The Invisible Light

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Contents.

Editorial:

The front cover shows the BSHR stand at UKIO 2024. We had a good conference with a well-attended stand, including education on the stand. The history session was well attended. We hope to see you at UKIO next year.

Sadly in 2024 we have seen several significant deaths of those involved in the history of radiology. These are Michael Jordan, the late CEO and General Secretary of the Society and College of Radiographers, who died unexpectedly in July. Michael trained in the old Bromley School of Radiography and had a deep interest in the history of radiography. I was pleased to have been able to help him with a history project in the past. Michael was a strength of the Society and College in his time which witnessed many significant changes. We reprint an appreciation by Audrey Paterson and Richard Price. Other deaths include Willi Kalender the pioneer of spiral CT scanning, our committee member Brian O'Riordan, and Stephen Bates who pioneered computer applications in CT scanning. It is noteworthy that there were the deaths of two who played such a pivotal role in the development of the CT scanner.

Adrian Thomas
adrian.thomas@btinternet.com

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Stephen Bates: An Appreciation.
By Adrian Thomas.

Sadly, Stephen Bates died in April 2024 after a long illness. The family decided not to hold a funeral, but to simply have a cremation.

Stephen worked with Godfrey Hounsfield and Peter Langstone right from the very beginning of the development of the CT/EMI scanner, and he wrote the first program to reconstruct the image for both the lathe test bed and then the prototype brain scanner. I first met Stephen when a group of us who knew Godfrey wrote his definitive biography (at least for now). [1]

Stephen played a major role in the development of the EMI/CT scanner. He had his first meeting with Godfrey Hounsfield in the November of 1967. Stephen had joined the CRL (Central Research Laboratories) of EMI in January 1967, joining a computer group. This was in the early days of computers and both analog and digital computers were in use. By 1968 Godfrey had persuaded the DHSS (The Department of Health and Social Security – who supported EMI in the development of the scanner) of the value of the scanner proposal and had also persuaded Stephen to write the computer program. The project to develop the scanner was a difficult one. The computers were primitive the reconstruction times for the CT scanner slices were long, and funding was veery tight. There is no truth to the urban legend that money from profits that EMI received from the Beatles funded the scanner.

In 1971 Stephen left CRL to join SE Labs which was a part of EMI. SE Labs were undertaking cutting edge work on computers and their software. Stephen returned to the CRL to work with Godfrey in 1971. By 1975 the EMI Emerald body scanner had been developed and Godfrey and Steven visited the hospital departments where the scanners had been installed. There were three sites: in the USA the Mayo Clinic and the Mallinckrodt Institute in St Louis, and in the UK at Northwick Park Hospital in Harrow. The high regard in which Godfrey held Stephen can be shown by the fact that he was the only person, other than Godfrey's family, who was invited to the Nobel Ceremony in 1979 when Godfrey received the prize with Allan Cormack.

Following the introduction of the scanner, EMI became embroiled in a series of patent litigations, and Steven was able to assist with questions involving the early years of the development of the scanner.

Godfrey made a series of visits to the USA in 1977, and Stephen accompanied him on occasions. The situation for EMI became difficult and in early 1978 Steven, with others, was involved in producing a report for McKinsey in Chicago about the current situation.

[1] Bates S, Beckmann E, Thomas AMK, Waltham R. (2012) Godfrey Hounsfield: Intuitive Genius of CT. London: The British Institute of Radiology.

The contributions that Stephen made to computer science and to the development of the EMI/CT scanner were quite remarkable, and the radiological community owes him a huge debt of gratitude.

The John Clifton essay prize 2024.

The John Clifton essay prize for 2024 had seven excellent submissions, and judging was difficult.
The first went to Kimberley Bradshaw for her excellent essay ‘Albert Salomon: The Man Behind the Mammogram’. This essay is reproduced below.
The runner up prize went to Samuel Ward for his essay ‘The Making of an Early Interventional Radiologist’. This essay will be reproduced in *The Invisible Light* next year.

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Willi A Kalender (1949-2024): An Appreciation.
By Adrian Thomas.

The death of Willi Kalender at the age of 75 marks a significant loss to radiology. He worked at the Institute of Medical Physics, Friedrich-Alexander- University, Erlangen-Nürnberg.

Willi Kalender was born in Thorr, Nordrhein-Westfalen, Germany, in 1949. He received both his master's degree and his PhD in medical physics from the University of Wisconsin, Madison in 1979. In 1988 he completed his post-doc-toral lecturing qualifications (habilitation) for medical physics at the University of Tübingen in Germany.

From 1979 to 1995 Kalender worked in the research laboratories of Siemens Medical Systems in Erlangen, Germany. He was the head of the department of medical physics from 1988 to 1995. He became adjunct associate professor of medical physics at the University of Wisconsin in 1991 and from 1993 to 1995 he lectured at the Technical University of Munich in Germany. Kalender was appointed full professor and director of the newly established Institute of Medical Physics at the Friedrich-Alexander-University Erlangen-Nürnberg, Germany in 1995.

His main research interests are in the area of diagnostic imaging, and the development and introduction of volumetric spiral CT has been a particular focus.

He was nominated as distinguished visiting professor at Stanford University Department of Radiology in 2001, and adjunct full professor of the department of medical physics at the University of Wisconsin. He is also a member of the International Commission on Radiation Units and Measurement (ICRU). He was honorary lecturer of the European Congress of Radiology and the European Association of Radiology in 2002.

Kalender received many rewards and in 2012 was awarded FBIR, the Honorary Fellowship of the British Institute of Radiology (BIR). Kalender was elected member of the National Academy of Engineering (2016) for the development of spiral computed tomography.

I met Willi Kalender on several occasions when attending the European Congress of Radiology in Vienna and took the photograph that accompanies this piece. He was charming and very knowledgeable about the development of CT. Some years ago, Arpan Banerjee, Uwe Busch and I wrote an anthology of modern radiology 'Classic Papers in Modern Diagnostic Radiology' [2] where we reprinted the classic papers that define our modern radiological practice. This book may be downloaded from the Springer website. In the section on CT, we reprinted Kalender's 1990 classic paper 'Spiral volumetric CT with single-breathhold technique, continuous transport, and continuous scanner rotation'. [3] Willi Kalender graciously wrote the foreword, and commented:

> I am very pleased to have been asked to write the foreword to this book.
> The technical advances in diagnostic radiology in the last few decades have transformed clinical practice and have been nothing short of astonishing.
> The subject of diagnostic radiology is now very large, and radiology departments are involved in all areas of modern patient care. The defining event in modern radiology, and arguably the most significant development in radiology since Wilhelm Röntgen discovered X-rays, was the invention of the CT scanner in the 1970S. The CT scanner introduced modern cross-sectional imaging and also digital imaging. We now have MRI and ultrasound, and these techniques are replacing many traditional X-ray procedures. The developments in radiology have been the result of a fruitful interaction between the basic sciences, clinical medicine and the manufacturers. This can be seen by looking at the various sources of these publications. Change is produced by the interactions between the various disciplines.
> The editors have had a very difficult task in selecting the key discoveries and descriptions. The radiological literature is very large. Medical imaging continues to develop rapidly, and these papers are the foundations of our current practice.

