating room for the cleaners, a concern hardly common for a professor at the time, although in line with her social values. As a lecturer, she was charming, able to explain difficult matters in a simple way, obviously enjoying it.[67] She could be hard when her students or assistants did sloppy work, however.[68]

Gleditsch treasured her stays abroad, which gave her "noble goods" as well as an understanding of science, culture, and new acquaintances from all over the world.[69] In one year in Curie's laboratory Gleditsch worked with scientists from seventeen different countries.[70] As there were many women present, a network developed; Gleditsch had a central role linking together the women in all the laboratories of radioactivity.[71] She kept in touch with Marie Curie and her daughter Irène Joliot-Curie in Paris, Lise Meitner in Berlin, May-Sybil Leslie (1887-1937) in Manchester, Eva Ramstedt (1879-1974) in Stockholm, Elizabeth Róna (1890-1981) and Marietta Blau (1894-1970) in Vienna, and many more. Some came to Oslo in times of war. Her contacts were helpful when planning a new laboratory; for purchasing instruments and radioactive material; and for collaborating in research that could not be done at home.

66. Gleditsch to the University board, 4 June 1938; letters in the Archives of the University of Oslo, Department of Chemistry, Eb-0093: 8 Bygninger, RARK; G.S. (ref. 63).
67. Alexis C. Pappas, "100 år siden professor Ellen Gleditsch ble født," *Kjemi, 40* (1980), 53-56, on 54.
68. "Personalities and powers: Ellen Gleditsch," *Time and tide*, 22 Jul 1927; Ivan Rosenqvist, radio obituary on Gleditsch, 8 Dec 1968, NRK (Norwegian Broadcasting Corporation) Radio Archive, no. 51577; "Dr. Ellen og Dr. Milda: En interessant doktordisputas i dag," *Oslo Aftenavis*, 7 Oct 1925.
69. Gleditsch (ref. 8), 246.
70. Gleditsch (ref. 10).
71. Rayner-Canham and Rayner-Canham (ref. 2), 12-28.

The medical community in Norway also benefitted from Gleditsch's network, as she arranged the first import of radium certified by Curie to the University hospital (Rikshospitalet) in 1912.[72] The demand for radium exceeded production and to distinguish between high and low grade radium was difficult, but through Curie she obtained good quality at a reduced price. Later radium treatment continued at the Comprehensive Cancer Center (Radiumhospitalet), inaugurated in 1932, with which the Nuclear Chemistry Section, headed by Gleditsch's student Alexis Pappas (b. 1915) until 1985, cooperated and still cooperates on common research projects. Also the initiative for the first professorship in nuclear chemistry came from the director of the Comprehensive Cancer Center, Reidar Eker (1903-1996), who also headed the Norwegian Cancer Society.[73]

In 1935 and again in 1937 Gleditsch spent a month or more at the Institute for Radium Research in Vienna to get acquainted with their techniques and research. She wrote to her colleague Berta Karlik many years later that although her first "love" was the Paris Institute, the Vienna Institute had her admiration.[74] Vienna Institute opened in October 1910 as the first specialized institute of radioactivity in Europe. Franz Exner was its official director, and Stefan Meyer its managing director, who purchased instruments, equipment and furniture, and set the research agenda.[75] Meyer, who succeeded Exner in 1920, was known for his openness towards women—during his time more than one third of the Institute's researchers were women.[76] Until Curie died (in 1934) Gleditsch went to Paris whenever she had leave.[77] In the 1930s, however, Vienna became her new destination. One of her assistants, Ernst Føyn (1904-1984), had worked in Vienna and regularly met with Elizabeth Róna and Hans Pettersson (1888-1966), who had both worked in Vienna, at Pettersson's oceanographic research station in Bornö in the south of Sweden.[78] Berta Karlik (1904-1990) and Ellen Gleditsch also came to Bornö "for lively discussions of our results."[79]

72. Tor Brustad, "Radiologiens inntog i Norge," *Forskningspolitikk*, no. 1 (2000), 6-10.
73. Jorolf Alstad, private communication, 9 Feb 2005; Website of the Comprehensive Cancer Center, http://www.radiumhospitalet.no/Norsk/Om_oss/Historikk.
74. Gleditsch to Karlik, 31 Jan 1950, "Letters written to Berta Karlik after the death of Stefan Meyer," Archives of the Austrian Academy of Sciences, Institute for Radium Research, AAW, box 32.
75. Rentetzi, "Gender and radioactivity research" (ref. 11); Maria Rentetzi, "Women in physics: Women physicists in the Institute for Radium Research in Vienna, 1920-1938: A statistical report," *Soziale technik, 2* (2001), 9-12. See also Maria Rentetzi, *Gender, politics and radioactivity research in Vienna, 1910-1938* (Ph.D. dissertation, Virginia Tech, 2003, publication forthcoming); Bischof (ref. 11); Wolfang Reiter, "In appreciation. Stefan Meyer: Pioneer of radioactivity," *Physics in perspective, 3* (2001), 106-127.
76. Gleditsch to Meyer, 27 Apr 1919, AAW, box 12.
77. Gleditsch to Curie, 20 Jul 1919, Marie Curie Archives, letter no. 841, AMC.
78. E.g., Elizabeth Róna had stayed for one month in Paris in 1926, Marietta Blau for the academic year 1933/4, and might have made Gleditsch's acquaintance through her colleagues in Paris, see Liste du personnel 1904-1934; Marelene F. Rayner-Canham

Gleditsch corresponded with Karlik extensively, and she was very grateful to her for arranging her stay in Vienna: "You are so kind, that my heart swells with gratitude and pleasure and pride. And I do look forward to this stay more than to anything which has happened for years."[80] To Gleditsch the Vienna trip had purposes beyond hard science; it was like a romantic dream; she wanted to "live as an Austrian, speak like an Austrian (as well as possible), work like an Austrian and play like an Austrian. If you will help me...[in] this, I shall be very thankful." Friedrich Paneth (1887-1958) and Marietta Blau were other important contacts for Gleditsch. During World War II, both Róna and Blau, who were Jews, worked in her department in 1938/9.[81] Gleditsch helped Blau bring her mother out of Austria.[82] This help went both ways; Róna became especially important for one of Gleditsch's students, to whom she provided a source of radioactive isotopes.[83]

We have found no sources indicating that Blau received money from the University during her stay in Norway. Róna had a small amount each month, and another refugee who found shelter at Gleditsch's laboratory, the Hungarian Tibor Gráf (1908-1999) was paid occasionally. [84] Both Norway and Sweden experienced

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and Geoffrey W. Rayner-Canham, "Elizabeth Róna: The Polonium woman," in Rayner-Canham and Rayner-Canham, eds. (ref. 2), 209-216; Leopold E. Halpern, "Marietta Blau: Discoverer of the cosmic ray 'stars'," in ibid., 196-204; Elizabeth Róna, *How it came about: Radioactivity, nuclear physics, atomic energy* (Oak Ridge, 1978).

79. Róna (ibid.), 64.

80. Gleditsch to Karlik, 4 May 1937, AAW, box 41.

81. Gleditsch knew Blau had problems with Dr. Wambacher, a nazist at the Institute, and asked her to come to Oslo. Róna was invited to replace a staff member who was on leave, see Gleditsch to Paneth, 15 Nov 1938, Archiv zur Geschichte der Max-Planck-Gesellschaft, Berlin-Dahlem, III. Abt., Rep. 45 (Nachlaß Friedrich Adolf Paneth), no. 39; Róna (ref. 78), 42-43. See also Ruth Lewin Sime, "Twice removed: The emigration of Lise Meitner and Marietta Blau," in Friedrich Stadler, ed., *Österreichs Umgang mit dem Nationalsozialismus: Die Folgen für die naturwissenschaftliche und humanistiche Lehre* (Vienna, 2004), 153-170.

82. Halpern (ref. 78), 199. See also Peter Galison, "Marietta Blau: Between Nazis and nuclei," in Galison, *Image and logic: A material culture of microphysics* (Chicago, 1997), 146-160, and Robert Rosner and Brigitte Strohmaier, *Marietta Blau—Sterne der Zertrümmerung, Biographie einer Wegbereiterin der modernen Teilchenphysik* (Vienna, 2003).

83. This student was Ivan Rosenqvist (1916-1994); video interview by Elen Roaldset, Department of Geology, University of Oslo, 8 Sep 1988, Forum for University History.

84. Róna might have taught at the Department of Chemistry, as the Rayner-Canhams say (Rayner-Canham and Rayner-Canham (ref. 78)). However there is neither anything in the annual reports of the University, nor in the lecture catalogues indicating that Róna gave lectures. The only official record is that she worked in the lab. The appropriation protocols from the Chemistry Department, which inform even on quite small payments during Gleditsch's career, contain no records of Blau, nor of Róna, also the archives of the University board lack information on them. The only information on Róna's payment is

an increasing influx of scientific refugees after 1933 and both countries responded with restrictions. In Sweden students protested against the employment of ten Jewish medical doctors. Although the Norwegian Student Society never openly expressed anti-Semitic attitudes, in the Parliament there were many who argued against a liberal admission of refugees.[85] Foreign students and professors applied to the University, but apparently few were allowed to immigrate. The University and Faculty boards did not welcome competition from foreigners for the few and much-coveted positions on offer, and in some cases positions remained unfilled because no qualified Norwegian had applied. Refugees that did make it to the university had to make do with payment for occasional lectures or access without pay to university facilities. This might have been the case for Blau. A few organizations tried to make the university employ refugees, e.g., Nansen aid (Nansenhjelpen) and the Organization for Refugee Intellectuals (Foreningen for landflyktige åndsarbeidere). She was lucky enough to interest Einstein, who recommended her for a position in Mexico.[86] Blau later moved to the United States, but she returned to Vienna after her retirement, where she died in 1970. Róna first fled to Hungary, her native country, then to the United States, where she stayed until she died in 1981.[87]

Students and colleagues

During Gleditsch's time as professor (1929-46) her department granted 40 master's degrees and six doctorates of philosophy. Gleditsch supervised six master's and one doctoral candidate in radiochemistry (table 1), and ten candidates in other topics of inorganic chemistry. Almost all radiochemistry students continued to work at the department as personal assistants to Gleditsch (Bergliot Qviller Werenskiold, Alexis Pappas), teaching assistants (Qviller Werenskiold, Pappas, Sverre Klemetsen, Aamund Salveson, Paul Thrane Cappelen, Ernst Føyn), assistant professor (Cappelen), and full professor (Pappas).

At the turn of the century only a few laboratories (including the metallurgical and meteorological) reported publications in their annual reports. In chemistry university fellow Claus Nissen Riiber (1867-1936), assistant professor Bødtker, and, after 1909/10 two full professors, Goldschmidt and Hiortdahl, reported their

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given in a letter from Gleditsch to Wilhelm Palmær, undated, but probably from August 1939, collection in the Royal Swedish Academy of Sciences, Center for History of Science, Stockholm; Archives of the University of Oslo, Department of Chemistry, Da-0002: Anvisningsprotokoller og inventarprotokoler 1901-1942, RARK.

85. We are grateful to Jorunn Sem Fure for lending us her drafts on the University of Oslo during the war. Our information about Norway and scientific refugees is aquired from her on-going research. See also Sverker Oredsson, *Lunds universitet under andra världskriget: Motsättningar, debatter och hjälpinsatser* (Årsbok, 1996).

86. Rosner and Strohmaier (ref. 82), 40-41.

87. Halpern (ref. 78); Rayner-Canham and Rayner-Canham (ref. 78).

Table 1: Master and doctoral theses on radioactivity before 1946

Name of candidate	Time of examination	Title of thesis
Master's theses:		
Bergliot Qviller Werenskiold	Spring 1930	An examination of a group of Norwegian thorium minerals
Sverre Klemetsen	Spring 1932	On the determination of the ratio Ac/U in cleveite, as well as the mineral's total activity compared to uranium
Ivan Rosenqvist	1940	Title not available; the work dealt with the determination of lead in rocks
Alexis C. Pappas	Autumn 1940	On the potensiometric determination of uranium, alone and together with iron, potassium permanganate or cerisulfate. With application to minerals
Aamund Salveson	Spring 1943	An investigation of the distribution of RaD ions between solid phase and fluid phase for the system $Pb(NO_3)_2$ - $Pb(NO_3)_2$ saturated solution
Paul Thrane Cappelen	Spring 1943	Determination of exchange of lead ions using Radium D as indicator
Doctoral thesis		
Ernst Føyn	Autumn 1938	On some relations in uranium minerals. The number of alpha particles emitted from radium and the ratio actinouranium:uranium

Sources: Protocols of Master theses in chemistry, AMNF; Norges Realister [1907-1962 (year of matriculation)] (Oslo, 1963); list of doctoral candidates in *Universitetet i Oslo 1911-1961.*

Career after thesis

Assistant at the Chemistry Department 1931/8,
Research leader at the State teacher's school of domestic science, Stabekk (near Oslo) from 1936

Assistant at the Chemistry Department 1931/4,
Teacher from 1934

Assistant at the University of Oslo 1940/1, Chemist at the Norwegian Road Laboratory 1941/6,
Imprisoned at Sachsenhausen 1942/5, Doctoral degree in geology 1945, Geochemist/ Sectional leader at the Norwegian Defence's Research Institute 1946/50, Assistant professor, University of Bergen 1950/2,
Research Leader, Norway's Geotechnical Institute 1952/65,
Adjunct professor in sedimentology and geotechnics, University of Oslo 1956/65
Full professor of mineralogy and geoploy from 1965

Teaching assistant / Scientific assistant to Gleditsch at the Chemistry Department 1938, 1940, 1941/7,
Work as industrial chemist in Unifor corporation and N. A. Gasaccumulator, Oslo, 1941-46,
Fellowship from the Norwegian Research Council of Science and Technology (NTNF), 1947/52, including
Studies at the Radium Institute in Paris 1948-49,
Studies at the Laboratory for Nuclear Science, M.I.T., 1949/50,
Lecturer in nuclear chemistry at the University of Oslo 1952/7,
Doctoral degree, University of Oslo 1953,
Constituted professor of Radio-Istotope Chemistry at the University of Oslo, 1957/62
Full professor of Nuclear Chemistry at the University of Oslo from 1962

Reserve Police / Department of sabotage 1944,
Secretary of the Methanol commission in Mo 1946/7,
Lecturer in chemistry at Oslo Technical School 1948,
Studies in biology and biochemistry at Oslo 1948/52,
Pasteur fellowship and trip to Paris 1952,
Professor of chemistry at Wisconsin State College, U.S.A.

