# 1

# Preliminary Remarks



The essential difference between a physics or chemistry book and a historical study lies in the accuracy and completeness of the sources. Any physics or chemistry article usually begins with a short introduction describing the background to the research, without necessarily going back to the original work. Furthermore, it is questionable whether all the articles cited have actually been read. For example, nearly all theses on material irradiation refer to an article by Kinchin and Pease for the creation of defects, more out of tradition than necessity. On the other hand, a historical approach must necessarily go back to the emergence of the idea, the concept, etc., which poses a number of problems for an amateur historian who, in order to be as close as possible to the truth, comes up against several difficulties. In the 19th century, articles contained few references to previous works and ideas were often germinated collectively, hence their appearance in several laboratories. Also, many early articles were written in the authors' own languages (in German, or Swedish, for example; fortunately, translation software makes it possible to understand them). Moreover, during the Second World War, a time of intense discoveries in the field of irradiation, advances were only disseminated in confidential internal reports. Added to this was the difficulty of obtaining certain reports, articles and books. Despite all this, writing this book required me to consult some 1,700 documents and translate around a hundred from German, only to cite 620 of them in this book.

The number of articles collected is nevertheless sufficient to extract some information on the evolution of the subject, bearing in mind that this corpus is dependent on the way in which I have traced the history of the concepts. The more difficult it is to find the source, the more articles there will be on the subject. Nevertheless, Figure 1.1 shows two key dates for the irradiation of materials: around 1900, when the discoveries of X-rays and radioactivity opened up the field of irradiation, and around 1940, when the Manhattan Project and the first nuclear

*A Historical Approach to Materials Under Irradiation*,
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reactors created a strong demand for scientific and technological data. The decline in the number of articles from the 1960s onwards does not correspond to a reduction in activity, but to the fact that the main concepts were well known.

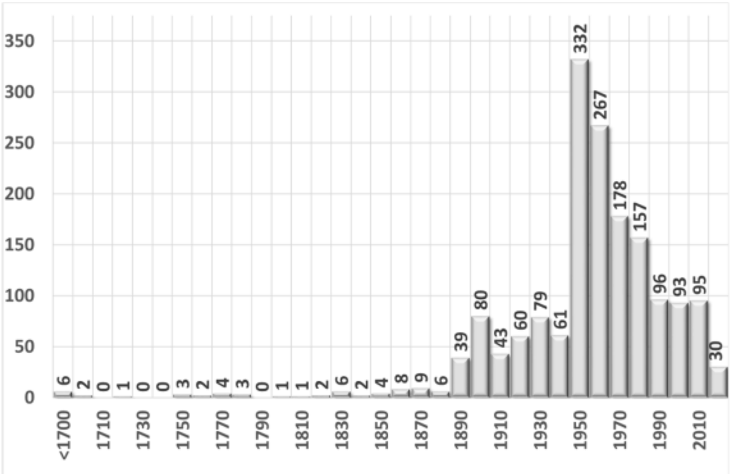


**Figure 1.1**. *Calendar distribution of publications consulted, highlighting the two key dates (1900 and 1950) in research on the irradiation of materials. For a color version of this figure, see www.iste.co.uk/bouffard/irradiation.zip*

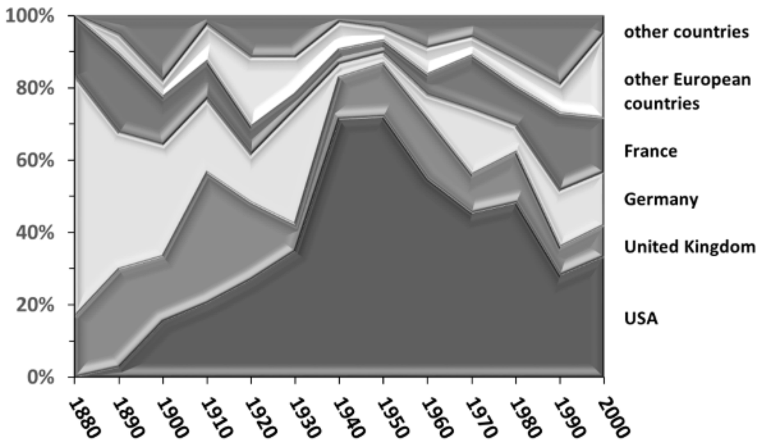


**Figure 1.2.** *Trends in the geographical origin of publications. The rise of the United States can be seen as early as the 1920s, while the Second World War considerably reduced the importance of Germany, the United Kingdom and France. For a color version of this figure, see www.iste.co.uk/bouffard/irradiation.zip*