[2] Classic Papers in Modern Diagnostic Radiology. Adrian M K Thomas, Arpan K Banerjee & Uwe Busch. Springer Verlag (2004).
[3] W.A. Kalender, W. Seißler, E. Klotz, P. Vock. Spiral volumetric CT with single-breathhold technique, continuous transport, and continuous scanner rotation.
Radiology 176 (1990): 181-183

In 2000 Kalender wrote a book 'Computed Tomography: Fundamentals, System Technology, Image Quality, Applications'. [4] This remarkable and interesting book gave a comprehensive and user-friendly description of the theoretical and technical system fundamentals of computed tomography (CT) as it was in 2000, describing the original conventional single-slice acquisitions to the new volume acquisition with the recent Multislice Spiral CT. The book covers in detail all characteristic parameters relevant for image quality and all performance features significant for clinical application. Kalender was concerned that operators were informed how to optimally use a CT scanner, which will depend on the different diagnostic requirements. The book includes a detailed discussion about the dose required and about dose measurements as well as how to reduce dose in CT. Special considerations was paid to Spiral CT.

In the preface to this book Kalender noted that: 'X-ray computed tomography (CT) brought slice imaging into wide use for the first time and represented its breakthrough. Today, CT is an essential part of radiological diagnostics and can be seen as a mature and clinically accepted procedure. It has supplemented or replaced classical x-ray imaging in many areas. Kalender went on to say that: A rapid technical development phase in the seventies was followed by an uneventful phase with no essential highlights in the eighties. This was partly caused by the expectation that the importance of CT would decrease successively due to the introduction of magnetic resonance (MR) tomography. Contrary to these expectations, CT is in a phase of rapid technical development and again broadening its application spectrum. The development of spiral CT and the transition from scanning single slices to the rapid scanning of complete volumes has made CT attractive again and has led to decisive developments in technical and in clinical perspectives. The introduction of multi-row detector systems and scan times in the sub second range currently constitute the high point of these developments.

The radiological community owes Willi Kalender a huge debt of gratitude.

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[4] Kalender, Willi A. (2000). Computed Tomography: Fundamentals, System Technology, Image Quality, Applications. Munich: Publis MCD Verlag.

An Appreciation: Brian O'Riordan (1935 - 2024).

By Adrian Thomas.

Brian was an active member of our UK radiology history group and was a long-standing member of the council of the BSHR. He was deeply interested in the history of dental radiology. Brian was Consultant Oral Surgeon at the Department of Oral & Maxillofacial Surgery at Mount Vernon Hospital and Consultant Dental Radiologist to the Department of Oral Radiology, Guy’s, King’s & St Thomas’ Dental Institute, at King’s College, University of London. He was an active member of The British Society of Dental and Maxillofacial Radiology and made significant contributions in many areas.

In an e-mail Brian wrote that: Some of you will know of my great interest in Art and especially the effect on artists of the discovery of X-rays in 1895. Artists in Paris were thinking of different ways of presenting their ideas and when they read in the newspapers the banner headlines “A new way of Seeing”. There were other discoveries at the time which led to a ferment of creative ideas especially among Marcel Duchamp, František Kupka, Francis Picabia and Pablo Picasso, etc.

Developments following Röntgen’s discovery of 1895:

1896 H Becquerel, Radioactivity.
1897 J J Thompson Electrons (Corpuscles).
1898 M Curie, Radium.
1911 C T R Wilson, Cloud chamber.
1911 E Rutherford, Nuclear structure.

Brian noted that all of these discoveries led to Duchamp producing the paintings The *King and Queen surrounded by Swift Nudes* (1912) and *Bride Stripped bare by her Batchelors* (1915). Both of these (paintings) showed electrons whizzing around the figures and stripping them. The path of these electron is very difficult to see in reproductions of the paintings. You will have to go to the galleries!!

Picasso had a ‘think-tank’ that met regularly. One of its members was an insurance actuary named Maurice Princet who was very interested in science and used to explain to the other members the work of the great Henri Poincaré who was interested in representing the Fourth dimension. This was of great interest to Picasso who eventually produced the painting *Les Demoiselle d’Avignon* in 1907, the first Cubist painting and showing one of the ladies from three and four dimensions in the one figure. As a result of Maurice Princet’s influence he in sometimes called the mid-wife of Cubism.

Brian wrote that: My multiple secondaries were diagnosed in Jan 2023, so I was put into the 'last chance saloon' with Radium 223. It has not worked! During the treatment I was mildly radioactive and had to take care in the first two weeks of each treatment, so I commandeered one of our toilets and stuck a 'Radiation Hazard' sign on the door. Because I was mildly radioactive, I had a fanciful imagination that I was like Dr. Dumouchel. He was a schoolfriend of Duchamp who studied medicine and became interest in the uses of X-rays in Medicine. Duchamp depicted him (1910) with an aura around his hand representing the healing power of his calling and radioactivity. I have attached this portrait.

Brian's humour as he faced his illness was inspirational, and we remember him with affection.

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UKIO 2025: Community & Consciousness: One Health.

UKIO 2025, will be back in Liverpool on 2-4 June 2025. The 2025 title will be 'Community & Consciousness: One Health' and aims to encourage us as an imaging and oncology community to think about sustainability and the importance of joined-up thinking that considers the impact of our individual actions on the global village. The health of the population and the health of the planet are intrinsically connected and so this year's congress will also continue last year's theme of 'putting people first' both in terms of patients and the sustainability, health and wellbeing of the workforce

Once again, there will be plenty of opportunities for Industry to run their own sessions in the themed content hubs and be represented in curated UKIO sessions, and UKIO is keen to see the Education on the Stands programme continue to grow. The BSHR had a stand at UKIO 2024 and took part in education on the stand, and our thanks are due to Michael Jackson. We hope to have education on our stand in 2025 and could anyone who wishes to participate please contact me.

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BSHM Congress 2025.

The 31st BSHM Congress in 2025 will be held at the University of Leeds from Wednesday 10 to Saturday 13 September. The themes and topics are:

- Herbs, Potions and Magic Bullets
- Medical and Healthcare Learning

- Disability and Rehabilitation
- Miscellaneous Topics
- Keynote lectures, oral and poster presentations
- John Blair Lecture (supported by the John Blair Trust)

There are discounted registration fees for BSHM members (and BSHR members are therefore BSHM members). There are reduced registration fees for student delegates.

The John Blair Trust

Prizes: best undergraduate oral and poster presentations

Travel grants: UK undergraduates of medicine/allied sciences

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Interesting Web Sites.

Gray Cancer Institute, Mount Vernon Hospital, Northwood - June 2023.
https://www.derelictplaces.co.uk/threads/gray-cancer-institute-mount-vernon-hospital-northwood-june-2023.39181/
Edwin Aird pointed out this interesting web page. Its from the excellent 'Derelict Places: Documenting Decay' and posted by Landie Man on Sep 1, 2023. The Gray Cancer Institute is an important place for the history of radiology and radiobiology. Edwin told me that apparently the Gray Chapel is now being used by the hospital management, presumably following some cleanup. I visited Mount Vernon Hospital some years ago for the installation of a commemorative plaque for Hal Gray which I was involved in organising.

Royal Society Publishing& Memoirs.
https://royalsocietypublishing.org/journal/rsbm
Did you know that all articles in our Biographical Memoirs are free to access online? Explore the stories behind some of the greatest scientists who've ever lived:
Captivating accounts of the lives and scientific achievements of Fellows of the Royal Society.
All memoirs are now free to access online.
However, there is a paywall for much of the content.