Scientific assistant at the Chemistry Department until 1944,
Assistant professor 1944/54, including trips to Sweden and Denmark,
Leader of the Market Council 1954/7,
Consultant for several enterprises and public institutions from 1957,
Lecturer in chemistry at the Military Academy 1950/68,
Teaching of chemistry at the Oslo School of Engineering 1963/81, leader of the chemistry section from 1965

Studies at the Institute for Radium Research in Vienna 1934-35,
Assistant at the Chemistry Department until 1941,
Assistant professor at the Department of Marine Biology 1942/8,
Associate professor 1948,
Full professor of chemical oceanography from 1964

Vol. 2; Åb; the students' own directories in *Studentene fra* 1913-1938 [year of matriculation] (for the 25- and 50-years anniversary of their high school graduation); list of personnel at the University of Oslo, 1811-1984 (ref. 40); Forelesninger and oral histor conversations.

Table 2: Gleditsch's Coauthors

Name of co-author	Position and Affiliation at the time of publication with Gleditsch	Period of publication with Gleditsch (type and number of publications)
Marie Curie	Professor, Curie Laboratory, Sorbonne, Paris	1908 (2 articles)
Thorstein Hallager Hiortdahl	Professor, Chemistry Laboratory, University of Oslo (retired in 1918)	1917/28 (2 textbooks)
Eva Ramstedt	Associate professor of radiology, University of Stockholm (Stockholm's Högskola)	1917 (1 textbook)
Bjarne Samdahl	Assistant, Chemistry Laboratory, University of Oslo	1922 (1 article)
Margot Dorenfeldt Holtan	Assistant professor, Chemistry Laboratory, University of Oslo until 1924 (married in 1923)	1925 (1 article)
Ole Wilhelm Berg	Assistant, Chemistry Laboratory, University of Oslo until he died in 1923	1925 (1 article)
Erling Christian Botolfsen	Occupied with teaching and research at the Chemistry Laboratory, University of Oslo	1925 (1 article)
Catherine Chamié	In charge of Measurement Service, Curie Laboratory/Radium Institute, Paris (and an external at a Russian school)	1926 (1 article)
Liv Gleditsch	Teacher at the State teacher's school of domestic science	1927/28 (3 articles)
Ernst Føyn	Assistant, Chemistry Laboratory, University of Oslo until 1941	1932/42 (7 articles)
Bergliot Qviller Werenskiold	Assistant, Chemistry Laboratory, University of Oslo	1932 (1 article)
Sverre Klemetsen	Assistant, Chemistry Laboratory, University of Oslo	1932 (1 article)
Ruth Bakken	Librarian and assistant of Gleditsch, Department of Chemistry, University of Oslo	1935/48 (6 articles)

Name of co-author	Position and Affiliation at the time of publication with Gleditsch	Period of publication with Gleditsch (type and number of publications)
Thorvald Frederick Egidius	Probably co-worker of Gleditsch in the 1930s	1936 (4 articles and conference presentations)
Sonja Hanneborg (b. Dedichen)	Assistant of Gleditsch	1938 (2 articles)
Elizabeth Róna	Refugee from the Institute for Radium Research at Vienna, working at the Department of Chemistry in 1939	1939/41 (3 articles and conference presentations)
Einar Jensen	Assistant at the Department of Chemistry, University of Oslo until 1946, then assistant professor until 1947	1940/47 (2 textbooks)
Tibor Gráf	Refugee from Hungary and co-worker of Gleditsch at the Department of Chemistry, University of Oslo, from January 1940	1941/47 (4 articles)
Ivan Rosenqvist	Assistant at the University of Oslo	1941 (1 article)
Alexis Pappas	Worked at the Radium Institute in Paris (Gleditsch's student until 1940, assistant from 1942)	1948 (1 article)
Paul Thrane Cappelen	Assistant professor, Department of Chemistry, University of Oslo	1949 (1 article)
Aamund Salveson	Student at the bacteriological institute, Faculty of medicine, Rikshospitalet / Pasteur fellowship including travel to Paris (Gleditsch's student until 1943, assistant until 1945)	1952 (1 article)

Sources: List of Gleditsch's publications, collection Ms. 4° 2437: Ellen Gleditsch articles and speeches, NBM; List of personnel (ref. 40); Åb; Bjarne Bassøe, ed., *Ingeniørmatrikkelen: Norske Sivilingeniører 1901-55 med tillegg* (Oslo, 1961); *Vi fra NTH: De første ti kull, 1910-19* [directories of students graduated from NTH] (Stavanger, 1934), 19, 229, 240; *Norges Realister*; Liste du personnel 1906-1934; A.B., "Eva Ramstedt," in Nils Bohman, ed., *Svenska män och kvinnor, Biografisk uppslagsbok*. Vol. 6. (Stockholm, 1942-55), 210-211; Marelene F. Rayner-Canham and Geoffrey W. Rayner-Canham, "Catherine Chamié: Devoted research of the Institute de Radium," in Rayner-Canham and Rayner-Canham, eds. (ref. 2), 82-86; *Studentene fra* [1913-1938 (year of matriculation)]; *University of Oslo 1911-1961*; Archives from the Chemistry Department, RARK, oral history conversations.

work. Associate Professor Lars Vegard (1880-1963) was the first from physics to list his publications, in 1912/13. Most of the publications had a single author. However, from around 1920 co-authoring articles with advanced students had become common. Gleditsch began this practice in 1922 (table 2).[88]

Apart from Rosenqvist and Føyn, who became professors in other (related) fields, and Pappas, Gleditsch's *students* worked as general chemists rather than within radioactivity; Salveson and Klemetsen continued within teaching, Cappelen as consultant and later lecturer at Oslo School of Engineering, and Qviller Werenskjold became head of the newly founded research section at the State teacher's school of domestic science at Stabekk (today the National Institute for Consumer Research).[89] This school provided jobs for more of Gleditsch's students or assistants, e.g., her former undergraduate student, Ellen Rosenqvist, worked at Stabekk during the war.[90] Gleditsch's sister Liv (figure 5), the first woman to complete a master's degree in (organic) chemistry in Norway (in 1923), worked as a part-time teacher at the teacher's school at Stabekk. For most of her life she worked as a teacher, but she assisted Gleditsch in 1919/20, and is included among Gleditsch's coauthors (table 2). Liv Gleditsch excelled in mathematics.[91]

Apart from Curie and Catherine Chamié in Paris, most of Gleditsch's co-authors worked at the Department of Chemistry as assistants or professors, a few were radiochemists, but the majority were chemists of other specialties. Among them were Bjarne Samdahl (1896-1969), later professor of pharmaceutical chemistry, and Rosenqvist, who shifted to mineralogy and geology; both became close colleagues and lifetime friends.[92] Ruth Bakken, the department's librarian, was Gleditsch's assistant before she completed her undergraduate degree in chemistry, and also worked with Gleditsch's Polish colleague at the University of Lwow, Alicja Dorabialska (1897-1975), with whom Gleditsch became acquainted in Paris during 1925/6.[93]

Alexis Pappas became the first professor of nuclear chemistry in Norway when the Norwegian Cancer Society in 1956 offered a five-year professorship within this field. From his student time he "dreamed of traveling through this wonderful scenery and exploring the radioactive nuclei. To see their multiple facets both

88. Her joint work with Curie was conducted when she was assistant in Paris. The publications with Hiortdahl and Ramstedt were textbooks, thus her co-authoring period in radiochemistry at Oslo can be counted from 1922.
89. *Studentene fra 1922* (Oslo, 1947); *Studentene fra 1935* (Oslo, 1960); Conversations with Paul Thrane Cappelen Jan 2003 and Oct 2004. For information on the State School of Domestic Science, see Jo Tenfjord, *I arbeid for Norges hjem: Statens lærerskole i husstell, Stabekk, 1909-1959* (Oslo, 1959) and Inger Johanne Nossum, *Stabekk i våre hjerter—En 90-års kavalkade* (Oslo, 1999).
90. Ellen Rosenqvist, private communication, 21 Oct 2004.
91. Conversations with Chris Koch, May 2004; *Studentene fra 1913* (Oslo, 1938), 91.
92. Ivan Rosenqvist, video interview; conversation with Chris Koch, May 2004.
93. Stephanie Weinsberg-Tekel, "Alicja Dorabialska: Polish Chemist," in Rayner-Canham and Rayner-Canham (ref. 2), 92-96, on 95.

FIG 5 Liv Gleditsch (1895-1976) in the laboratory. *Source:* Courtesy of Nils Petter Gleditsch.

from the inside and from the outside, but also to utilize their properties,"[94] which became a possibility after a period as Gleditsch's assistant at the University. He then studied radiochemistry under Irène Joliot-Curie and Moise Haïssinsky (1898-1976) at the Radium Institute in Paris in 1948/9, and at the Massachusetts Institute of Technology's Laboratory for Nuclear Science under Charles Coryell (1912-1971) and Victor F. Weisskopf (1908-2002) in 1949/50.

When Pappas returned to Norway in 1950 he started to teach nuclear chemistry and supervise master's students. Over the next decade the group increased in size and its quarters, still temporary and borrowed, became ever more crowded. In 1958 the section moved to the building housing the Central Institute for Industrial Research (SI). The following year the group took the name Section for Nuclear

94. Pappas (ref. 1), 167.

Chemistry at the Department of Chemistry.[95] Before Pappas retired in 1985 more than 100 students had taken their degrees under his supervision.[96] There is still a nuclear chemistry group at Oslo, with two full professors, an associate professor, a professor II, a chief engineer, and a few doctoral students.[97] What Gleditsch struggled over decades to establish was achieved under her student about a decade after her retirement.

Like many of her students, Pappas thought of Gleditsch as his scientific mother.[98] He described Gleditsch as always available for students, always lively, with a generous interest in young people and their problems. "If you have a problem—go to Ellen" Gleditsch invited students to her home,[99] and helped and supported them in "every way."[100] One way appears from her letter of recommendation of Pappas to Irène Joliot-Curie: "[A] young, very pleasant man with a rare intelligence, certainly one of the best students I've had."[101]

International careers

Gleditsch helped to send other students to Paris also: Randi Holwech, a chemical engineer from the NTH in Trondheim, and Sonja Dedichen, an undergraduate student, both women. She made foreign contacts for several young male inorganic chemistry students, including Hans Christensen, Eskild Lous, Kjell Nielsen, and Hassa Horn, most of whom went to Strasbourg.[102] About Holwech Gleditsch wrote to Curie that "she is intelligent, well gifted and pleasant, and I hope you will accept her in your lab."[103] Holwech and Gleditsch spent the academic year 1919/20 in Paris.[104] Holwech later studied art in Norway and Europe and earned her living as an artist.[105]

95. Ore and Høeg (ref. 40), 556-557.
96. Arve Kjelberg, "Multiple Fac(e)ts of a professorship, as seen from the outside," in Hagebø and Salbu, eds. (ref. 1).
97. Jorolf Alstad, private communication, Mar 2005.
98. Ivan Rosenqvist, radio obituary on Gleditsch; Pappas (ref. 67).
99. Anna Rosenqvist, radio obituary on Gleditsch, 8 Dec 1968, NRK Radio Archive, no. 51577.
100. Bergljot Qviller Werenskjold autumn 1984, quoted in Kronen and Pappas (ref. 2), 141-142; Ivan Rosenqvist, radio obituary on Gleditsch.
101. Gleditsch to Irène Joliot-Curie, 12 Jul 1948, Archives Joliot-Curie, Letters of Irène Joliot-Curie, AMC.
102. Kronen and Pappas (ref. 2), 181-182; Bjarne Bassøe, ed., *Ingeniørmatrikkelen: Norske Sivilingeniører 1901-55 med tillegg* (Oslo, 1961), 222.
103. Gleditsch to Curie, 20 Jul 1919, letter no. 841, AMC.
104. Liste du personnel, 1904-1934.
105. Brochmann, ed., *Vi fra NTH,* 240-241; Bassøe, ed. (ref. 102), 222; *Studentene fra 1911* (Oslo, 1936).

Marriage sometimes stymied the careers Gleditsch promoted. Sonja Dedichen, who had studied radioactivity with Gleditsch, announced in the middle of a two-year stint with Curie just before starting on the second year that she was about to be married. Gleditsch had written Curie: "I regard her as intelligent and serious, and she is excessively kind, but very childish."[106] Curie replied, after Dedichen's first year, [107]

> She has had several accidents owing to lack of attention which, as you can imagine, were very inconvenient. But she has made very serious efforts to perfect her working methods, and my opinion of her is much improved, at the same time we love her for her kind and gentle character. I think she will greatly profit from another research year here. Then she will be able to complete a fuller project and gain far greater satisfaction from it.