Figure 1.2 shows the geographical distribution of those involved in this research. In the 19th century, advances came first from Germany, then from the UK and France. By the 1910s, Germany and the UK were competing with the United States. By the end of the Second World War, the situation had changed radically. The United States accounted for around two-thirds of all publications, while German research had virtually disappeared, although it would regain significant influence from 1975 onwards. The importance of France from the 1960s onwards is certainly overestimated, thanks to a better knowledge of the actors, most of whom I have come across during my career. Other countries that have contributed to our understanding of the effects of irradiation include Japan, Canada, Hungary and Russia, followed by Poland, Sweden, Holland, Australia, Spain and many others.

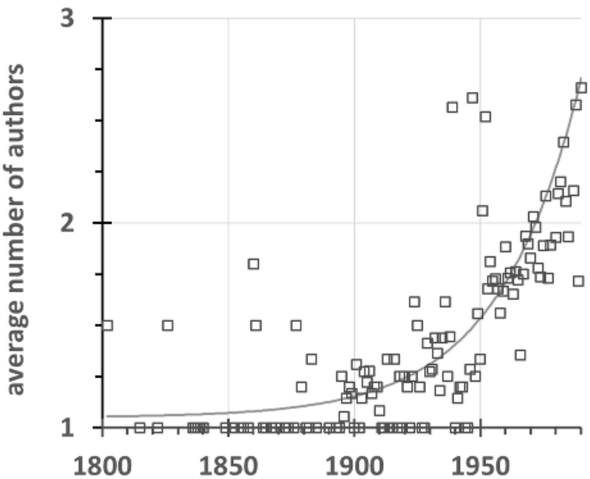


**Figure 1.3.** *Evolution of the average number of authors per publication, calculated on the basis of 1,690 references grouped together for this work. Before 1900, the vast majority of publications were signed by a single author. The solid line is a guide for the eye, adjusted for exponential variation*

Figure 1.3 shows the average number of authors per article. Until 1900, this number remained constant at around 1.1 authors per article, then rose steadily to reach three in 2000. This evolution is consistent with the evolution of research organization described by Krzysztof Szymborski in "*The Physics of Imperfect Crystals – A Social History*" (Szymborski 1984). He divides this history into three periods. First, research was carried out by independent researchers, often from the aristocracy. The notion of a research laboratory did not exist. The signatures on articles were simply "W.C. Röntgen", "*Note de H. Becquerel*" or "by William

Crookes, Fellow of the Royal Society "or, more precisely, "by J.J. Thomson, M.A., F.R.S., Cavendish Professor of Experimental Physics, Cambridge". The number of people who made a major contribution in this period remained limited to around 30, including E. Goldstein, C. Doelter, J.J. Thomson, E. Rutherford, W.H. Bragg, P. Curie, J. Frenkel and K. Przibram.

Next came the formation of schools of thought around a single personality, usually at a university. Examples include the Cavendish Laboratory at Cambridge University, home to eight Nobel Prize winners including J.J. Thomson, E. Rutherford and W.L. Bragg; the Physical Institute at Göttingen University, with N. Born, R.W. Pohl and J. Frank; the Institut für Radiumforschung, Wien, with K. Przibram, the Leningrad Institute of Physics and Technology with A. Joffe and J. Frenkel and many others.

Finally, the last stage developed by Szymborski is entitled "emergence of speciality". In the case of irradiated materials, this stage appeared during the Second World War with the Metallurgical Laboratory at the University of Chicago and the creation of nuclear research centers: Oak Ridge National Laboratory (1943) in Tennessee, Brookhaven National Laboratory (1947) in New York State (USA), Chalk River Nuclear Laboratories (1942) in Ontario (Canada), Atomic Energy Research Establishment (1945) in Harwell, Oxfordshire (United Kingdom), Centre d'Études Nucléaires de Fontenay aux Roses (1946) and Saclay (1947) (France), Kernforschungsanlage Jülich GmbH (1956) and Forschungszentrum Dresden–Rossendorf (1956) (Germany).

Before delving into the history of materials under irradiation, we will take a look at what led to the emergence of this discipline: the notions of impure or disordered materials, instrumental developments in high-voltage and vacuum techniques and, of course, the discoveries of X-rays, electrons and radioactivity.

## 1.1. References

Szymborski K. (1984). The physics of imperfect crystals – A social history. *Historical Studies in the Physical Sciences*, 14(2), 317–355.