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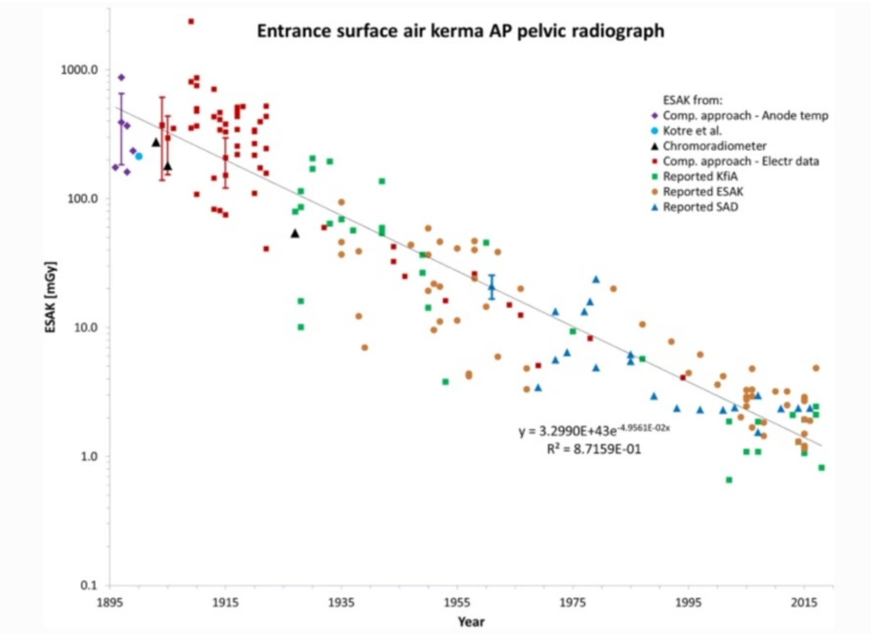
Interesting Books and Papers:

New Book: Pioneers in Radiology Worldwide.
Année: 2024
Collection: Collections du Musée de la Radiologie
Nombre de pages: 240
Auteur(s): Multiples

ISBN: 978-2-916669-31-1
'The book brings together the biographies of 195 X-ray pioneers from 38 different countries. Bibliographic and research work was carried out to identify and know the men who believed and developed Röntgen's original discovery.
These early heroes of the world contributed to the prodigious development of this discipline. They created a new specialty, Medical Radiology and Radiotherapy, which have established themselves universally.'
https://eboutique.radiologie.fr/produit/pioneers-in-radiology-worldwide/
https://www.livres-medicaux.com/radiodiagnostic/61035-pioneers-in-radiology-worldwide.html?_gl=1*1lr38jh*_up*MQ

Fine-needle aspiration (FNA) biopsy: historical aspects.
Emmanouil Magiorkinis B.Sc., M.D., Ph.D., Path.
©Polish Histochemical et Cytochemical Society Folia Histochem Cytobiol. 2009:47(2): 191 (191-197) doi: 10.2478/v10042-009-0027-x
This is a most interesting paper which aims to present the origins and the historical evolution of fine-needle aspiration biopsy and to also underline its importance in the history of modern cytology. This is of interest to those who perform radiologically guided biopsies.

The skin dose of pelvic radiographs since 1896.
Kemerink et al. Insights into Imaging (2019) 10:39
https://doi.org/10.1186/s13244-019-0710-1
Gerrit J. Kemerink Department of Radiology and Nuclear Medicine, Maastricht University Medical Center, P. Debijelaan 25, 6229 HX Maastricht, The Netherlands and his co-workers have published a most interesting paper.
Objectives: To derive conversions of antiquated exposure data into modern equivalents and to apply these in the assessment of the skin dose of pelvic radiographs since 1896.



Antiquated exposure data were successfully used for dose reconstruction. Extreme dose variability was a constant. Efforts to cut down doses were effective as skin doses went down from sub-erythema values to about one milli-gray.

The graph depicted is their figure 4, Entrance surface air kerma (which includes backscatter) for pelvic radiographs 1896-2018 (n = 182).
The paper is well worth a read.

How not to lie with statistics: The genius of Doug Altman (May 13, 2024).
https://www.auntminnieeurope.com/clinical-news/ct/article/15670593/how-not-to-lie-with-statistics-the-genius-of-doug-altman
A brief article and emphasising the importance of the correct use of statistics.

Electricity and Pancakes.
Adrian Thomas describes how the poet William Cowper used electricity to treat a friend who suffered a stroke. Posted on 3rd June 2024 by Lee Coppack | British Society for the History of Medicine (blog) https://bshm.org.uk/electricity-and-pancakes/
Electrotherapy is an interesting topic and many radiology/radiotherapy departments have their origin in electrotherapy departments.

Welsh Radical William Morgan (1750-1833): Apothecary, Scientist and Actuary.
Thomas AMK & Donaldson, C.
Topics in the History of Medicine. 2024; Volume 4: 151-174.
Topics in the History of Medicine – Volume 4
https://bshm.org.uk/thom/v4 ISSN 2753-9695
William Morgan was a remarkable man. He was interested in electricity and was a friend of Benjamin Franklin. It is thought that Morgan produced the first tube that could have generated X-rays!

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Michael Jordan FCR 1931 – 2024: An Appreciation.

Professor Audrey Paterson OBE H DHealth Brad FCR MSc
Professor Richard Price FCR PhD MSc TDCR

(Originally published in Synergy, an online publication of the SoR, and reproduced with permission.)

Michael Jordan, radiographer and former General Secretary and Chief Executive of the Society and College of Radiographers passed away unexpectedly during the weekend of the 6th of July 2024. He is survived by his wife Ann, and his daughters Gill and Sue and their families.

Michael hailed from Nottingham, moving from there to London to train as a radiographer under John Ashworth, a past President of the Society, at the Bromley School of Radiography. It was here that he met his wife Ann who also became a radiographer.

Image 1: Michael Jordan FCR in 1993.

In 1954, having passed his qualifying examinations, he worked at Brook General and Lewisham Hospitals before joining the Society in 1960, first, as Assistant Secretary under Mr K C Denley before succeeding him as General Secretary in 1976. He says he applied for the Assistant Secretary's post more by accident than on purpose and recalled that he was attending a Fellowship course at the Middlesex Hospital when he spotted an advertisement for the position. There was speculation that John Ashworth would apply, leading Michael to ring him on the pretext that he was thinking of applying. Ashworth's answer made it clear that he was not, and Michael forgot about it until John Ashworth rang to ask why he had not yet submitted his application, encouraging him to do so. Michael applied and was successful following interview by Ken Denley, Ray Hutchinson, Bill Rugg and Noreen Chesney. His initial salary was around £500 per year.

The relationship with Ken Denley was always formal and, even in the 2020s when talking about his early years, Michael always referred to him as Mr Denley, never by his first name. He recounted, too, that he was taken to task by Mr Denley for calling Council Member Ernest Higginbottom, Ernie.

Michael Jordan's influence on the Society was considerable. He was intimately involved in the major changes to education, from the introduction of A-level entry requirements in 1978, the change to a three-year training period, and on to degree programmes at the end of the 1980s/early 1990s. Michael took part in the Society's centenary oral history project and in his interview, he gave a flavour of his role in the long path to degree education.