Instead she gained satisfaction in marriage to Øystein Hanneborg. A decade later she resumed her career, first as assistant to Gleditsch (1935-38), resulting in two joint publications (table 2), then as Research Fellow at the Department of Marine Biology, where she collaborated with Ernst Føyn.[108]

When Lise Meitner fled to Stockholm in 1938, she wanted an assistant in her laboratory. Gleditsch suggested her former student, Einar Jensen (1907-1959).[109] But Meitner was looking for a physicist, and declined to take Jensen.[110]

In addition to Róna and Blau, Tibor Gráf, a Hungarian physicist, came to Oslo to escape Nazi persecution and work with Gleditsch. He was arrested in 1942, transferred to Auschwitz in 1943, and later released. He returned to Oslo and remained until 1947.[111] Gráf, an engineer, had worked at the Curie Laboratory from 1932 to 1939.[112] At the University of Oslo he constructed the first Geiger-Müller counter.[113] Gráf and Gleditsch investigated together the gamma-ray of ^{40}K, which would become important for geology. In 1947 Lise Meitner, again in need of an assistant, considered Gráf. Gleditsch characterized him as a little bit selfish, "but not in any aggressive way. In France, where he worked at the Institut du Radium

106. Gleditsch to Curie, 15 Dec 1924, Curie letter collection, no. 18450, letter no. 162, BN.

107. Curie to Gleditsch, 5 May 1926, Curie letter collection no. 18450, letter no. 172, BN.

108. *Studentene fra 1921* (Oslo, 1949), 126; (Oslo, 1971), 101.

109. Gleditsch to Meitner, 3 Jan 1939, MTNR 5/15, CCA.

110. Letters from Meitner to Gleditsch and to Jensen, 1939, MTNR 5/9 and 5/15, CCA.

111. Kristian Ottosen and Arne Knudsen, eds., *Nordmenn i fangenskap 1940-1945*, 2nd edn. (Oslo, 2004), 242 [alphabetical list of imprisoned Norwegians 1940/45]. According to Ottosen and Knudsen's register, Gráf died in Auschwitz (unknown date), but thanks to Elisabeth Sandberg at the Forum for University History, University of Oslo, it has been confirmed that he died in Sweden, in 1999.

112. Tibor Gráf's curriculum vitae, AMC.

113. Conversations with Paul Thrane Cappelen, Oct 2004.

for five-six years, they respected him and his work, but did not like him much."[114] However, he knew his physics and mathematics for counters, "he is certainly one of the best specialists we have." These qualities satisfied Meitner, who employed Gráf for many years.

Gleditsch looked to international exchanges to diminish the potential for international conflicts. "Although most of the day is spent working in the laboratory, you will get plenty of impressions of the country in which you live, of the people with whom you mix. You will pass from bewilderment to budding understanding, and from understanding to respect and love."[115] She had felt the strength and importance of these values in her development; and they prompted her to join several peace organizations such as the Norwegian branch of the Women's International League for Peace and Freedom, and the International Federation of University Women.[116] Her stay in France during World War I had left her hostile to Germany—a view not shared with many at the University of Oslo.[117]

War

After April 9, 1940, when the Germans occupied Norway, work in the university was irregular and curtailed.[118] In September 1941, the Germans intervened against the university, dismissed its rector Didrik Arup Seip (1884-1963), dissolved the University board, and appointed a member of the Norwegian National Socialist Party (Nasjonal Samling, or NS), professor Adolf Hoel (1879-1964), rector. This intervention triggered the creation of a secret action committee, with psychology professor Harald Schjelderup as leader.[119] The committee had members from all faculties, who chose a certain number of others, who in their turn would recruit

114. Gleditsch to Meitner, 9 Jan 1947, MTNR 5/15, CCA.
115. Gleditsch (ref. 8), 246.
116. Gleditsch joined even more women's organizations and social networks, e.g., Norwegian Association for the Rights of Women (Norsk Kvinnesaksforening), the Women's Democratic World Organization (Kvinnenes Demokratiske Verdensforbund, or KDV), the Female Students' Choir, and the board of the magazine *Kvinnen og Tiden* (*The woman and time*); see Elisabeth Lønnå, *Stolthet og kvinnekamp: Norsk Kvinnesaksforenings historie fra 1913* (Oslo, 1996), 104-106; Lars Rowe, "*Forsvaret av freden og kampen mot krigsbrannstifterne:" Fred som politisk våpen i den kalde krigen 1949-1956* (master's thesis, University of Oslo, 1999), 76; Ruth Rønneberg, Alfhild Saarheim, Kari Utheim Riis, and Ba Mürer, *Kvindelig Studenters Sangforening femti år* (Oslo, 1945), 62-76; *Studentene fra 1905* (Oslo, 1930), 110-111). For more on Gleditsch's work in the IFUW, see Lykknes, Kvittingen and Børresen (ref. 2).
117. Ivan Rosenqvist, video interview.
118. Åb 1939/40, 451-455.
119. Håvard Nilsen, "Harald Schjelderup og aksjonsutvalget," in Jorunn Sem Fure, ed., *Studenter under hakekorset. Fra 60-årsmarkeringen av Universitetets stengning i 1943* [book published in connection with the 60th anniversary of the closing of the University in

more, without anyone knowing who else was a member. In this way the whole university could be mobilized with no-one knowing the identity of the initiator. Ellen Gleditsch was among the first members of the committee, together with professors Torleif Dale from the medical faculty, Einar Molland from theology, associate professor in medicine Jan Jansen, university fellow (pedagogy) Einar Høigaard, and secretary Arne Halvorsen. The action committee distributed information and anonymously organized campaigns against forcing young people to work for the NS, and admitting students on the basis of their political affiliation.[120]

On November 30, 1943 the Germans attacked the university again. After some deliberately set fire in the aula, the Germans closed the university to teaching (not to research) and arrested more than 1,200 students, regarded as a threat to Josef Terboven (1898-1945), the German Reichskommisar for Norway. [121] When Ellen Gleditsch came to work at the Chemistry Department that morning the professors were warned of an imminent German action. About 100 students left the department. Half an hour later the Germans arrived and threatened professors and students. In this tense situation a comic event occurred: The German officer who first ran into Gleditsch's office, where she sat with one of her female assistants, exclaimed: "Nur Frauen! [only women]." The German policemen did not arrest women students.[122] Although German police surrounded the university buildings the next day, Gleditsch, as a woman, could enter. The laboratories were a mess; instruments, glassware, lunch packs, and the students' belongings were strewn around. She had taken the precaution of removing valuable platinum plates, which she placed in a bank vault the next day.[123]

Gleditsch and her colleagues were concerned about their assistants, many of whom went to work in industry or hospitals. Some fled to Sweden.[124] Gleditsch helped as best she could, sometimes buying them train tickets.[125] At the end of December 1943 Gleditsch was arrested, in suspicion of advising students to leave the country. Set free the same evening, she continued her illegal activities.[126] Pretending an interest in sewing national costumes, she obtained permission to travel across

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1943] (Oslo, 2003), 15-32; Ole Kristian Grimnes, "Mostandskampen ved Universitetet," in ibid., 7-13.

120. Nilsen (ref. 119).

121. Anders Bratholm, "Studentenes motstandskamp 1940-45" in Fure (ref. 119), 47-54; Grimnes, "Motstandskampen;" Collett (ref. 20), 159-170.

122. Ellen Gleditsch, "Mens Universitetet var stengt," talk in NRK Radio, 30 May 1945, NRK radio archives, no. 684.

123. Conversation with Chris Koch, May 2004.

124. Gleditsch (ref. 122).

125. Conversation with Chris Koch, May 2004. Koch remembers that some of them deposited some belongings as a guarantee, e.g. silver that was never fetched after the war.

126. Gleditsch (ref. 122). Conversations with Chris Koch, May 2004; Chris Koch quoted in Kronen and Pappas (ref. 2), 164.

the country which enabled her to deliver messages. Her brother Adler (1893-1978) and sister Liv were also arrested; Adler, a topographer, for passing maps of German installations to the Allies, Liv for printing and distributing anti-propaganda pamphlets. Both remained jailed until the country was liberated, Liv for a few months, Adler for three years.[127] Gleditsch's younger brother Kristian (1901-1973) and his wife, Nini Haslund Gleditsch (1908-1996) fled to England—Gleditsch had responsibility for their daughter, Chris Koch (b. 1931), during the war.

When Gleditsch and her colleagues learned the locations of deported Norwegian students, they joined with parents and others to send parcels with vitamins, toothpaste, bouillon, and other necessities. The student restaurant at the University served free soup every day, Professor Kristine Bonnevie organized the shipping of flour from Denmark to the Norwegian students abroad. Fields around the university buildings at Blindern were distributed among the employees and used for growing carrots and potatoes. Gleditsch had her plot and took her share in guarding the fields at night.[128] Bonnevie and Gleditsch's "damaging political activities among the students" were reported to the state police by a minister (probably Nazi Minister Ragnar Skancke) in 1944. The report suggested that "these ladies be shown to an appropriate residence outside Oslo, and not be allowed to return without specific permission from the state police."[129] As far as we know the police took no action.

Gleditsch actively participated in peace work after the war, for example, in UNESCO, where she spoke for revision of textbooks to remove disrespectful comments on neighboring countries and for international control of the atomic bomb. She resigned in 1952 in protest to the admission of Spain (then still under Franco) into the organization.[130]

127. Conversation with Chris Koch, May 2004; Kronen and Pappas (ref. 2), 163; Ottosen and Knudsen (ref. 111).
128. Conversation with Chris Koch, May 2004.
129. Copy of the letter of 5 Jan 1944 is kept in letter collection no. 456 (Gleditsch papers), NBM.
130. Gleditsch also joined the Norwegian branch of the World Peace Council (Fredens Forkjempere i Norge, or FFiN) and the Norwegian-Russian cultural union (Sambandet Norge-Sovjetunionen); see Lars Rowe, *"Nyttige idioter"? Fredsfronten i Norge, 1949-1956* (Forsvarsstudier 1/2002), 46-52, 112; Ingunn Rotihaug, *Sambandet Norge-Sovjetunionen 1945-1970* (master's thesis, University of Oslo, 1998), 51; Ingunn Rotihaug, *"For fred og vennskap mellom folkene" Sambandet Norge-Sovjetunionen 1945-70* (Forsvarsstudier 1/2000); Geir Bentzen, "En tid for begeistring—nordmenn og Sovjetunionen i 1945," *Arbeiderhistorie* 2002, 121-137, on 124. The authors are grateful to Geir Bentzen and Lars Rowe. Stortingsproposisjon (Parliament proposition) no. 58, 1946-47; Ellen Gleditsch, "UNESCO," *Kvinnen og Tiden,* no. 21 (1946), 39-41, 50, on 39; Ellen Gleditsch, "UNESCO art. II," *Kvinnen og Tiden,* no. 12 (1947), 39-42; "UNESCO: Ellen Gleditsch foreslår revisjon av lærebøkene," *Aftenposten*, 23 Nov 1946; "UNESCO-kommisjonen og Spaniasaken," *Dagbladet,* 13 Dec 1952; Kronen and Pappas (ref. 2), 171-176.

3. SCIENTIFIC WORK IN NORWAY

In February 1914, during her stay at Yale, Gleditsch visited Theodore Richards at Harvard to learn about his determinations of the atomic weight of "radioactive lead."[131] Richard's determinations involved purification of chemicals through many washing and crystallization processes. He wrote of first sample of "radioactive lead:"[132]

> [It was] recrystallized eight times from the aqueous solution, but even after this treatment was not absolutely white in color, containing still a trace of iron. Three more crystallizations from hydrochloric acid solution yielded a product of pure whiteness, but because of the slow elimination of the impurities, this sample, C, could hardly be considered a final product. Therefore, all the remainder of the material was dissolved in a great volume of water, acidified with nitric acid, and saturated with hydrogen sulfide. The carefully washed sulfide was dissolved in nitric acid, and the nitrate was thrice crystallized (once in platinum) from acid solution.

All this was before the equally meticulous weighing and combining processes.

Richards depended on materials from all over the world.[133] Gleditsch and Boltwood provided a sample of lead chloride from North Carolina uraninite characterized by Richards and his collaborator Max E. Lembert as "perhaps the most valuable of all our samples."[134] Gleditsch also provided lead from thorianite, and received thanks for it in Richards' Nobel lecture of December 1919.[135] Later she sent Richards samples of lead from Norway; cleveite, scheeleite, and bröggerite (named after the Norwegian geologist Waldemar Christopher Brøgger).[136]

131. Letter from Theodore William Richards to Ellen Gleditsch, 27 Feb 1914, Letter collection no. 456, NBM.
132. Theodore W. Richards and Max E. Lembert, "The atomic weight of lead of radioactive origin," *The journal of the American Chemical Society, 36* (1914), 1329-1344, on 1332.
133. Theodore W. Richards and Charles Wadsworth, "Further study of the atomic weight of lead of radioactive origin," *Journal of the American Chemical Society, 38* (1916), 2613-2622; Richards and Lembert (ref. 132).
134. Richard and Lembert (ibid.), 1334.
135. Letter from Theodore William Richards to Ellen Gleditsch, 9 Mar 1914, Letter collection no. 456, NBM. Theodore William Richards, "Nobel lecture December 6, 1991," in *Nobel lectures, including presentation, speeches, and laureates' biographies, CHEMISTRY, 1901-1921* (Amsterdam, 1966), 280-292, on 290.
136. George Stannon Forbes, "Investigations of atomic weights by Theodore William Richards," *Journal of chemical education, 9* (1932), 453-458. Letter from Theodore William Richards to Ellen Gleditsch, 29 Mar 1916, Harvard University Archives, Papers of T.W. Richards, HUG 1743.1.8, Box 3; Richards and Wadsworth (ref. 133).

Isotopes of common elements

When Soddy introduced the concept of isotopy in 1913, he suggested that lead derived from uranium would have a lower, and lead from thorium a higher, atomic weight than ordinary lead.[137] Richards and his co-workers had shown that the atomic weight of lead varied.[138] This result was easily accepted, since as a product of various radioactive decay chains it had to come in various isotopes. The announcement by Francis Aston that elements of non-radioactive origin, neon, and chlorine, consisted of more than one isotope, was harder to accept. In Gleditsch's words,[139]

> The discovery of isotopes among the common elements caused general surprise although it had been anticipated, and in spite of the fact that it does not contradict present day ideas on the constitution of matter. On the whole it was less readily accepted than the theory of isotopy put forward a few years earlier. This was mainly due to the difficulty of admitting that an element can have a complex constitution and at the same time a perfectly constant atomic weight.

The atomic weight of chlorine

Aston announced in 1919 that he had found evidence of two isotopes of chlorine, of masses 35 and 37, with an average atomic weight of 35.46.[140] Gleditsch follows up the discovery because the mass difference between the two isotopes of chlorine was large, a partial separation between the isotopes had been achieved, and the atomic weight determinations on chlorine could be carried out very accurately. Together with Bjarne Samdahl she investigated whether chlorine from different sources always had the mixture of isotopes Aston had found. If the isotopic composition varied with the source, the concept of constancy of atomic weight would have to be reconsidered.[141]

Chlorine had already been subject to several investigations, since the atomic weights of other elements, for example, lead, were often determined via their chlorides. The chlorine used had always contained the two isotopes in the same ratio. Gleditsch and Samdahl observed that chlorine and the prepared chlorine compounds in question derived from sodium chloride of marine origin. Perhaps chlorine from other sources had a different atomic weight?[142]

137. Francis W. Aston, *Isotopes* (London, 1923), 40.
138. See e.g., Richards and Lembert (ref. 132).
139. Ellen Gleditsch, *Contribution to the study of isotopes* (Skrifter vitenskapsakademiet i Oslo, klasse I, 1925), on 35.
140. Francis W. Aston, "The constitution of elements," *Nature, 104* (1919), 393; Francis W. Aston, "The mass spectra of chemical elements," *Philosophical magazine, 39* (1920), 611-625; Francis W. Aston, *Mass spectra and isotopes* (London, 1942), 141-143.
141. Ellen Gleditsch (ref. 139), 35, 37-38.
142. Ellen Gleditsch and Bjarne Samdahl, "Sur le poids atomique du chlore dans un

> There are minerals, in which chlorine is a primary constituent, and which have never been altered by water, minerals crystallized from the molten magma under the action of chlorine-bearing vapors or solutions. Such minerals do not contain chlorine in large propositions, and consequently will never have served for preparations of chlorine or chlorine compounds. On the other hand they may be found ancient and unaltered, so that a determination of the combining weight of their chlorine ought to give the proportions of the isotopes in chlorine existing at the time when the minerals were formed.

Professor of Mineralogy, Goldschmidt provided an appropriate mineral for this study, apatite from Ødegaarden.

Gleditsch and Sandahl determined the atomic weight they sought in two different ways. They precipitated the chloride with silver nitrate to obtain silver chloride, which they washed, dried, and reduced to metallic silver with a current of hydrogen. They inferred the atomic weight of the chlorine from the weights of the dried silver chloride and metallic silver. The second method, conducted by Margot Dorenfeldt Holtan (1895-?) determined the densities of the saturated solutions of sodium chloride from Ødegaarden and from commercially prepared chlorine.[143] The densities agreed to within an amount less than the errors of weighing. Gleditsch and Samdahl's results likewise indicated that chlorine from Ødegaarden had the same isotopic composition as chlorine of marine origin, namely 35.46. "Considering the occurrence and the origin of the apatite we are justified in believing that when primary minerals were formed from the molten magma, chlorine already contained the two constituents in the same proportion as now, or that the two isotopes were formed at that time in this same proportion."[144]

Meanwhile Irène Curie had been conducting similar experiments in Paris. She tried to resolve whether sodalite from Bancroft, Canada, apatite from Ødegaarden, and sodium chloride from Dar Oura, Central Africa, all terrestrial and ancient minerals, contained the two chlorine isotopes in the same proportion as chlorine from sea salts. Her methods were essentially those of Gleditsch and Samdahl's; a comparison between silver chloride from the mineral and ordinary silver chloride. However she had not included a purification of the chlorides with respect to the contamination of other halides.[145] Her results for the Canadian and Norwegian minerals confirmed the accepted value of the atomic weight of chlorine, whereas the chlorine of Dar Ouara, gave a difference in atomic weight outside of experimental

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mineral ancien, l'apatite de Bamle," *CR, 174* (1922), 746-748; Ellen Gleditsch and Bjarne Samdahl, "The atomic weight of chlorine in an old mineral, apatite from Bamle," *Archiv for mathematik og naturvidenskab, 38* (1923), 3-10, on 3-4.

143. Margot Dorenfeldt, "Relative determination of the atomic weight of chlorine in Bamle apatite," *American chemical journal, 45* (1923), 1577-1579.

144. Gleditsch and Samdahl (ref. 142).

145. Gleditsch (ref. 139), 47.

error (35.60 versus 35.46). Irène Curie suggested that small traces of bromine or iodine had caused the discrepancy but her test reactions were negative. She concluded, therefore, that the atomic weight of chlorine of Dar Ouala exceeded that of ordinary chlorine, but emphasized that the results were only preliminary. In the event she went on to something else and Marie Curie asked Gleditsch to continue the investigation.[146]

The atomic weight of chlorine was an important topic in 1922 as it was decisive for the constancy of atomic weights. When Gleditsch wrote to Curie in February that year she expressed surprise to find Irène Curie's publication at the library in Oslo: "When we met this summer we spoke a lot about work and publications, but not about Irène Curie's publication on chlorine in minerals, a publication that at the time I did not know of, and by strange coincidence I didn't tell you that we had undertaken a similar work here in my group."[147] Gleditsch wanted to continue the investigation since she and Samdahl had achieved something, and she did not want to discourage him.[148] In their first paper (in French) they referred to, but did not comment on Curie's results, in the second they stated that theirs agreed well with hers; Gleditsch probably thought that the discrepancies arose from small experimental errors. In her presentation before the Norwegian Chemical Society in November 1922, however, Gleditsch suggested contamination by bromine.[149] In a review of the study of isotopes, in 1925, she again mentioned traces of bromine in Curie's mineral as the main causes for Curie's diverging results. Yet this did not alter the general proposition: "the constancy of the atomic weight of mixtures of stable isotopes remains a fact."[150] Although the proportion of the isotopes might be distorted, by diffusion of gases, or low-pressure evaporation of fluids, the elements as they occur naturally do not show any variation in their atomic weights.[151]

146. M. Curie to Gleditsch, 23 Dec 1922, Marie Curie Archives, letter no. 991, AMC; Gleditsch to M. Curie, 15 Jan 1923, Marie Curie Archives, letter no. 996, AMC.
147. Letter from Gleditsch to M. Curie, 28 Feb 1922, Marie Curie Archives, letter no. 941, AMC.
148. Ibid.
149. The presentation was later published: Ellen Gleditsch, "Om atomvegtsbestemmelser av grundstoffer av forskjellig oprindelse," *Naturen* (1923), 118-129. Although only referring to Gleditsch and Samdahl's French publication of 1922, where Curie's results are scarcely mentioned, but not discussed, Marelene and Geoffrey Rayner-Canham credit Gleditsch for showing bromine to be the reason for Curie's deviating value. Gleditsch never investigated Curie's specific sample nor the contamination of bromine specifically; also Curie, although not capable of proving this, suggested bromine and iodine to be the causes of error. This is also quite likely, as chlorine, bromine, and iodine are all halogens, thus having similar chemical properties. See Marelene F. Rayner-Canham and Geoffrey W. Rayner-Canham, "Stefanie Horovitz, Ellen Gleditsch, Ada Hitchins, and the discovery of isotopes," *Bulletin for the history of chemistry, 25* (2000), 103-108.
150. Gleditsch (ref. 139), 48.
151. Gleditsch (ref. 149).

Marie Curie asked Gleditsch to investigate a chlorine-bearing mine-water from the U.S. This water has high ratios of chlorine to sodium and calcium to sodium. "It was in fact a most valuable specimen and I was most grateful for having an opportunity to examine it."[152] The old and probably unaltered water gave atomic weights consistent with earlier investigations. These determinations inspired Gleditsch to use altered sources. If laboratory experiments succeeded in changing the proportions of isotopes (e.g., by diffusion), it would seem incredible that nature, "having at her disposal much more powerful means, should not have realized some separation, partial or even complete."[153] A lecturer in geology at the University of Oslo, Thorolf Vogt (1888-1958), suggested a trial with volcanic salmiac to follow up on this idea: "This seemed very promising. The mineral is found near volcanoes, especially after eruptions; it has sublimated out from the gaseous state and is found in rather well developed crystals on the lava. It represents a mineral which has been subjected to alterations, the chlorine in it has passed through states, when a partial separation of the isotopes might have occurred."[154]

So Gleditsch wrote to A. Piutti, professor of mineralogy in Naples, asking him for a quantity of volcanic salmiac. Piutti sent samples from Vesuvius deposited on lava crusts after an eruption. The atomic weight determinations confirmed her earlier results. Despite different origins and occurrences, chlorine's atomic weight did not vary.[155]

A few years later Ellen and Liv Gleditsch studied chlorine deposits in isotopic composition and concentration in chlorine deposits in salt mines in Alsace.[156] They found, again, a weight of 35.46. A follow-up investigation by William D. Harkins and S.B. Stone at the University of Chicago on meteorites gave an isotopic composition similar to Gleditsch's and many others.[157] To Harkins, Aston's explanation that the isotopes originally were thoroughly mixed would hold for marine, but not

152. Gleditsch (ref. 139), 39.
153. Ibid., 40.
154. Ibid.
155. Ellen Gleditsch, "Sur le poids atomique du chlore," *Archiv for mathematik og naturvidenskab, 39* (1924), 3-8; simultaneously published in *Journal de chimie physique* (1924), 456-460.
156. Ellen Gleditsch and Liv Gleditsch, "Contribution à l'étude des isotopes, sur le poids atomique du chlore dans les sels de potasse d'Alsace," *Journal de chimie physique et de physico-chimie biologique, 24* (1927), 238-244.
157. See e.g., William D. Harkins and S.B. Stone, "The isotopic composition and atomic weight of chlorine from meteorites and from minerals of non-marine origin," *Journal of the American Chemical Society, 48* (1926), 938-949. Alan W.C. Menzies at Princeton University also investigated the atomic weight of chlorine in meteorites: Alan W.C. Menzies, "The isotopic composition and the atomic weight of chlorine in meteorites," *Nature, 116* (1925), 643. The study of elements of cosmic origin was not new; at Harvard meteoritic iron, nickel, and cobolt had been compared to those of terrestrial origin, no difference was found (see Gleditsch (ref. 139), 37).

meteoritic or terrestrial chlorine.[158] According to Harkins the atoms of the lighter isotope of chlorine were simply the more stable:[159]

> Presumably such chlorine [sodalite, werntite and apatite] of igneous origin has not been mixed with that in the sea within known geologic time. Therefore any theory of the observed constancy of its isotopic composition, which is based on an original thorough mixing, would necessarily assume that the mixing occurred either during the very hypothetical and, on the basis of recent theories, improbable, molten state of the earth or at an even earlier time. Since a very intimate mixing on such a cosmic scale does not seem particularly plausible, it appears better to interpret the constancy of isotopic composition as due largely to the relative stability of the isotopes, and to the abundance and stability of the atomic species from which they are formed.

Also today relative stability is used as an explanation for the isotopic compositions of the naturally occurring elements.

Johannes Brønsted (1879-1947) at Copenhagen and Georg von Hevesy (1885-1966) at Freiburg, both members of the committee that evaluated applicants to the Oslo professorship in 1929, regarded Gleditsch's work on the atomic weights of chlorine as one of her most important contributions.[160] Aston also thought highly of her "very careful investigations."[161] Lead was another matter. The annual report of the Deutsche Chemische Gesellschaft's atomic weight commission of 1926. criticized the determinations of lead, that Gleditsch, Margot Dorenfeldt Holtan, and Ole Wilhelm Berg (1897-1923), had made on cleveite from Aust-Agder in the south of Norway, using both the direct method of atomic weight determinations and density measurement.[162] Although aware of the weaknesses in their weighing in the direct method, they arrived at values consistent with their results using the indirect method, namely 206.17. But to their surprise the atomic weight of the lead (206.17) was not nearer to that of radium G (206) since cleveite from Aust-Agder seemed to be "a very pure specimen and since it contained hardly

158. William D. Harkins, "The evolution of the elements and the stability of complex atoms," *Journal of the American Chemical Society*, *39* (1917), 856-879; William D. Harkins, "The constitution and stability of atom nuclei," *Philosophical magazine*, *42* (1921), 305-339.

159. Harkins and Stone, (ref. 157), 946-947. See also John G. Burke, *Cosmic debris: Meteorites in history* (Berkeley, 1986), 253-257.

160. Expert opinions of Johannes Brønsted and Georg von Hevesy, SAO.

161. Aston (ref. 140), 186.

162. Otto Hönigschmid, "Sechster Bericht der Deutschen Atomgewichts-Kommission," *Berichte der Deutsche chemische Gesellschaft*, *59* (1926), 22-24. Ellen Gleditsch, Margot Dorenfeldt Holtan, and Ole Wilhelm Berg, "Determination du poids atomique du mélange isotopique de plomb de la clévéïte de Aust-Agder, Norvège," *Journal de chimie physique et de physico-chimie biologique, 22* (1925), 253-263; Gleditsch (ref. 139), 16-25.

any thorium, the end-product in the thorium-series could not to any appreciable degree influence the atomic weight of the mixture of isotopes."[163]

Otto Hönigschmid, who wrote the report for the Deutsche chemische Gesellschaft, critized Gleditsch's direct method as "a primitive experimental art completely unsuitable for precision determinations."[164] Heinrich Goldschmidt had to evaluate Gleditsch's work on lead in connection with her candidacy for professor in 1929. He decided that since both direct and indirect methods gave the same answer Hönigschmid's criticism had little force.

The (International) Committee on Atomic Weights mentioned Gleditsch and her colleagues' work without discussing it.[165] Gleditsch wrote after presenting the result of the indirect determination: "This result brings forth the fact that even if the chemical method used by us did not in itself permit of very great exactitude, we had by careful work and by taking the mean of several determinations arrived at the true value."[166] This statement reflects the respect Gleditsch had for work performed at Harvard, which her small and poorly equipped laboratory at Oslo could not match.