One of Michael's early roles at the Society was as one of its Whitley Council representatives, taking on the mantle from Mr Denley in 1966. After almost two decades of fruitless negotiations, in 1968, Michael succeeded in reaching an on-call agreement that linked on-call payments to grades and salaries for the first time. Michael also represented the Society in the landmark Limbert case in the mid-1960s which led to significant change in NHS disciplinary procedures. Limbert lost his job as a result of unfair disciplinary action that had not followed due, or any, process. As a result, the Society refused to carry job advertisements from the hospital, maintaining an embargo for several months despite a number of appeals from the Ministry of Health. The Society only relented when the Ministry confirmed that the lessons learned in Mr Limbert's case would inform revision of NHS disciplinary processes.

In the 1970s much of Michael's time was taken up dealing with the abysmal pay rates for members and, in the pre-Halsbury Report period, he was instrumental in organising the Society's industrial and strike action, the march by members which he led with the president of the time, John Evans, and the rally in 1974. As he recounts in 'The Maturing Years A History of the Society and College of Radiographers 1970-1995', members were inflamed that a pay increase for other health workers had left radiographers even further behind. Action groups were formed in a number of the Society's Branches with 'radiographers determined as never before to ensure that they received a fair deal'.

After taking up the post of General Secretary on the 1st of January 1977, Michael oversaw the establishment of the College of Radiographers in the same year, and brought in much needed expertise from outside the profession to lead the organisation's industrial relations and education activities. Subsequent structural reform reduced the burden on Council by establishing standing committees with authority to make decisions within policy boundaries. Michael was also instrumental in stabilising the finances of the Society which were in a parlous state due to rampant inflation at the time, and the work associated with industrial action and the Halsbury Inquiry. The financial situation was not helped by an explosion in the boiler room at the Society's Headquarters less than a month after Michael became General Secretary, necessitating further expenditure of £12,000 to cover the shortfall in the insurance claim. In terms of education, the diplomas in nuclear medicine and medical ultrasound came to fruition during the 1970s and, importantly, were open to professions other than radiographers. On the professional front, Michael was at the helm when Council took the decision to amend the Articles of Association and repeal Article 21 at the 1978 Annual General Meeting. After more than 50 years, radiographers were once again permitted by their professional body to provide reports, a first step on the road to the development of the now widespread role of reporting radiographer.

In the 1980s, Michael oversaw the purchase of 13 Upper Wimpole Street, a much-needed move to extend the Society's headquarters to accommodate an increasing number of staff and other facilities needed to provide for increasing numbers of Society members and expansion of the Society's portfolio of activities to support them.

Progressive, collaborative and, when necessary, combative, Michael was at the helm for the Clegg report, TUC affiliation, the establishment of Med X Ray, and the advent of Patrons for the College amongst many other events. He was not afraid to speak his mind to Council members or to Government ministers and civil servants, for example his calling out of Patrick Jenkin MP in the 1980s for his criticism of radiographers intent on strike action because they would receive a pay cut if the Clegg report was implemented, and his battle with the Chief Scientific Officer in the 1990s in relation to his opposition to degree education for radiographers.

Image 2: Michael Jordan at the Society of Radiographers for the Oral History Project in June 2019.

Michael Jordan was a constant presence at the heart of the Society's annual conferences, usually with Ann, his wife. His judgement was always sound and one of his favourite stories was about a past president who accused him of 'nearly making a mistake'.

Michael retired as General Secretary and Chief Executive Officer in 1993, and at the Presidential Inauguration that year he was awarded the Silver Medal of the Society in recognition of his service to the profession. Michael gave of his time unselfishly and no more so than in the Society's Oral History Project in 2019 and he was of great assistance in our preparation of the book 'The Society of Radiographers,100 Years 1920-2020'. A true servant of the profession who dedicated almost forty years to radiography; a former colleague and a friend who will be sorely missed.

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Book Review: The Elements of Marie Curie (How the glow of radium lit a path for women in science).
Author: Dava Sobel
ASIN: B0CW1BQ7BH
Publisher: Fourth Estate (8 Oct. 2024).

Reviewed by Edwin Aird.

This new book on the life of Marie Curie (Marya Salomea Sklodowska Curie) takes its place among other biographies of this amazing woman. So many of the other biographies only plot Marie's life story. But the aim of Sobel is to knit together the extraordinary life of Marie Curie with many of the women that passed through her laboratory.

This is done in a special way: although she plots Marie's life sequentially the female visitors to the lab often appear almost as afterthoughts within some of the chapters. Sometimes I found it difficult to find the reference to the person in the title of the chapter heading, e.g. extreme example: **Eugenie** Feytis: not for 5 pages. The chapter for **Lucie** Blanquies begins: "**Ellen** Gleditsh- (a name from the previous chapter) was born in Mandal…". Chapter 11 (**Eva** Ramstedt) begins with the Langevin affair, and Eva is not introduced until fourth page of the chapter; (also much later in the book when the International Federation of University Women (IFUW formed by Ellen Gleditsch), [5] is discussed because Eva opens her own branch in Sweden). This causes a bit of confusion for the reader, but I recognise that it aids continuity of Marie's life story. It's a special way to introduce so many of the young women who visited her laboratory. [1]

[In the year 2024 when ISHRAD has gathered together pioneers in Radiology (with the help of BSHR) it is interesting to find these references to radioactivity pioneers. If Sobel had tried to write extensively about all her protégés the book would have been twice the size. See: Pioneers in Radiology Worldwide SFR book!]

Marie Curies story is an exceptional one, and Sobel makes this clear in her praise of not just the intellectual effort needed but the energy needed for the physically demanding tasks (for such a slight person) when purifying radium from tonnes of pitchblende, and the fighting for acceptance in the man's world.
Initially she was helped by her husband (particularly with the Nobel committee to get her accepted together with him), but after his very sad early death Marie had to fight her own battles: with the university; eminent societies etc. She did, of course receive a second Nobel in Chemistry. [5/225 women have Nobel prizes in Physics; 8 /194 Women have Nobel prizes in Chemistry; only 5 people in the world have 2 Nobel prizes, the others are men.]

[5] See Chapter Headings at end of this review.

Sobel discusses her dealings with Ernest Rutherford ….as a co-worker and correspondent; and her discovery of radium and the theory of radioactivity (her own name for this phenomena) provided Rutherford with a tool with which to explore the structure of the atom. Marie Curie agreed, on the advice of Rutherford, that her carefully produced radium standard (of 21.99 mg) should be stored at the International Bureau of Weights and Measures in Sevre. Secondary standards were then produced in Vienna, but brought to Paris at the BIPM before the certificates were signed by: Marie Curie; Ernest Rutherford; and Stefan Meyer; (and later by Irene Joliot-Curie who took her mother's place on the International Radium Standards Commission).

Marie Curie was a role model for many young women who wanted to spend their careers in science and represented an example to follow.
Some of the women (in the chapter headings) are discussed below.
There are others that occur within the text that are not identified in chapter headings, for example: (well-known in their own countries): Margarethe von Wrangell (from Germany); Sonia Cotelle née Slobodkine (Polish); Renée Galabert (French); Jeanne Lattes (French); Stefania Marcineanu (Romanian).
I have tried to cross-check any omissions with other author's work, e.g. Soraya Boudia list: for example, Sobel has omitted to mention some names, including Alice Prebil (A Croatian nuclear physicist she worked at the Curie lab 1932-1934; married Philip Leigh-Smith and became the first British woman to receive a PhD in nuclear physics). But I believe Sobel was not wishing to look this far ahead for the women visiting Curies' lab.