The age of minerals

Bröggerite and cleveite are particularly suitable to age determination because they are old and almost unaltered by weathering and atmospheric gases.[167] Bröggerite was also one of the few minerals for which the atomic weight of lead had been determined (by Richards and Wadsworth).[168] By measuring the ratio of lead to uranium Gleditsch could calculate a sample's age. At first scientists included lead present from the formation of the mineral in age calculations, which led to incorrect answers. Gleditsch was one of the first to emphasize the importance of knowing the exact isotopic composition of lead in minerals.[169]

The lead method descended from Boltwood's determination, in 1905, that helium and lead were always found in uranium-radium minerals.[170] Using the lead-uranium ratio (Pb/U, the "lead-method") thus became an alternative method

163. Ibid., 17.

164. Otto Hönigschmid (ref. 162).

165. Gregory Paul Baxter, "Thirty-second annual report of the Committee on Atomic Weights. Determinations published during 1925," *Journal of the American Chemical Society*, *48* (1926), 541-552.

166. Gleditsch (ref. 139), 25.

167. Ellen Gleditsch, "Studier over brøgeritt, et radioaktivt mineral, og en bestemmelse af dets alder," *Fysisk Tidsskrift, 17* (1919), 101-120.

168. Richards and Wadsworth (ref. 133).

169. Alexis C. Pappas (ref. 67).

170. Lawrence Badash, "Rutherford, Boltwood, and the age of the earth. The origin of radioactive dating techniques," American Philosophical Society, *Proceedings, 112* (1968), 157-169.

to helium-uranium for calculating the age of minerals. If lead also proved to be the end product of the uranium decay series, which helium was not, the lead-method would be even more preferable. By 1906, despite uncertainties, sufficient evidence for lead as the end product had been found and the lead method could be used for age calculations.[171]

Rutherford published his results on the "helium-method" in 1905 and 1906,[172] whereas Boltwood withheld his for two more years possibly because of uncertainties about the value of the half-life of radium.[173] Boltwood used the "lead-method," crediting Rutherford and assuming that lead in minerals originated from uranium, thus neglecting contributions from thorium decay, and lead present from the formation of the ore.[174] By measuring the amount of uranium and lead present and using uranium's disintegration constant, he calculated the age of the mineral.[175]

Steadily the limitations of the helium-method became apparent, giving only minimum ages. Gleditsch later explained this:[176]

> Helium is a rare element and its occurrence in minerals seems connected with the radioactive processes that have taken place in them. It is also far from certain that all the helium [generated] is confined within a mineral.

171. Joe D. Burchfield, *Lord Kelvin and the age of the earth* (New York, 1975), 175.
172. Ernest Rutherford, *Radio-activity* (Cambridge, 1905), 486; Ernest Rutherford, *Radioactive transformations* (New York, 1906), 189.
173. Lawrence Badash, ed., *Rutherford and Boltwood: Letters on radioactivity* (New Haven, 1969), 100-106, on 103. Letter from Boltwood to Rutherford, 18 Nov 1905 in ibid., 103. Lawrence Badash, *Radioactivity in America: Growth and decay of a science* (Baltimore, 1979), 84-85, 161-164.
174. Ibid., 103; Bertram B. Booltwood, "On the ultimate disintegration products of the radio-active elements. Part II. The disintegration products of uranium," *American journal of science, 23* (1907), 77-88, on 87. That lead stemmed from actinium as well was discovered much later, see "Actinium's ancestor" (page 172).
175. Boltwood described his method as follows: As the half-life of radium at the time was assumed to be 2,600 years (calculated by Rutherford in 1906, later modified by Gleditsch), the decay constant of radium would, accordingly, be equal to 2.7×10^{-4}. Furthermore, the number of grams of radium associated with one gram of uranium in a radioactive mineral had been determined (by Rutherford and Boltwood, 1906, later modified) to 3.8×10^{-7}. When radioactive equilibrium was achieved, an equal number of molecules of each disintegrate per second, and neglecting the differences in atomic weights, the fraction of uranium transformed per year would be ($2.7 \times 10^{-4} \times 3.8 \times 10^{-7} =$) 10^{-10}. Thus, the age of the mineral would equal Pb/U x 10^{10}. His results included a Norwegian mineral from Moss District, which turned out to be 1300 million years, and the oldest, a Ceylon mineral from the Sabaragamuwa province, 2,200 million years of age (Boltwood (ref. 174), 86-87). The latter was many times older than the most liberal estimates of the earth given by Kelvin, so radioactivity definitely revolutionized previous age calculations and assumptions. Badash (ref. 173), 92-94.
176. Ellen Gleditsch, "De radioaktive Stoffer og Jordens Alder," *Teknisk ukeblad, 8* (1919), 110-114, on 113.

> It is likely that a fraction will diffuse out, partly from the surface, partly through crevices and scratches; and this fraction cannot be determined. The ratio helium/uranium will therefore give a *minimum value* for the age of the mineral.

For the lead method, maximum values would result since lead originally formed might add to the lead stemming from uranium.

Arthur Holmes, who further developed the lead-method, was aware of the need to account for original lead and lead deriving from thorium. Minerals for which the amount of original lead was much larger than that of uranium-lead were "valueless in age-estimations."[177] As for thorium, Holmes held on to Boltwood's conclusions that lead was not its end product.[178] "Wherever lead occurs in primary minerals it is associated with uranium, and there is little doubt that it can be completely accounted for in this way."[179] With these assumptions Holmes arrived in 1911 at 1,640 million years for the oldest sample he investigated, a Ceylon mineral.

With the concept of isotopy, it became apparent that only the lead isotope formed from uranium should be used in the calculations, and Holmes refined his methods accordingly. The first edition of his influential book *The age of the earth* (1913), does not include the new findings but the following editions do.[180] Still, geologists remained skeptical about radiological dating until the late 1920s.

The turning point in geological reasoning came with Joseph Barrell's review of the problem in 1917.[181] Barrell (1869-1919), professor of geology at Yale, argued that cycles—rhythms as he called them—were important to understand geological changes. Instead of regarding uniformity as an overall principle, it should be regarded as norm for the measurement of geological change. Geologists had to use radioactivity to establish "the magnitude of the framework into which the geological picture must be set."[182] Barrell's work cooled the controversy but did not resolve it.

177. Arthur Holmes, "The association of lead with uranium in rock-minerals, and its application to the measurement of geological time," Royal Society, *Proceedings, A85* (1911), 248-256, on 254; see also Arthur Holmes, "Radioactivity and the measurement of geological time," Geologists' Association, *Proceedings, 26* (1915), 289-309.
178. Boltwood felt certain that lead was not the final product of the thorium decay series because no proportionality could be found between lead and thorium in minerals, whereas the opposite held for lead and uranium. This might have been due to partial leaching of thorium lead, probably because lead formed from thorium would exist in a relatively soluble compound, according to Holmes (Arthur Holmes, "Physics of the earth –IV. The age of the earth," *Bulletin of the National Research Council*, no. 80 (1931), 213-215).
179. Holmes, "association" (ref. 177).
180. Arthur Holmes, *The age of the earth* (London, 1913, 1927, 1937).
181. Joseph Barrell, "Rhythms and the measurement of geologic time," *Bulletin of the Geological Society of America, 28* (1917), 745-904; Burchfield (ref. 171), 195-197.
182. Barrell (ref. 181), 751.

millions of years. To Gleditsch geological uniformity was not trustworthy, whereas the uniformity of radioactive decay seemed secured by the impossibility of influencing these processes by chemical, physical, or mechanical means.[193] This discussion, directed at the Scandinavian public, aroused little or no debate in Norway. Not until Willard F. Libby invented ^{14}C dating after World War II did geologists at NTH in Trondheim start to make radioactive age determinations.[194]

Gleditsch published her main work on bröggerite in French in *Archiv for mathematik og naturvidenskab* in 1919.[195] For this she received the Nansen award of the Norwegian Academy of Sciences the following year.[196] Expert referees for her professorial appointment in 1929 emphasized her work on the age of minerals, Wilhelm Palmær (1868-1942) of Stockholm underlined her very profound and detailed work, and her predecessor Goldschmidt regarded her age determinations of bröggerite and cleveite her "best achievement."[197] However, Goldschmidt noted that Aston had just revised the determination by the use of his mass spectrograph, taking into account a third isotope of lead, ^{207}Pb, arising from the actinium decay series. The discovery that actinium came from a third isotope of uranium (^{235}U) was made in 1917 by A. Piccard, and the actinium puzzle was not fully resolved until Aston identified ^{207}Pb in 1929.

Actinium's ancestor (^{227}Ac)

While in Paris in 1908/9 Gleditsch participated in research on radium and its parent by investigating the Ra/U ratio in minerals. Through this and other contributions it appeared that uranium was not the immediate parent of radium; instead the long-lived intermediate ionium (^{230}Th) filled this role.[198] In the 1930s Gleditsch approached the actinium problem similarly by investigating the Ac/U ratio. Radiochemists then arranged the radioactive elements in three series (figures 6-8), but did not know the exact relation between the actinium series and the uranium and thorium series.[199] "Did actinium originate as a branch of the uranium series?"

193. Gleditsch (ref. 167), 120.
194. Ore and Høeg (ref. 40), 562.
195. Gleditsch, "Études" (ref. 188).
196. After listing the winners of the Nansen award 1915-1923, Leiv Amundsen in his history of the Norwegian Academy of Sciences explains that the prize was equal to NOK 1,000 the first years and 2,500 the last years, without specifying what year the change set in (Leiv Amundsen, *Det Norske Videnskaps-Akademi i Oslo 1857-1957*. Vol. 2 (Oslo, 1957), 180). In later publications she extended her age determination to include the Norwegian mineral cleveite, see Gleditsch (ref. 139).
197. Wilhelm Palmær's expert opinion, Files of the Faculty of Science and Mathematics, 1929, SAO; Heinrich Goldschmidt's expert opinion, Files of the Faculty of Science and Mathematics, 1929, SAO.
198. Lykknes, Kragh, and Kvittingen (ref. 2).
199. James E. Wildish, "The origin of protactinium," *Journal of the American Chemical Society*, *52* (1930), 163-177.

THE URANIUM SERIES

Radioelement	*Corresponding Element*	*Symbol*	*Radiation*	*Half-Life*
Uranium I	Uranium	^{238}U	α	4.51×10^9 yr
Uranium X_1	Thorium	^{234}Th	β	24.1 days
Uranium X_2*	Protactinium	^{234}Pa	β	1.18 min
Uranium II	Uranium	^{234}U	α	2.48×10^5 yr
Ionium	Thorium	^{230}Th	α	8.0×10^4 yr
Radium	Radium	^{226}Ra	α	1.62×10^3 yr
Ra Emanation	Radon	^{222}Rn	α	3.82 days
Radium A (99.98% | 0.02%)	Polonium	^{218}Po	α and β	3.05 min
Radium B	Lead	^{214}Pb	β	26.8 min
Astatine-218	Astatine	^{218}At	α	2 sec
Radium C (99.96% | 0.04%)	Bismuth	^{214}Bi	β and α	19.7 min
Radium C′	Polonium	^{214}Po	α	1.6×10^{-4} sec
Radium C″	Thallium	^{210}Tl	β	1.32 min
Radium D	Lead	^{210}Pb	β	19.4 yr
Radium E (~100% | 2×10^{-4}%)	Bismuth	^{210}Bi	β and α	5.0 days
Radium F	Polonium	^{210}Po	α	138.4 days
Thallium-206	Thallium	^{206}Tl	β	4.20 min
Radium G (End Product)	Lead	^{206}Pb	Stable	—

FIG 6 The uranium decay series today, with the previously used names. *Source:* Samuel Glasstone, *Sourcebook on atomic energy*, 3rd edn. (New York, 1967), 152.

In 1911 G.N. Antonoff, on a visit to Rutherford's laboratory, isolated a uranium product with chemical properties similar to uranium X (UX, ^{234}Th), which he called uranium Y (UY, ^{231}Th). Its activity was far less than anticipated for a descendent of uranium and it did not transform into UX. Nor did UY seem to be a direct product ("immediate or otherwise") of UX, "for in such a case one would expect larger quantities of it in old preparations than in those freshly made," which was not observed.[200]

200. G.N. Antonoff, "The disintegration products of uranium," *Philosophical magazine*, 22

The Thorium Series

Radioelement	*Corresponding Element*	*Symbol*	*Radiation*	*Half-Life*
Thorium	Thorium	[illegible]Th	α	1.39 × 10[illegible] yr
Mesothorium I	Radium	[illegible]Ra	β	6.7 yr
Mesothorium II	Actinium	[illegible]Ac	β	6.13 hr
Radiothorium	Thorium	[illegible]Th	α	1.91 yr
Thorium X	Radium	[illegible]Ra	α	3.64 days
Th Emanation	Radon	[illegible]Rn	α	52 sec
Thorium A	Polonium	[illegible]Po	α	0.16 sec
Thorium B	Lead	[illegible]Pb	β	10.6 hr
Thorium C (66.3% / 33.7%)	Bismuth	[illegible]Bi	β and α	60.5 min
Thorium C′	Polonium	[illegible]Po	α	3 × 10[illegible] sec
Thorium C″	Thallium	[illegible]Tl	β	3.1 min
Thorium D (End Product)	Lead	[illegible]Pb	Stable	—

FIG 7 The thorium decay series today, with the previously used names. *Source:* Glasstone (ibid.), 153.

Antonoff concluded that UY was a branch product of uranium. The origin of actinium, long considered to require branching, could then be connected to uranium Y.

According to the group displacement laws and the theory of isotopes, there were only two possible positions for actinium's parent: a beta-emitting radium isotope or an alpha-emitting isotope of an unknown group V element. Since actinium had never been detected in a radium solution, Soddy in 1913 concluded that the long-lived alpha-emitting isotope of the missing group V element, which he called "eka-tantalum," could be the parent of actinium.[201] The same year Fajans and Oswald Helmuth Göhring discovered a short-lived, beta-emitting isotope, named *brevium* (UX_2, today recognized as ^{234}Pa), which decayed into an isotope of uranium (^{234}U),

(1911), 419-432, quote on 430; Badash (ref. 173), 174.

201. Ruth Sime, *Lise Meitner: A life in physics* (Berkeley, 1996), 50; Frederik Soddy, "The origins of actinium," *Nature, 91* (1913), 634-635.

THE ACTINIUM SERIES

Radioelement	*Corresponding Element*	*Symbol*	*Radiation*	*Half-Life*
Actinouranium ↓	Uranium	^{235}U	α	7.13×10^8 yr
Uranium Y ↓	Thorium	^{231}Th	β	25.6 hr
Protactinium ↓	Protactinium	^{231}Pa	α	3.43×10^4 yr
Actinium 98.8% ↓ | ↓ 1.2%	Actinium	^{227}Ac	β and α	21.6 yr
Radioactinium	Thorium	^{227}Th	α	18.4 days
Actinium K	Francium	^{223}Fr	β	21 min
↓ Actinium X ↓	Radium	^{223}Ra	α	11.7 days
Ac Emanation ↓	Radon	^{219}Rn	α	3.92 sec
Actinium A ~100% ↓ | ↓ ~5 × 10^{-4}%	Polonium	^{215}Po	α and β	1.83×10^{-3} sec
Actinium B	Lead	^{211}Pb	β	36.1 min
Astatine-215	Astatine	^{215}At	α	$\sim 10^{-4}$ sec
↓ Actinium C 99.7% ↓ | ↓ 0.3%	Bismuth	^{211}Bi	α and β	2.16 min
Actinium C′	Polonium	^{211}Po	α	0.52 sec
Actinium C″	Thallium	^{207}Tl	β	4.8 min
↓ Actinium D (End Product)	Lead	^{207}Pb	Stable	—

FIG 8 The actinium decay series today, with the previously used names. *Source:* Glasstone (ibid.), 154.

ruling it out as the parent of actinium.[202] But an unknown alpha-emitting isotope of brevium might still be the mother of actinium.[203]

In 1913 Hahn and Meitner sought the mother substance in UX_2.[204] After four years they found traces of actinium emanation in the silica preparations they em-

202. Josef Hurwic, "La découverte de brevium," *Revue d'histoire des sciences et de leurs applications, 34* (1981), 359-361.
203. Badash (ref. 173), 208.
204. Sime (ref. 201), 70.

ployed. These were further concentrated, extraneous activities accounted for, and the amount of actinium present determined by its emanation and decay products. Hahn and Meitner called the new element (isotope) *protactinium*, as it was most probably the mother substance of actinium.[205] Soddy and John Cranston made the same discovery but kept the Mendeleevian name *Eka-tantalum*, as Soddy had originally used.[206]

Protoactinium came from UY. Did UY come from uranium I (^{238}U) or uranium II (^{234}U)? If either of them initiated the actinium series, a branch would be required that did not close after one generation, as did all previously known branches. This problem demanded atomic weight determination of at least one member of the actinium series. From this member the rest of the series could be deduced from the decay scheme. The end product of the actinium series, actinium D (AcD), was assumed to be a lead isotope. Since it was always associated with uranium-lead in the minerals, its atomic weight was difficult to determine. Actinium's short half-life prevented accumulation of enough material to determine its atomic weight. The most obvious candidate for atomic weight determination was protactinium, which occupied Hahn for several years, and was eventually determined by Aristid von Grosse in 1934.[207] Piccard's suggestion of 1917, that uranium had a third isotope, had no hard evidence behind it.[208] Aston's mass spectrograph changed everything since it brought to light ^{207}Pb as the end product of the actinium disintegration family.[209] Although ^{235}U thus appeared a likely ancestor of actinium, its existence remained uncertain for years as isotope data were imprecise and the possibility of some other process producing ^{207}Pb in uranium minerals could not be ruled out.[210]

Based on Boltwood's investigations in 1908,[211] Rutherford calculated that eight percent of uranium atoms decay into actinium. Hahn and Meitner repeated the calculation using the ratio of protactinium to uranium since Pa gave well-de-

205. Ibid., 70; Otto Hahn and Lise Meitner, "Die Muttersubstanz des Actiniums, ein neues radioaktives Element von langer Lebensdauer," *Physikalishe Zeitschrift, 19* (1918), 208-218. See also Ruth Lewin Sime, "The discovery of protactinium," *Journal of chemical education, 63* (1986), 653-657.

206. Frederick Soddy and John A. Cranston, "The parent of actinium," Royal Society of London, *Proceedings, A94* (1918), 384-405. For details on the predicted eka-tantalum of Mendeleev, see Johannes Willem von Spronsen, *The periodic system of chemical elements: A history of the first hundred years* (Amsterdam, 1969), 221-222. Josef Hurwic says that Fajans and Göhring discovered protactinium, see Hurwic (ref. 202).

207. Sime (ref. 201), 72; Badash (ref. 173), 208.

208. A. Piccard, "L'Hypothèse de l'Existence d'un Troisième Corps Simple Radioactif dans la Pléiade Uranium," *Archives des sciences physiques et naturelles, 44* (1917), 161-164.

209. F.W. Aston, "The mass spectrum of uranium lead and the atomic weight of protactinium," *Nature, 123* (1929), 313.

210. Sime (ref. 201), 115.

211. Betram B. Boltwood, "On the radio-activity of uranium minerals," *American journal of science, 25* (1908), 269-298.

fined and reproducible chemical reactions and detectable alpha radiation. Their results indicated a branching ratio of three percent. [212] Subsequent calculations gave branching ratios of two to five percent in the disintegration from ^{238}U. This uncertainty, together with variations in the ratio of protactinium to uranium in minerals, strengthened the view that "the actinium series is not a direct offspring of the uranium series."[213]

Gleditsch and colleagues join the hunt

The homelessness of actinium and the discrepancies in the Ac/U ratio aroused Gleditsch's interest. Together with Ernst Føyn and Sverre Klemetsen (1901-?) she determined the ratios Ac/U and Pa/U in three minerals by measuring their alpha activities and comparing them with a uranium oxide standard. They found the branching ratio to vary between 2.7 and 3.3 percent.[214]

The experiments required the painstaking separation of actinium from the rare earths (including protactinium and thorium/ionium). Since they assumed that protactinium followed the reactions of tantalum, the activity of protactinium was measured via that of "tantalum." Gleditsch described the precipitation and purification of actinium and protactinium as "extremely delicate," comprising "serious difficulties," which was probably the reason for the differing results of Boltwood, Hahn and Meitner, and James Wildish.[215] Being an experimental chemist, acknowledging the limitations of her methods, she indicated an error of five to ten percent, and considered her consistent results as "probably accidental."[216] The main experimental difficulty was separating thorium and ionium from the other rare earths as well as from actinium.

Two years later (1934) Gleditsch and Føyn reported new results with new minerals and different methods. They measured the ratio of actinium to ionium, and this, together with a generally accepted value for the ratio uranium/ionium, gave the percentage disintegration of actinouranium to uranium I.[217] Analysis of seven different minerals resulted in a branching ratio of 4.0%, which coincided

212. Otto Hahn and Lise Meitner, "Der Ursprung des Actiniums," *Physikalische Zeitschrift, 20* (1919), 529-533; Otto Hahn and Lise Meitner, "Über die chemischen Eigenschaften des Protaktiniums," *Berichte der Deutschen chemischen Gesellschaft, 52* (1919), 1812-1828.
213. Wildish (ref. 199), 164.
214. Ellen Gleditsch and Ernst Føyn, "Dosage de l'actinium dans les minerais d'urane," *CR, 194* (1932), 1571-1572; Ellen Gleditsch and Sverre Klemetsen, ""Sur le rapport actinium-uranium dans une uraninite ancienne, la clèveite de Aust-Agder," *CR, 194* (1932), 1731-1732.
215. Gleditsch and Føyn (ref. 214), 1571.
216. Ellen Gleditsch and Sverre Klemetsen, "Sur le rapport actinium-uranium dans une uraninite ancienne, la clèveite de Aust-Agder," *CR, 194* (1932) 1731-1732, on 1732.
217. Ellen Gleditsch and Ernst Føyn, "Sur le rapport actinium-uranium dans les minéraux radioactifs," *CR, 199* (1934), 412-414.

with recent investigations by von Grosse and Tcheng Da-Tchang, but disagreed with those of Wildish, which varied from 1.47 to 5.16.[218]

In 1928 von Grosse at the University of Chicago isolated protactinium pentoxide (Pa_2O_5).[219] He found that except for precipitation by ammonia, a reaction characteristic of many metals, protactinium and tantalum had only one reaction (among the reactions he investigated) in common – the solubility of their oxides in hydrofluoric acid.[220] Hahn and Meitner, and also Gleditsch, had failed to purify protactinium because they believed its reactions followed tantalum's. Their determination of the branching ratio of actinium to uranium was therefore unreliable.[221] Von Grosse isolated protactinium from radium residues, which principally comprised silicon dioxide (SiO_2), ferric oxide (Fe_2O_3) and lead monoxide (PbO), which contained the protactinium. Separation of the protactinium with zirconium phosphate from this mixture of basic oxides followed after leaching the melt.[222]

In 1934 pure protactinium pentoxide (Pa_2O_5) was finally reduced to metal by bombarding it with a stream of electrons in a high vacuum, transforming the oxide into a halide, and cracking the halide on an electrically heated tungsten filament, again in a high vacuum.[223] Shortly after the isolation of metallic protactinium, von Grosse determined its atomic weight, yielding a mean value of 230.6. The accepted value today is 231.0.[224] This was also the value Aston predicted five years earlier. With the atomic weight of protactinium the weight of every member of the actinium series could be determined. Evidence for the existence of ^{235}U grew.[225]

The activity of the actinium series compared to that of the uranium series (*R*) was later (1939) modified by Alfred O. Nier (1912-1994) to 4.6%, this being 0.6%

218. Aristid von Grosse, "On the origin of the actinium series of radioactive elements," *PR, 42* (1932), 565-570; Marcus Francis and Tcheng Da-Tchang, "Sur la valeur du rapport de bifurcation de la famille de l'actinium par rapport à la famille de l'uranium-radium," *CR, 198* (1934), 733-735. Wildish (ref. 199), 175.

219. Aristid von Grosse, "The isolation of protactinium," *Nature, 120* (1927), 621; Aristid von Grosse, "Die Konzentrierung und Isolierung des Elements 91—Protactinium," *Die Naturwissenschaften, 15* (1927), 766-767; Aristid von Grosse, "Das Element 91; seine Eigenschaften und seine Gewinnung," *Berichte der Deutschen Chemischen Gesellschaft, 61* (1928), 233-246.

220. Aristid von Grosse, "The analytical chemistry of element 91, ekatantalum, and its difference from tantalum," *Journal of the American Chemical Society, 52* (1930), 1742-1747.

221. Aristid von Grosse, "On the origin of the actinium series of radioactive elements," *PR, 42* (1932), 565-570.

222. Aristid von Grosse and M.S. Agruss, "The isolation of 0.1 gram of the oxide of element 91 (protactinium)," *Journal of the American Chemical Society, 56* (1934), 2200. For a more detailed technical description, see Aristid von Grosse and M.S. Agruss, "Technical extraction of protactinium," *Industrial and engineering chemistry, 27* (1935), 422-426.

223. Aristid von Grosse, "Metallic element 91," *Journal of the American Chemical Society, 56* (1934), 2200-2201.

224. Aristid von Grosse, "The atomic weight of protactinium," *Journal of the American Chemical Society, 56* (1934), 2501.

225. Sime (ref. 201), 115.

higher than the value obtained by Gleditsch five years earlier. Nier plotted the experimental values for $^{207}Pb/^{206}Pb$ (corrected for common lead impurities) as a function of the age of the mineral from which the lead came. A value for R equal to 0.046 gave the closest fit to the experimentally determined points.[226] Again this led to modification of the decay constants and half-lives of UI and AcU. The assumption of Boltwood and Rutherford that uranium and actinium were genetically related was thus correct, although branching was not involved as they had assumed.[227]

Investigations of ^{40}K

Until Gráf arrived in 1939/40, Gleditsch had used an electroscope to measure radioactivity. She then shifted to Geiger-Müller (GM) counters, to investigate the radioactivity of rocks, a field she baptized radio-geology. Using the GM-counter Gleditsch and Gráf discovered an intensive gamma-ray from ^{40}K, which prompted a reevaluation of the past and present heat balance of the earth.[228]

Gleditsch and Gráf developed a simple method to determine the amount of potassium in diverse substances—a necessary step to allow correction of their measurement for the presence of activities foreign to the uranium and thorium series.[229] They measured the radioactivity emitted from a material under investigation with a GM tube and compared the activity to a substance containing known amounts of potassium. This could be done without chemical transformations or loss of material and with a sensitivity down to 0.1% potassium in the sample. In two studies they found deviations in the intensities of the radiation from various salts, indicating the presence of a ray from potassium more penetrating than its beta ray.[230]

226. Alfred O. Nier, "The isotopic constitution of radiogenic leads and the measurement of geological time II," *PR, 55* (1939), 153-163. Von Grosse commented that the variation in magnitude of ten percent was not problematic, as variations in investigations before 1932 were much larger (Aristid von Grosse, "The actinium series of radioactive elements and their influence on geological age measurements," *PR, 55* (1939), 584-585).
227. Badash (ref. 173), 208-209. Today it is known that naturally occurring uranium consists of three isotopes, ^{238}U (99.3%), ^{235}U (0.720%) and ^{234}U (0.00550%). That 4.6 atoms of ^{235}U disintegrate per 100 atoms of ^{238}U is accepted also today. Branching is also known to exist today, although it was a blind alley in the search for the origin of actinium. E.g., actinium (^{227}Ac) decays in ninety-nine percent into thorium (^{227}Th), whereas one percent decays into francium (^{223}Fr). The element francium and the branching of actinium were discovered by Marguerite Perey in 1939, at the Radium Institute in Paris (George B. Kauffman and J. P. Adloff, "Marguerite Perey and the discovery of francium," *Education in chemistry, 26* (1989), 135-137).
228. Pappas (ref. 67).
229. Ellen Gleditsch and Tibor Gráf, "Dosage rapide du potassium par la mesure de son rayonnement radioactif," *Archiv for mathematik og naturvidenskab, 44* (1941), 63-72.
230. Ellen Gleditsch and Tibor Gráf, "Sur la radioactivité des sels de potassium," *Archiv for mathematik og naturvidenskab, 44* (1941), 145-157; Gleditsch and Gráf (ref. 229).