From Natalie's (Pigeard-Micault) book: "The women of the Curie laboratory therefore seems to undermine the first of the clichés about female pioneers in science that we still find (that they are not good enough?). The second cliché – if they marry, most stop their professional activity – must also be revised. Only seven out of twenty-three apparently stopped their careers after marriage".

Harriet Brooks (chapter 7) was one of these: Marie was still grieving in 1906 and didn't provide much support for her. Canadian born Harriet Brooks arrived 1906 (at 30 years old with experience in radioactivity research, some at McGill University under Rutherford and at also the Cavendish). In particular she studied the "emanation" from radium, eventually called Radon.
Harriet didn't stay long under these circumstances and when Rutherford offered her a fellowship in Manchester, she accepted rather than stay at the Institute 1907; but she didn't take up…since she then got married.

Let us look at a few of the others: Hertha Ayrton (chapter 13), a very able scientist (maths, physics, electricity; she had invented the "Ayrton Fan" in London, based on some work she had done with vortices, to help disperse the new weapon of war: chlorine gases used in the trenches of WW1) who became a firm friend of Marie Curie. She appealed to her for help when her daughter was imprisoned for militant activism for the suffragette cause. But also, recognising Marie's state of health gave her support (she was a trained nurse) offered her accommodation at a house in England not her house in London, but an old Hampshire mill house at Highcliffe–on sea). Marie stayed there for 2 months with her children (Irene was nearly 15 and benefitted from the English tuition she received).

A Sobel quote: “Marie’s normally quiet demeanour had evolved into an almost total social isolation. In a letter to **Eugenie** Feytis, her former student, who was now teaching physics at Sevres, she apologized for the change in her behaviour”

In chapter 14: Suzanne (Veil) Sobel mentions Einstein (see also my note with the Solvay Conference photo): “Marie tested her own strength and courage that summer by taking Irene and Eve on a walking tour through the alpine valleys of the Engadin in south-eastern Switzerland. There they hiked daily with Albert Einstein and his son Hans; Einstein was expanding his theory of relativity. Rutherford’s experiments with alpha particles had revealed the structure of the atom.” These little bits of physics demonstrate that Sobel had to do much work to understand the subject to write intelligently about it.

At the end of **Chapter 19 (Leonie)** Sobel write: “Rather than ally herself with the IFUW (see Ellen Gleditsch above) ……she agreed, along with Albert Einstein, Hendrik Lorentz (leader at first Solvay Conference, Kristine Bonnevie, and others-to be inducted into the International Committee on Intellectual Cooperation, an advisory arm of the new League of Nations.” (1919)

Missy (Marie Mattingly Meloney) was not a student or researcher, but a journalist. Marie Curie needed money to purchase more radium (having not patented it). She’d talked to “Missy” when she visited Marie in her lab. Somehow Missy, having appealed to the women of America was able to raise enough money in 1921 to buy 1 gram of radium (then worth $100,000). [At that time USA already possessed several grams of radium]
She wanted Marie Curie to come to USA, with both her daughters (Eve Curie enjoyed speaking to the press and was a good public relations person to have on the trip to the USA to collect the gift). Marie was also interested in how USA was producing radium in its chemical companies.
The climax of the trip was the handing over of the radium safe by President Harding at a White House reception. The radium was not in the safe at that point but the safe was “a mahogany chest weighing more than 46kg which would contain the radium in 10 tiny glass tubes”, (the weight due to the amount of lead protection) when Marie Curie was ready to depart back to France.

Sobel describes how exhausting this trip was for Marie (traveling on one of the White Star Line Ships - The Olympic- nearly the size of the Titanic). Even though she tried to rest she still suffered from exhaustion and Missy cancelled half her engagements. She returned on 28th June (1921) with the radium.

In October 1929, Curie returned to the United States for another tour, accompanied by Meloney: for a few days in the White House with President Herbert Hoover; to receive

$50,000 (which still bought 1gram radium at that time). This gift was used to treat cancer patients in Poland. She stayed with Meloney when she was in New York but was ill part of this time. Curie spent her sixty-second birthday with Meloney and motored with her in Central Park, and then they visited the J.P. Morgan Library.

Sobel uses **Marguerite Perey** (who joined the lab in 1929) in an **Epilogue** to her book. Marguerite continued to work after her mentor had died (1934), working with Actinium to understand its properties. She deduced that it contained a new element, which she labelled "Actinium K" (to place with an atomic number of 87 in the periodic table. Later she changed this name to the patriotic: Francium". "Everything I have done", she declared, "I owe to Marie Curie". In 1962 she became the first woman admitted to the Académie des Science.

Dava Sobel writes excellent prose (she current editor of the *Meter* poetry column in Scientific American); and her flow of story in Marie Curie's Biography works well. However, the use of these women pioneers as chapter headings always doesn't quite work. She doesn't give them enough space; and the chapter heading can be misleading. (see above).
However, the more I re-read this book and research the women involved in depth the more I enjoy Sobel's version, although I still am still critical of her lack of depth in describing the individual work of these women. But she captures something special by the interweaving; as one reviewer (Dr Patricia Fara, Emeritus Fellow, Cambridge) writes:" …….by restoring these pioneers to visibility, acclaimed historian Dava Sobel casts fresh light on the life and achievements of the first scientist to win two Nobel prizes". Reading between the lines one can see that there is an implication that the reader has to do more work to find out the detail of the lives of these women.

For those readers interested in all the women who attended the lab , I can recommend : Natalie Pigard Micault's book 2013; Marie Curie and Women in Science by Soraya Boudia (2011); or more broadly in terms of the women and their science: A devotion to their science by M F and G Rayner-Canham (1997);   Julie Desjardins: The Marie Curie Complex: The hidden History of women in Science (Women writing Science 2010).

Other contents of the book:
4 coloured pages: The periodic table; photos (including Rutherford; Andre Debierne - laboratory director); Bertram Boltwood; Henri Becquerel…and others; Figure: "The Elements according to Relative Abundance".

At the back of the book:
A complete list of **The Radioactivists.**
Annotations for each chapter: adding notes for clarification or extension, e.g.: **Chapter 3** "Paul Langevin later applied piezoelectricity to the problem of submarine detectors by sonar" (used in WW1).

Chapter 7. “The various titles of workers in the Curie lab, from *chef de travaux to trvailleur libre,* are outlined in “The Research School of Marie Curie in the Paris Faculty, 1907-1914” by J.L. Davis of the unit for the History, Philosophy and Social Relations of Science at the University of Kent, Canterbury, published in Annals of Science 52 (1995)”.
Glossary (of scientific terms).
The Radioactive Decay Series.
Quotation Sources.

Footnote:

1. I haven’t been able to decipher the meaning of elements placed in brackets in the chapter headings (except for the obvious ones: Harriet (emanation)…she was very involved with the production of Radon. Marthe (Chlorine) […production of fan for helping to remove poisonous gas from trenches in WW1]; Marguerite Perey (Francium) the woman who discovered Francium. There may be others obvious to readers: Her secretary Leonie (Oxygen) Razet.
2. In an excellent interview for Barnes and Noble (October 2024) Sobel admitted that she was planning to spend time in Paris at the Curie Museum, but that Covid (2019) prevented this (This gives us some indication of the time she has spent preparing and writing this book); but was able to use the web and all the digitised material , particular letters to put his book together, She also commented that following each chapter heading she gives a quote relevant to the element.