Gleditsch and Gráf continued their work on potassium, but postponed publishing it until 1947 owing to war conditions. They reported gamma rays much more intense than previously known. Luis Harold Gray (1905-1965) and G.T.P. Tarrant had counted three gamma-quanta emitted for every 100 disintegrating potassium atoms; Gleditsch and Gráf counted seven.[231] By comparing their measurements of potassium (as a pure K_2SO_4 salt) with counts given by cleveite, they concluded that one gram of potassium emits the same number of quanta per second as $(1.23 \pm 0.15) \times 10^{-10}$ g of radium.[232] These findings had immense implications for the understanding of the part ^{40}K plays in heat production in rocks as well as in ionization of the air. Then recent measurements by Victor Francis Hess (1883-1964) had disclosed a large discrepancy between the value of the ionization in air produced by the gamma-rays of the different radioactive substances in Quincy granite, and that computed from the concentrations of these substances known from the measurements of Robley Evans (1907-1996) and Clark Goodman.[233] Hess' estimate for the total ionization of the air by granite came to less than half the experimental value. The results of Gleditsch and Gráf yielded a value for the ionization by potassium much closer to the measured value.[234] This meant that "in the case of granites, the gamma-rays of potassium play a more important part in the ionization of the air than those of the uranium and thorium families together."[235]

The high intensity gamma-ray found by Gleditsch and Gráf also implied a much higher heat production from potassium-containing rocks. Together with findings by Leonidas D. Marinelli (1906-1974) et al. of a higher beta-ray energy than previously estimated, their results increased the total heat output per gram of potassium by a factor of eight.[236] Potassium then accounted for twenty percent

231. L.H. Gray and G.T.P. Tarrant, "Phenomena associated with the anomalous absorption of high energy gamma radiation," Royal Society of London, *Proceedings, A143* (1934), 681-706.
232. Ellen Gleditsch and Tibor Gráf, "On the gamma-rays of K^{40}," *PR, 72* (1947), 640-641.
233. Victor Francis Hess, "Analysis of the gamma rays from granite and the ionization balance of the atmosphere," *Norsk Geologisk Tidsskrift, 27* (1947), 1-13.
234. Hess estimated 0.50 ion pairs formed per cm3 per second *(I)* by potassium, based on Evans and Goodman's result that one gram of potassium is equivalent in its gamma-ray effect to 1.6×10^{-11} g of radium, and this gave a total ionization of the air by granite of 2.06 *I*. This contrasted the experimental value of 5.18 *I*. Using Gleditsch and Gráf's results, the ionization of air by granite reached 4.16 ± 1.25*I*.
235. Ellen Gleditsch and Tibor Gráf, "Significance of the radioactivity of potassium in geophysics," *PR, 72* (1947), 641.
236. For 3.6 ± 0.8 gamma-quanta of 1.55 ± 0.05 MeV emitted per second, $(7 \pm 2) \times 10^{-6}$ cal. would, according to Gleditsch and Gráf, be released per year per gram of potassium. The recent findings of Marinelli et al. of a higher beta-ray energy would give a total heat output of $(38 \pm 7) \times 10^{-6}$ cal. per year per gram of potassium - $(31 \pm 6) \times 10^{-6}$ cal. for the beta decay alone—in contrast to Evans and Goodman's compute of $(5 \pm 2) \times 10^{-6}$ cal. per year

of the total heat production in acidic igneous rocks. According to Gleditsch and Gráf, potassium played a much more important role in the early history of the earth, when "the heat produced by ^{40}K alone was about 200 times that generated at present by all the radioactive elements in the earth together."[237]

Gleditsch and Gráf's work generated great interest. Hess and J. Donald Roll eliminated the possibility that the greater gamma-intensity found in certain igneous rocks arose from artificial radioactivity induced by cosmic rays. William Urry showed that by adding the amounts of uranium, thorium, and potassium equal to the original amounts in the granite, the radiation was doubled, "strongly support[ing] the latest value for the gamma emission of potassium-40 determined by Gleditsch and Gráf."[238] Other scientists confirmed their result of 3.6 quanta per second per gram of potassium.[239]

Gráf continued to work on the radioactivity of potassium after moving to Stockholm to work with Meitner. In 1948 he published a new half-life for potassium, as he had found errors in the value he and Gleditsch had used in the heat production of ^{40}K. Consequently he had to recalculate the heat production from potassium; he now found that eleven percent of the total radioactive heat derived from potassium.[240] Before Gráf recalculated the half-life, the theoretical heat produced in the earth's crust by radioactivity seemed too high for it to have existed for more than 10^9 years.[241] With the new value "the heat produced in the earth's crust could certainly not prevent rock formation."[242] Yet, at the time of the earth's origin the heat produced by the radioactivity of potassium alone probably exceeded ten times the total radioactivity now generated in the earth's crust. Gráf however did not investigate this finding further; his later work on radioactive potassium concerned the branch ratio between electron capture and beta-decay in the disintegration of ^{40}K.[243] More recent calculations have revealed that ^{40}K contributes about fifteen percent of the radioactive heat generated in the crust and that its share was larger

per gram of potassium (Robley D. Evans and Clark Goodman, "Radioactivity of rocks," *Bulletin of the Geological Society of America, 52* (1941), 459-490, on 480; Gleditsch and Gráf (ref. 235).

237. Ibid.

238. William D. Ury, "Gamma-radiation from granite," *PR, 73* (1948), 596-601. See also Francis Birch, "Recent work on the radioactive isotope of potassium and some related geophysical problems," *Journal of geophysical research, 56* (1951), 107-126.

239. G.A. Sawyer and M.L. Wiedenbeck, "Gamma-ray of K^{40}," *PR, 76* (1949), 1535; William R. Faust, "Specific activity of potassium," *PR, 78* (1950), 624; Birch (ref. 238).

240. Tibor Gráf, "On the half-life of K^{40}," *PR, 74* (1948), 831. He then obtained $(22 \pm 3) \times 10^{-6}$ cal. per year per gram of potassium (in contrast to $(38 \pm 7) \times 10^{-6}$).

241. The problem was raised by Francis Birch, "Geophysics and the radioactivity of potassium," *PR, 72* (1947), 1128.

242. Tibor Gráf, "Significance of the radioactivity of potassium in geophysics. II," *PR, 74* (1948), 831-832.

243. Tibor Gráf, "Electron capture/beta-decay ratio in K^{40}," *PR, 79* (1950), 1014; Tibor Gráf, "On the radioactivity of K^{40}," *Arkiv för fysik, 3* (1951), 171-208.

in the past, as predicted by Gleditsch and Gráf.[244] This is a consequence of the relatively larger half-lives of ^{238}U and ^{232}Th.

Disseminating science

Gleditsch eagerly shared her science with the general public. She started this mission with an essay on radium in the popular magazine *For kirke og kultur* (*For church and culture*) in 1907.[245] Later she described the latest results in radioactivity in the popular journals *Nordisk tidsskrift för vetenskap, konst och industri* (*Nordic magazine for science, art and industry*), *Teknisk ukeblad* (*Technical weekly*), *Tidsskrift for kjemi og bergvesen* (*Journal for chemistry and mining*), *Fra fysikkens verden* (*From the world of physics*), and *Veneficus* (a pharmaceutical magazine). Her more demanding articles for Scandinavian colleagues appeared in *Archiv for mathematik og naturvidenskab* (*Archive for mathematics and science*).

After retiring in 1946, Gleditsch wrote about the history of science. She had already published more than twenty-five biographies on chemists and physicists and a couple of articles on the history of chemistry. She wrote preferentially about French chemists: Auguste Laurent, Marcelin Berthelot, Claude Louis Berthollet, and, above all, Antoine Lavoisier, to whom she dedicated a whole book.[246] Inevitably, she covered contemporary Nobel laureates: Richards, Soddy, Aston, Irène and Frederic Joliot-Curie, Edwin McMillan, and Glenn Seaborg.[247] Her last manuscript, devoted to the Swedish chemist Carl Wilhelm Scheele, was finished shortly before she died on June 5, 1968.[248] Her historical accounts are mainly internalistic, partly hagiographic, but informative to a Norwegian audience. More interesting today are her notices of the people she knew, although they, too, tended to be biased. Of

244. Knut S. Meier and G.K. Billings, "Potassium," in K.H. Wedepohl, *Handbook of geochemistry*. Vol 2:2 (Berlin, 1970), 19-B-2; G.J. Wasserburg, Gordon J.F. MacDonald, F. Hoyle, and William A. Fowler, "Relative contributions of uranium, thorium, and potassium to heat production in the earth," *Science, 143* (1964), 465-467.
245. Ellen Gleditsch, "Radium," *For kirke og kultur* (1907), 211-223.
246. Ellen Gleditsch, "Auguste Laurent 1807-1853," *Meddelelser fra Norsk Farmaceutisk Selskap, 28* (1966), 10-11; Ellen Gleditsch, "Marcelin Berthelot 1827-1907," *Tidsskrift for Kjemi, Bergvesen og Metallurgi, 25* (1965), 177; Ellen Gleditsch, "Claude Louis Berthollet," *Naturen*, no. 4, 1965; Ellen Gleditsch, *Antoine Laurent Lavoisier* (Oslo, 1956); Forelesn (Spring 1937, Spring 1941).
247. Ellen Gleditsch, "Theodore William Richards," *Tidsskrift for Kemi, Farmasi og Terapi, 13* (1916), 1-8; Ellen Gleditsch, "Nobelpristagerne i Kemi: Frederick Soddy, Francis W. Aston" *Tidsskrift for Kemi og Bergvæsen, 2* (1922), 159-162; Ellen Gleditsch, "Årets nobelpristagere i kjemi," *Urd, 39* (1935), 1477-1478; Ellen Gleditsch, "Edwin M. McMillan og Glenn T. Seaborg: Nobelprisen i kjemi i 1951," *Fra fysikkens verden*, no. 4 (1951), 173-179.
248. Ellen Gleditsch, "Carl Wilhelm Scheele," *Naturen*, no. 6 (1968).

Soddy she wrote: [249]

> There is something of the fairytale of Aladdin about Soddy in the way he makes his debut—in his statement of the great law in radioactivity....And he is also Aladdin-like, not only as a scientist with particular interests, but also as an unusually cultivated and knowledgable man, witty and creative in speech and writing.

Gleditsch devoted several articles to Marie Curie, almost always in a praising tone. Once she mentioned that Curie's lectures were mediocre and her voice monotonous and low, shortcomings more than compensated by her scientific qualities. "[She] forgets nothing, she neglects nothing, and she judges with a well-developed critical sense every experiment's pros and cons."[250]

In another sort of popularization Gleditsch wrote textbooks. In 1917 she helped Professor Thorstein Hallager Hiortdahl revise his then old textbook on inorganic chemistry. Hiortdahl was then seventy-eight, Gleditsch about half his age, impatient, and with clear ideas about modernization. It was a trying experience. At one point Hiordahl wrote to Gleditsch about changing the word "daily" into "commonly": [251]

> This world is such that almost every person has some hobby-horse or other. You, in your ways, have some very pretty ponies, which are so brilliantly drilled, that whenever they encounter a participle they rise on their hind legs. But you ride yours with such grace, that you become irresistible and I submit, not in the least because on several occasions (do you remember some awful phrases on mould?) I have had to admit that you were right. There was, however, on page 86 in the manuscript a phrase with a participle, but where the ponies only pricked up their ears. I wrote "those daily employed," but you wrote "those commonly employed": I congratulated the participle for having escaped alive; but is there actually such a difference between these two expressions that it is worth while making a correction. If you wish, you can do so.

249. Gleditsch (ref. 247), 160. Other interesting aspects of Soddy are given in her later biography; Ellen Gleditsch, "Frederick Soddy 1878-1956," *Naturen, 8* (1963), 489-508. Ellen Gleditsch, "Maria Sklodowska Curie," *Tidsskrift for kemi, farmaci og terapi* (1912), 1-9; Ellen Gleditsch, "Maria Sklodowska Curie," *Tidsskrift for kjemi og bergvesen* (1934); Ellen Gleditsch, "Maria Sklodowska Curie," *Naturen* (1934); Ellen Gleditsch, "Maria Sklodowska Curie" [in English], *British Federation of University Women news sheet,* no. 14 (1934); Ellen Gleditsch, "Marie Sklodowska Curie og hennes sosiale og humanitære verk," *Kvinnen og Tiden,* no. 12 (1946); Ellen Gleditsch, "Marie Sklodowska Curie," *Nordisk Tidsskrift* (1959) (ref. 10).
250. Gleditsch (ref. 249), 1912.
251. Letter from Thorstein Hiortdahl to Ellen Gleditsch, 4 Jan 1917, Letter collection no. 456, NBM.

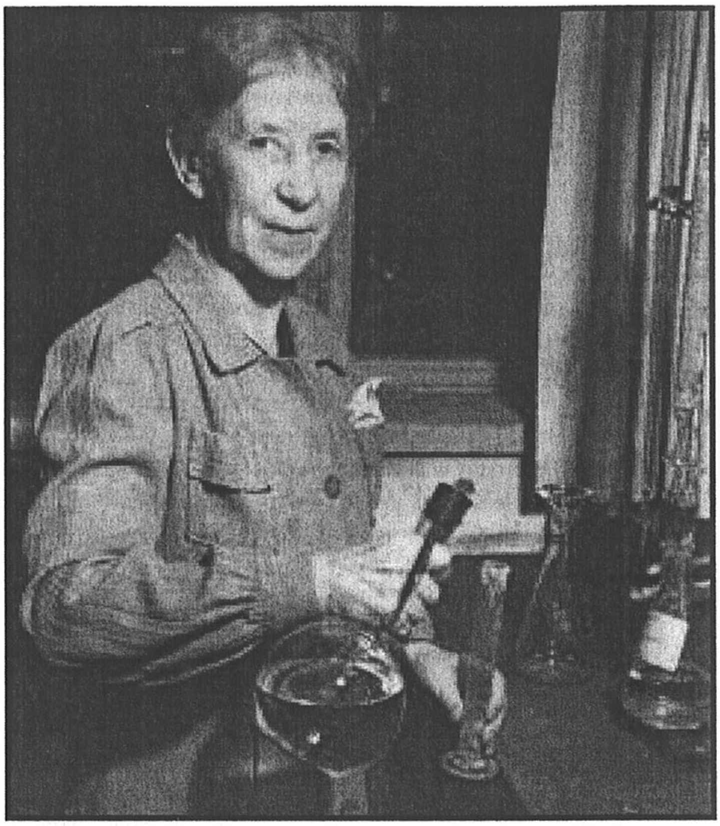

FIG 9 Ellen Gleditsch in her laboratory. *Source:* Courtesy of Scanpix.

Two days later, he wrote about the relative merits of CH_3COOH, the modern formula for acetic acid, and the empiric formula, $C_2H_4O_2$, which he preferred. "So, you want the 'modern' formula for acetic acid. The formula $C_2H_4O_2$ is completely modern, it expresses the actual facts (composition in percentages, molecular weight, gas density, etc.) and it will—as long as today's values for the atomic weights are retained—never become outdated." Still he had "cohabited with chemistry, almost for two generations," and preferred the empirical way.

Gleditsch vented her frustration about this collaboration to Boltwood: "Professor Hiortdahl is still living, but when I accepted to undertake the work I expected that he would give me free hands to change what I found necessary. I was mistaken, he is very interested in the book, and nothing can be written without his consent, and he is a very old man, so I often found it very hard to meet him half way....I do not think I will cooperate in writing a textbook anymore."[252] More than twenty years

252. Letter from Ellen Gleditsch to Bertram Boltwood, 1 Mar 1916, YUL.

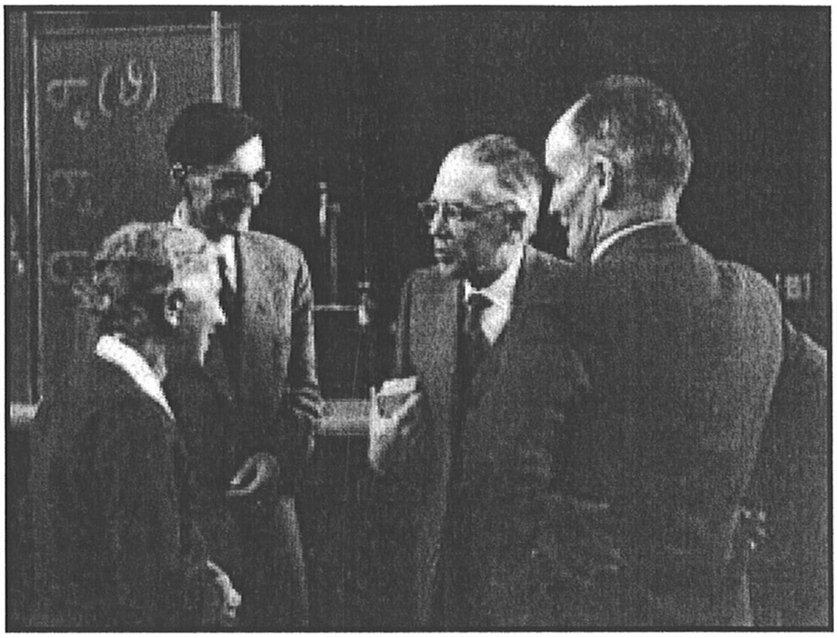

FIG 10 Ellen Gleditsch, Alexis Pappas, Emilio Segré and Egil Hylleraas in Oslo after Segré received the Nobel prize in physics in 1959. *Source:* Courtesy of Alexis Pappas.

later, in 1940, she did try again, this time with Einar Jensen. It had a second edition in 1947.[253] Inorganic chemistry had developed to such an extent that an entirely new book seemed necessary to Gleditsch. Jensen, a former student and teaching assistant in inorganic chemistry, was almost twenty years younger than she, his fresh attitude and modern ways of teaching probably suited her. Apparently this collaboration went without friction—for her side. She was now the senior author.

With her Swedish life-long friend, Eva Ramstedt, whom she first met in the Curie Laboratory in Paris, writing a book (in Norwegian and Swedish) on radioactivity was a pleasure.[254] They described the phenomenon of radioactivity, its history, methods, results and consequences at the time, 1917, and also the effects of radioactive radiations on the human body:[255]

> The influence on the skin is considerably weaker if the preparation is held at a distance, and especially if the rays have first to pass a metal screen. Therefore, when you are carrying radium salts with you, these should be kept in lead capsules;

253. Ellen Gleditsch and Einar Jensen, *Lærebok i uorganisk kjemi* (Oslo, 1940, 1947).
254. Ellen Gleditsch and Eva Ramstedt, *Radium og de radioaktive processer* (Oslo, 1917).
255. Ibid., 70-71.

> and when handling vials or bottles with radium salts, these should preferably be manipulated with tongs and exchanged from hand to hand, generally you should never keep [anything radioactive] for a long time in the same position in your hands.

Gleditsch also published a popular book on radioactivity, *Radioaktivitet og grunnstofforvandling* (*Radioactivity and the transformation of the elements*, 1924), and she gave radio talks about her subject in the best tradition of professors at the University. All reviewers emphasized her ability to make radioactivity intelligible to people ignorant of chemistry. A reviewer in a woman's magazine thought that "it would probably take a rather empty brain not to profit from reading [*Radioaktivitet og grunnstofforvandling*]." Gleditsch's gift for disseminating science was emphasized even by Heinrich Goldschmidt, who would be her harshest critic over the professorship in 1929.[256]

In 1948 Gleditsch was awarded an honorary doctorate at the University of Strasbourg. In his speech of presentation, the Dean of the Faculty of Sciences, said that there are two main reasons for awarding such a degree: admiration for his or her scientific work, and gratitude for the contributions to the university. Gleditsch was chosen for both reasons, as an internationally acknowledged scientist especially devoted to France, and as a friend of Marguerite Perey, founder of the Center for Nuclear Research at Strasbourg.[257] For years Gleditsch had sent Norwegian chemistry students to Strasbourg. "These students ["these tall blond boys and even girls, with shining eyes"], you must forgive them, Mademoiselle, if they disclosed some secrets to us. For without them we would not have known that of all professors in Oslo, nobody is as venerated as you, we would not have known that there you are the Mother of all students." In 1962 Gleditsch became the the first woman to receive an honorary doctorate from the Sorbonne in Paris; she was then celebrated as the "oldest living pioneer of nuclear physical and chemical research."[258] Gleditsch was a pioneer in radiochemistry and as a woman scientist. She helped transform the University of Oslo into a research institution. Although she did not succeed entirely in institutionalizing radiochemistry, she had the satisfaction of success by proxy through her student, Alexis Pappas.

256. Heinrich Goldschmidt, "Litteratur: Ellen Gleditsch og Eva Ramstedt, *Radium og de radioaktive processer*. Kristiania forlagt av H. Aschehoug & Co. (W. Nygaard) 1917," *Tidsskrift for kemi, farmasi og terapi, 15:5* (1918); K.R., "Moderne vitenskap: Ellen Gleditsch, 'Radioaktivitet og grundstofforvandling.' Olaf Norlis forlag," *Norges Kvinder*, 19 Nov 1924.
257. Speech by professor Kirrmann, in *Université de Strasbourg, 1948* (Travaux de l'Université), kindly given to the authors by Sébastien Soubiran, in charge of the scientific archives at the University of Strasbourg. George B. Kauffman and Jean-Pierre Adloff, "Marguerite Catherine Perey (1909-1975)," in Louise S. Grinstein, Rose K. Rose and Miriam H. Raifailovich, ed., *Women in chemistry and physics: A biobibliographic sourcebook* (Westport, CT, 1993), 470-475. Professor J.P. Adloff, quoted in Kronen and Pappas (ref. 2), 180-181.
258. Speech of Guillaume Valette, quoted in Kronen and Pappas (ref. 2), 193.

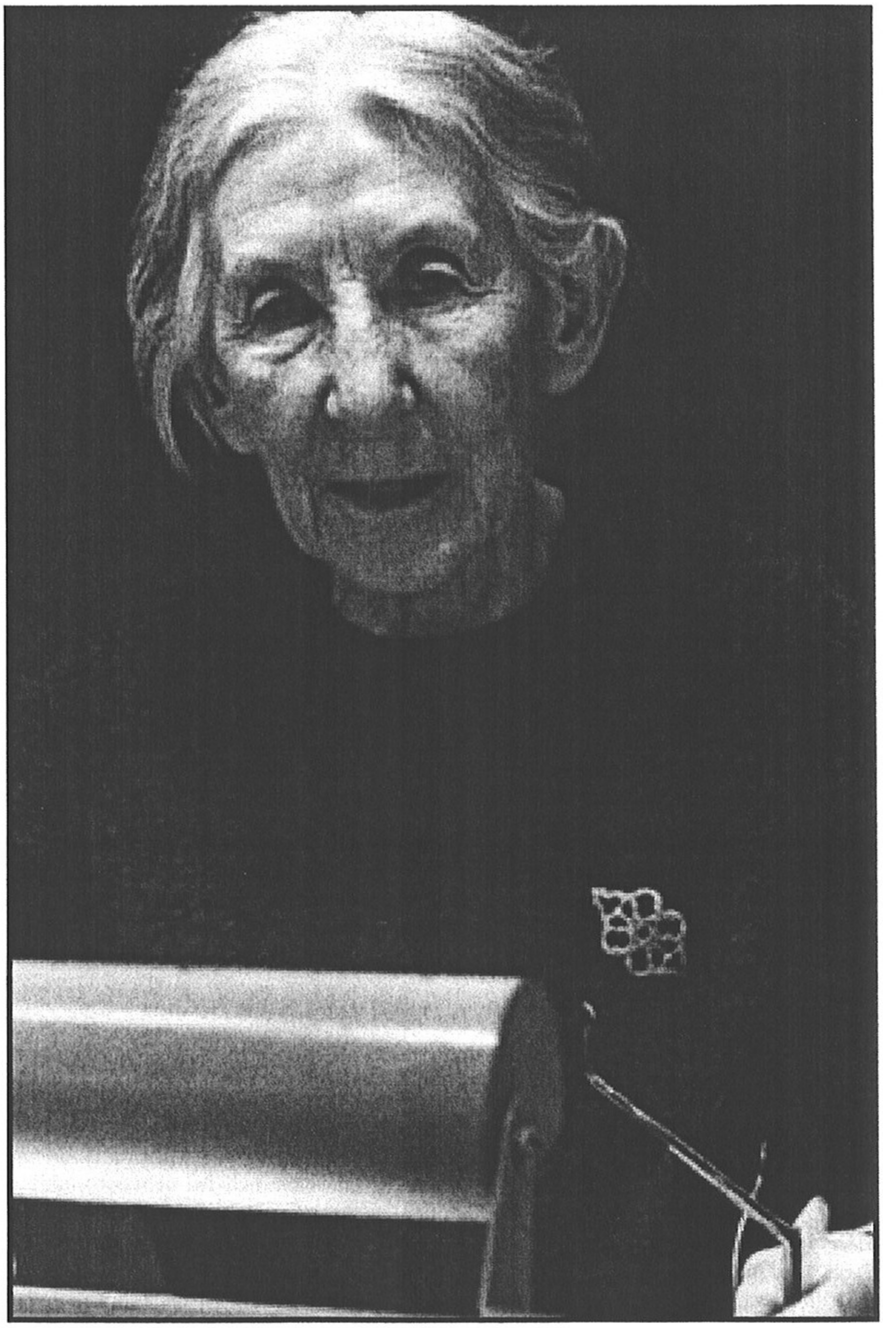

FIG 11 Ellen Gleditsch (88 years old) gave a one-hour talk about Marie Curie in the Chemistry Department of the University of Oslo in 1967, one hundred years after Curie was born. *Source:* Courtesy of Scanpix.

ANNETTE LYKKNES, LISE KVITTINGEN, AND ANNE KRISTINE BØRRESEN

Ellen Gleditsch: Duty and responsibility in a research and teaching career, 1916-1946

ABSTRACT

Ellen Gleditsch (1879-1968) became Norway's first authority of radioactivity and the country's second female professor. After several years in international centers of radiochemistry, Gleditsch returned to Norway, becoming associate professor and later full professor of chemistry. Between 1916 and 1946 Gleditsch tried to establish a laboratory of radiochemistry at the University of Oslo, a career which included network building, grant applications, travels abroad, committee work, research, teaching, supervision, popularization, and war resistance work. Establishing a new field was demanding; only under her student, Alexis Pappas, was her field institutionalized at Oslo. This paper presents Gleditsch's everyday life at the Chemistry Department, with emphasis on her formation of a research and teaching laboratory of radiochemistry. Her main scientific work during this period is presented and discussed, including atomic weight determination of chlorine, age calculations in minerals, the hunt for actinium's ancestor and investigations on ^{40}K.