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Soraya Boudia. (A different reference from that given by Sobel). An Inspiring Laboratory Director: Marie Curie and Women in Science. Chemistry International---Newsmagazine for International Union of Pure and Applied Chemistry Jan-Feb 2011; 33(1).

Chapter Headings, but with addition of family names (only for the women visiting the lab; and my interpretation of length of time with help from Boudia 2011):

6) Eugenie (Radiotellurium) Feytis. French (a student and babysitter, not a scientist).
7) Harriet Brooks. (Emanation) Canadian 1906-7.
8) Ellen (Copper and Lithium) Gleditsch .1907-1912 and 1919-20 Norwegian.
9) Lucie (Helium) Blanquies. 1908-1910 French.
10) Sybil (Thorium) Leslie. 1909-1911 English.
11) Eva (Radium) Ramstedt. Swedish.
12) Jadwiga (Gold) Szmidt. 1910-1911 Russian.
13) Hertha (Carbon) Ayrton. English.
15) Suzanne (Platinum and Iridium) Veil. 1912-1914 French.
16) Iréne (Lead) Curie.
17) Marthe (Chlorine) Klein. 1919-1920 French
18) Madeline (Radioneon) Monin Molinier. 1917-1921 French.
19) Léonie (Oxygen) Razet. Marie Curie's Secretary (but gets a Chapter Heading), for 30 years, wife of Pierre Razat who worked in the lab for several years.
21) Catherine (Mesothorium) Chamié. 1919-1920 Russian.
23) Alicja (Polonium) Dorabialska .1925-1926 Polish.
24) Éliane (Polonium)Montel. 1925-1927 French.
25) Angèle (Bismuth) Pompéï.1927- 1928 French.
26) Isabelle and Antonia (Thallium) Isabelle Archinard. 1928-1932 French, and Antonia Korvezee. 1929-1941Dutch.
27) Branca (Boron) Marques. 1930-1936 Portuguese.
28) Willy (Beryllium) Lub. 1930-1931 Dutch.
29) Marietta Blau. 1932-1933 Austrian and Marie-Henriette (Aluminium) Wibratte. 1931-1934 French.

Epilogue: Marguerite (Francium) Perey 1928-1937 French.

The other chapters by family members are:

1) Manya (Hydrogen)
2) Marie (Iron)
3) Madame Curie (Tungsten and Molybdenum)
4) Pierre (Uranium)
15) Maurice (Ionium)
16) Irene (Lead)

22) Frédéric (Radon)
30) Ève (Radiophosphorus)

And of course, her American friend and journalist promoter:

20) Missy (Silver) Marie Meloney…. surprisingly not (Gold)!

Addendum.

I'd like to add my own experiences with radium in the UK NHS between 1967 and 1974 [….after which radium was removed from UK hospitals and Caesium 137 took its place], to give some idea of the amount of radium in sealed sources at that time: radium needles (containing 1-2mg radium) were used for implants in cancers; radium tubes (containing 10-25mg) were used for gynaecological cancers of the cervix and uterus. As a young medical physicist, I would take the radiographs of the sources in the patient and calculate the dose rate at various points (using the excellent Manchester Radium Dosage System 2nd edition 1967). From this information the total dose was agreed with the clinician (at that time known as a "radiotherapist"); the total time for the sources to stay in the patient (varying from 3.5 days for gynae patients to 7 days for implant patients) was determined, and agreed with me by the ward sister.
To give an idea of the amount of radium distributed around the UK (by The National Radium Commission) in 1929 was 4g (as individual sources 1-25mg). Larger radium sources were used in "radium bombs"; for example, the Middlesex hospital at that time (1930) had a radium bomb of 3g radium.

Other:

"Einstein was dazzled by the sparkling intelligence of Curie…. she was impressed with him too, and soon afterwards gave him a glowing reference that helped him to secure his first professorship in Prague" [History of Physics, When Einstein met Curie. Graham Farmelo, Science 2021; 373. An article introducing: Jeffrey Oren's book 'The Soul of Genius: Marie Curie, Albert Einstein and the Meeting that Changed the Course of Science'. Pegasus 2021]

Solvay conference photograph, 1911.

Marie Curie is the only woman in the picture. On right of Marie Curie is Jean Perrin, and on her left is Henri Poincaré. Behind her Rutherford (and to his left: Heike Kamerlingh Onnes, Albert Einstein, Paul Langevin.

The ceremony to receive an Honorary Doctorate (one of many listed by Eve Curie in her biography) at Birmingham University, 1913.

[Oliver Lodge is on her right, one of our Radiology Pioneers, as principal of Birmingham University said of Marie Curie, when she was awarded an honorary doctorate; “The greatest woman of science of all time”. Hendrik Lorentz in centre back]

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Albert Salomon: The Man Behind the Mammogram.

By Kimberley Bradshaw.
The Prizewinning essay for the 2024 John Clifton Essay Prize.

'I bet this was invented by a man!'- Introduction.

In the United Kingdom, 1 woman is diagnosed with breast cancer every 10 minutes and 1 in 7 women will be diagnosed with breast cancer in their lifetime (Breast Cancer Now, 2024). Men are also affected, albeit rarely. On average, approximately 400 men are diagnosed with breast cancer in the United Kingdom every year, compared with around 55,000 women (Breast Cancer Now, 2024).

Historically, breast cancer diagnoses had been made entirely through clinical evaluation (Nicosia *et al*, 2023). Today, mammography is the gold standard modality for imaging breast tissue due to its ability to detect fine pathologies using a low radiation dose (Hogg *et al,* 2015). It is, consequently, the most frequently used diagnostic test in the world (Nicosia *et al*, 2023). In the year 2022-2023, in England alone, 2.18 million women over the age of 45 received a mammogram, as part of the National Health Service Breast Screening Programme (henceforth NHSBSP; NHS England, 2024). A detection-rate of 8.7 cases per 1000 women screened in the NHSBSP (NHS England, 2024) underscores just how vital mammography has become in the detection of asymptomatic breast cancer. For symptomatic men and women, meanwhile, mammography is also a vital element of the one-stop clinic. NICE (2016) states that for patients presenting with symptoms of breast cancer, a triple assessment should be performed. This consists of a clinical assessment, mammography and/or ultrasound imaging, and a biopsy. Although many challenges are faced by the modality, and the practitioners involved in modern mammography, it continues to prove its worth in the clinical setting.

Despite its proven facility, women have been widely reported to exclaim "I bet this was invented by a man!" whilst undergoing a mammogram examination. In this regard, they would be absolutely correct. Albert Salomon (1883–1976) was one of the earliest pioneers of this intricate radiographic technique, which has since become such an integral element of breast cancer diagnosis, treatment and aftercare.

Early Life and Education.

There is very little literature around Albert Salomon's early life. We do know that he was born in the municipality of Röbel, Mecklenburg, on the 26th of January 1883, that his mother died in childbirth, and he was raised by his father and various other relatives. At the time of Albert's birth, Germany was in a period of great political and economic change. The German Empire was in its infancy, having only formed in 1871, following three successful wars led by Prussia (Ureña Valerio, 2019). Liberal reform resulted in independence for Germany, along with their own banking system, coinage, legal system and administration. As a result, Germany saw a massive increase in its economy, and by 1914 it was considered an industrial giant (Geary and Berentsen, 2024).

Albert came from a working-class background. He was successful at school and began studying medicine at the University of Berlin in 1900. Fischer-Defoy (2024) remarked that Albert graduated with the grade 'very good' before eventually receiving his licence to practice medicine. His early career was spent working as a Junior Doctor at Friedrichshain and Pankow Hospitals in Berlin, as well as the Jewish Hospital in Breslau. In 1909, he began working at the University Hospital in Berlin under the renowned surgeon, Dr August Bier (1861-1949). It would be this post that would set Albert off on the path to becoming a pioneer.

Early Experimentation.

Dr August Bier was a pioneer of medicine in his own right. He experimented with cocainisation of the spinal cord and is credited as being the first surgeon to complete a spinal anaesthetic (Johnson and Cadogan, 2022). It will have no doubt been an honour for Albert to have Dr Bier as his mentor, given his involvement with pioneering medical techniques. Even to this day, Dr Bier's many accolades are celebrated, including his invention of the steel helmet in World War I (Jackson, 2024).

Under Dr Bier's mentorship, Albert found an interest in breast cancer and how imaging could be used to benefit diagnosis, although there is limited literature available regarding this. Dr Bier clearly had an experimental approach to learning, and it may be fair to suggest this influenced Albert to conduct his own experiments. As remarked by Thomas (2022) Roentgen's discovery of x-rays in 1895 was phenomenal, and medicine was never the same again afterwards, as practitioners strived to discover how x-rays could enhance the diagnosis and treatment of patients.

The first mammogram was not performed on a patient, but on specimens obtained through mastectomies. Albert x-rayed over 3000 specimens, documenting his findings in his paper 'Contributions to the Pathology in Clinical Medicine of Breast Cancer' (Nicosia *et al*, 2023), which was published in the German journal *Archives of Clinical Surgery* (Thomas and Banerjee, 2013). Albert's work with the breast specimens allowed him to distinguish how different types of breast cancer present on x-ray, leading him to conclude that different types of breast cancer behave differently (Knipe, 2024). He also correlated the microscopic, gross and radiographic anatomy of the breast (Bassett and Gold, 1988).

Through the x-rays of the samples, Albert not only distinguished between cancerous and non-cancerous breast tissue, but his early observations led to the discovery that microscopic calcifications can be significant in breast cancer presentation. In modern day mammography, breast calcification presentation is a significant marker used in both breast screening and in symptomatic diagnosis (Elfeky, 2023). He also demonstrated how breast cancer can spread through lymph nodes. This proved a significant finding for the future development of breast imaging. In his paper, Albert concluded that "Roentgen photographs of excised breast specimens give a demonstrable overview of the form and spread of cancerous tumours" (Salomon, 1913).

These early findings enabled Albert to develop new methods of breast cancer analysis, and further evaluate how treatment could be tailored to an individual patient (Fischer-Defoy, 2024). This work created the foundation on which mammography would later be developed and contributed to the progression of breast cancer treatment. However, the outbreak of war saw such medical developments halted, and no further literature was published regarding the use of mammography until 1927 (Knipe, 2024).

World War I, Married Life and Personal Tragedy.

World War I broke out on the 28th of July 1914 and would prove to be one of the deadliest conflicts in World history. Although the war resulted in major advancements in medicine (Holder, 2004), it would also be uncontroversial to argue that doctors faced many setbacks in the development of their profession, and this is true of Albert Salomon. Whilst stationed abroad during the war, Albert met Franziska Grunwald, a military nursing sister. They married in 1916, and their daughter Charlotte was born a year later.

For the remainder of the war, Albert worked as a senior military physician for the German Army and spent time stationed at a military hospital in Tucquegnieux, France. When hostilities finally ended, Albert returned to Berlin and qualified as a professor in 1921 (Fischer-Defoy, 2024). He continued to work under August Bier, as Associate Professor at the Berlin Charité University Hospital, combining his love of medicine with teaching, and inspiring the next generation of doctors.

In 1926, tragedy struck when Albert's wife Franziska committed suicide. She had suffered with chronic depression, but Felstiner (2009) suggests her depression was worsened by Albert's distant nature as he overworked to succeed in medicine. Her death not only left Albert a widower, but a single father, with an 8-year-old daughter to single-handedly care for. The unexpected loss shook Albert, and he kept busy by further throwing himself into his work and research. He was promoted into the role of Extraordinary Professor of Surgery in 1927 (Fischer-Defoy, 2024).

The Nazi Rise to Power in Germany.

In 1930, Albert remarried internationally renowned singer Paula Lindberg. Paula was Jewish, and Albert made the decision to convert both himself and his daughter Charlotte to the Jewish faith. Albert's family life was settled once more, but it was not long before further hardship and tragedy ensued.

In 1933, the Nazi Party came into power in Germany. This political change brought with it changes for the Jewish community. Felstiner (2009) reflects that as a result Albert lost his post as Extraordinary Professor of Surgery, and his wife's singing career ground to a halt. Albert's daughter Charlotte was forced to leave school, and began putting all her efforts into her love of art. She would eventually become a famous artist, whose work is still admired to this day. In truth, most of the literature written about Albert's life exists only because of Charlotte's continued legacy in the world of art. Despite being committed to his Jewish faith, Albert managed to retain his licence to practice medicine and worked as the Head of the Surgical Department at the Jewish Hospital in Berlin. Fischer-Defoy (2024) reports that his licence was not revoked purely on the basis that Albert was a World War I veteran, who had served Germany in the war. Albert was, however, only permitted to treat Jewish patients, and was no longer authorised to teach.

On the night of the 9th of November 1938, savage antisemitic attacks against the Jewish communities across Germany took place. This event is also known as the 'November Pogrom' or 'Kristallnacht' meaning 'crystal night' or 'the night of broken glass'. On this night, the Nazi Party ordered the police to arrest some 30,000 Jewish men (Ross, 2019), one of whom was Albert Salomon (Felstiner, 2009). Those who were arrested were processed and sent to concentration camps. Following his arrest on the 10th of November 1938, Albert was sent to Sachsenhausen Camp in Oranienburg, Germany. The camp had been established in 1936 and was just 22 miles north of Berlin. During his time as a prisoner, he was starved, tortured, and forced into intense labour alongside his fellow inmates. Bentley (2017) reflects that just four months after being imprisoned, Albert lost half of his entire body weight and was completely emaciated. It is speculated that Paula, who was well connected via her career as a celebrated singer, managed to have forged documents drawn up to have Albert released. Although it is known that Albert did escape the camp, there is no evidence to suggest who had helped Paula with the documentation.

Fearing for their lives, the Salomon family realised they would need to leave Germany whilst they were still able to do so. Albert sent Charlotte to live with her maternal grandparents in the South of France, and he and Paula left for Amsterdam on the 15th of March 1939. Fischer-Defoy (2024) states that immediately after evading arrest, Albert and Paula's property and possessions were seized by the authorities.

Life in Amsterdam During World War II.

Upon arrival in Amsterdam, Albert learned that his German medical qualifications were not recognised. Determined to continue the work and research to which he was completely dedicated, Albert decided to study Dutch, and eventually enrolled to study Medicine once more (Fischer-Defoy, 2024). While Albert and Paula remained safe in Amsterdam, the same could not be said for Albert's daughter Charlotte. Tragedy had struck the family once more in 1940, as Charlotte's maternal Grandmother committed suicide. Following this tragic event, Charlotte's Grandfather admitted to Charlotte that her mother and aunt had both committed suicide also. Bentley (2017) reflects that, upon this sad discovery, Charlotte wrote to her father expressing her anger at him for keeping such secrets. The ghosts of the family's past will no doubt have widened the distance between father and daughter. It was at this time that Charlotte painted some of her most famous artwork.

In May 1943, Albert and Paula were arrested and deported to Westerbork Transit Camp. Westerbork was designed as a holding point for Jews arrested in the Netherlands, before they were processed and sent to death camps elsewhere (Etheredge, 2024). Fischer-Defoy (2024) reflects that during their time in the camp, both Albert and Paula worked as auxiliary helpers within the barracks of the camp. It was their working roles within the camp that secured them their eventual freedom. In November 1943 whilst pretending to collect medical equipment from Amsterdam, the pair escaped. For the remainder of the war, Albert and Paula remained in hiding in Southern Holland.

When the war eventually ended, and it was safe to return to Amsterdam, Albert learned that his daughter Charlotte had suffered the most tragic fate years earlier. Throughout the summer of 1940, Charlotte and her grandfather had been imprisoned in Gurs, a concentration camp in The Pyrenees. They were both eventually released, given Charlotte's Grandfather's infirmity, and were able to return home to Villefranche-sur-Mer in the South of France. However, upon their return, Charlotte is thought to have suffered a nervous breakdown and she moved out of her grandfather's home. Much of Charlotte's later life is debated in literature. Bentley (2017) suggests that Charlotte had suffered many years of abuse at the hands of her grandfather and may have even been responsible for his death in 1942, although it is hard to know what is factual and what is speculation. Just months after her grandfather's death in 1943, Charlotte who was now aged 26 and married, was arrested again. She was five months pregnant at the time and deported to Auschwitz concentration camp in Poland. She was killed within an hour of arriving at the camp, a fate that met the majority of pregnant Jewish women taken to Auschwitz. Albert had hoped to relocate to the United States of America and be reunited with Charlotte after the war, and so this latest tragedy in Albert's life was a heavy blow.

The End of World War II and Return to Amsterdam.

In 1946, Albert received his licence to practice medicine in the Netherlands. In 1947, Albert and Paula travelled to the South of France where they were presented with all of Charlotte's artwork. Mackenzie-Smith (2018) writes that before her arrest, Charlotte had entrusted her life's work to her friend Georges Moridis, telling him "Keep these safe, they are my whole life." The art of Charlotte Salomon is to this day celebrated, and widely viewed as a collection of pieces that portray her tragic life story. Albert ultimately donated Charlotte's artwork to the Jewish Historical Museum in Amsterdam, where to this day it is subject to exhibition.

In the following years, both Albert and his wife Paula decided they could never face returning to Germany and assumed Dutch nationality, with Albert continuing to privately practice medicine. Albert passed away on the 7th of May 1976, and is buried in the Liberal Jewish Community cemetery in Hoofddorp, near Amsterdam. In 2000, a commemorative stone was placed at his grave in honour of his daughter Charlotte, and in 2011, a plaque in his honour was placed at the house in Robel where he was born. Albert's wife Paula outlived him by 24 years, passing away at the age of 102 in 2000. In 2012, memorial plaques for both Paula and Charlotte were placed at the site where the family once lived in Berlin.

Lasting Legacy and Modern-Day Mammography.

Although Albert Salomon's contribution to the world of breast cancer diagnosis and treatment was halted prematurely, his early findings paved the way for future generations of surgeons, clinicians and radiologists alike to further develop his ideas.

As noted above, Mammography is a vital tool in the diagnosis and treatment of breast cancer and has today been developed far beyond the early work of Albert Salomon. In the years following this groundbreaking work, further research was published by surgeon Otto Kleinschmidt in 1927. The first mammogram on a patient was performed in the United States of America by radiologist Warren Stafford in 1930 (Nicosia *et al,* 2023). We know that during the time of these advancements, Albert Salomon was experiencing great tragedy, stress and unrest in his life and his research was somewhat interrupted. Without the tragic personal circumstances with which he was faced, as well as the political unrest and horrific events caused by World War II, perhaps Albert Salomon would have been free to further his work and build on the success of his early research.

In the 1950s mammography was developed further by radiologist Raul Leborgne, who further determined the benign and malignant patterns of microcalcifications, as well as experimenting with breast compression to improve image quality and reduce radiation dose (Nicosia *et al, 2*023). Collins (2015) reflects that the first dedicated mammography unit was introduced in 1965. By the 1970s, mammography was recognised as a useful screening tool for breast cancer. In 2000, the U.S FDA approved the first digital mammography unit, resulting in high quality, low dose breast imaging.

Although the mammogram examination itself remains highly unpopular, its use has contributed to the many advancements that have been made in prognosis and care of patients diagnosed with breast cancer.

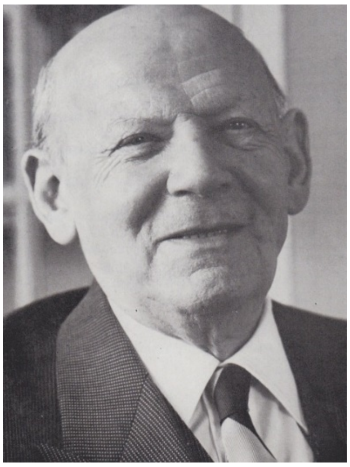
In the United Kingdom today, the role of the mammographer is a protected title, reserved for radiographers who have undertaken further postgraduate training. The introduction of the role has contributed to the widening scope of practice for diagnostic radiographers. Thanks to the developments within mammography, mammographers can easily enhance their scope of practice and undertake training to become advanced practitioners. Advanced practitioners may specialise in film reading, breast ultrasound, or stereotactic breast intervention. Mammographers can progress to a consultant breast radiographer role with experience. In the Society of Radiographers 2022-2023 workforce survey, 52.8% of consultant radiographers were working within the breast field (SoR, 2023), highlighting the opportunities for progression with the specialism.

Despite the opportunities mammography can lead to, there is currently a workforce shortage in the field, with approximately 12% of posts currently vacant (National Breast Imaging Academy, 2023). As a result, roles such as the assistant practitioner, and more recently, the mammography associate have been introduced to strengthen the workforce in the United Kingdom and improve the breast services offered within the National Health Service.

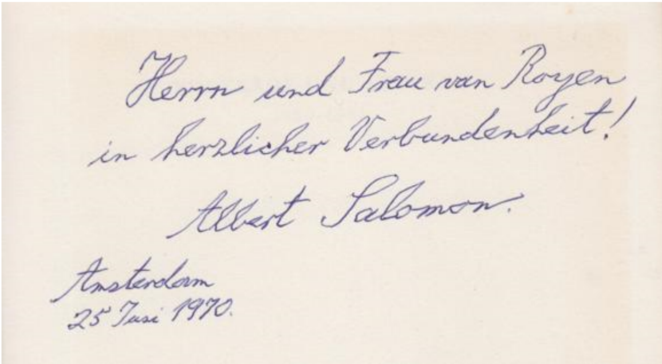
None of these advancements would have been possible without the early research of Albert Salomon, who overcame many personal tragedies, prejudices and adversities to continue his dedication to his work.

Images.

Dr Albert Salomon, pictured with his daughter Charlotte.
Case courtesy of Garth Kruger, Radiopaedia.org, rID: 30351



Dr Albert Salomon.
(Case courtesy of Garth Kruger, Radiopaedia.org, rID: 30351)



A letter written by Dr Albert Salomon, depicting his signature.
(Case courtesy of Garth Kruger, Radiopaedia.org, rID: 30351)

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