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Book review

Firstenberg, A. *The Invisible Rainbow: A History of Electricity and Life*. AGB Press. 2017. (pp. 558). Paperback (ISBN: 978-0-692-68301-9). $35.

The Invisible Rainbow: A History of Electricity and Life

Does electricity have any detrimental effects on plants, humans and other animals, and if so *how much of a problem is this* and *why is it not a much bigger concern to us,* are the main questions which Arthur Firstenberg aims to answer in his book '*The Invisible Rainbow. A History of Electricity and Life*'. To understand the *raison d'etre* for writing this book, it is important to realise that its writer, a researcher, journalist and consultant, as well as a practitioner of "several healing arts", experiences the effects of self-diagnosed electro-hypersensitivity. As such, *The Invisible Rainbow,* is not only a work of popular science aimed at providing a historical account of the introduction of electricity into society and describing, based on early warnings about side effects of electric shocks and scientific experiments on humans, other animals, and plants, how this may affect biological systems, it is also a campaigner's warning about the consequences of the ubiquitous presence of electricity for human health and the environment.

The Invisible Rainbow is divided in two parts, entitled 'From the Beginning…' and '…To the Present'; roughly corresponding to a description of the history of how electricity became ubiquitous in modern society, interwoven with descriptions of historic experiments of effects of electricity on plants and humans in part 1, and a discussion of health effects on humans and the environment more generally, and their alleged associations with exposure to electricity in more modern times in part 2. The reason I am referring to 'alleged' associations in relation to the second part of the book is that it builds the argument regarding the detrimental effects of electricity on human health for a considerable part on work by Dr Milham. His work, described in his book '*Dirty Electricity: Electrification and the Diseases of Civilization*' (ISBN 978-1938908187) and related peer-reviewed papers, although thought-provoking, is one of correlations rather than causations and relies on weak epidemiological evidence. Although I specifically highlight the link to Dr Milham's work, because I am most familiar with the epidemiology, and have discussed inherent weaknesses in these data and the analytic method previously (de Vocht and Burstyn 2014), this relates to a broader issue regarding the scientific arguments made in *The Invisible Rainbow*: evidence is systematically brought together from a wide variety of sources spanning over 200 to 300 years but is of very varying quality. This should not necessarily be a problem, but unfortunately the synthesis of all these studies, anecdotal evidence and other sources of data, relies on supporting the central thesis of the book rather than on the scientific rigour and quality of data. Evidence from rigorous experiments are combined *on par* with results from studies that are, at best, fringe science, and are supplemented with anecdotes. As a result, it is difficult for readers, especially those unfamiliar with scientific enquiries in general, are new to this field, or who are unfamiliar with adjacent disciplines to their own, to infer how robust the scientific basis is for claims made in the book.

Nonetheless, despite misgivings, Firstenberg expands on Dr Milham's work significantly in terms of the inference and triangulation of different areas of science and relates the correlations described by Dr Milham to other epidemiological and mechanistic studies to strengthen the argument that electricity may have a part to play in the observed disease trends. This is a considerable strength of this book: whereas much of the work in this area is limited by the absence of credible biological mechanisms that could explain the correlated phenomena, *The Invisible Rainbow* goes to great lengths to provide explanations of how, at least theoretically, exposure to non-ionising radiation would link to health and environmental effects. Of course, the studies by Milham are also by no means the only evidence on which Firstenberg's thesis is built, and as such this book is a very detailed and rigorous work and succeeds in advancing the original arguments.

An additional concern with respect to the inference made by Firstenberg, is that many of the studies used to support the book's central thesis, especially those describing experiments, were conducted several decades (and often over a century) ago. This is not a problem by itself as scientific studies, if not falsified, remain as much scientific evidence as more recent studies; however, here they are generally presented as of equivalent if not stronger evidence than recent studies. Arguably, the scientific method, including accuracy and precision of measurement, has made great leaps forward over that time period.

As a result of these issues, to accept the thesis of '*The Invisible Rainbow*' the reader has to accept two important preconditions—1) there have been no significant improvements in the quality of research in the last (at least) 100 years, and 2) there has been a worldwide conspiracy started soon after the introduction of electricity in society and lasting to present day dedicated to hiding the true impact on health from non-ionising radiation. Personally, I do not find these two preconditions very convincing, at least not to the extent required to accept the book's conclusions, but other readers may be more willing to accept these. If you are willing to accept these preconditions,

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then *The Invisible Rainbow*' is a great book. It is probably one of the most detailed and best researched ones on the topic, and the arguments laid out in the book are clear and concise. If you are however, like me, not that willing to accept these in their totality, this is still a very interesting book on the history of electrification and possible effects on humans and the environment. In addition, it is also very well written.

It is however worth pointing out that although electromagnetic radiation includes a wide spectrum of different types of radiation (including for example Extremely Low Frequency (ELF) and Radio Frequency (RF) radiation, but also visible light) as well as different possible exposure levels and sources – and which have different effects on biological materials - this distinction is rarely made. Electricity is treated as a generic concept throughout, but it is left up to the reader to work out, which is sometimes difficult, whether a specific paragraph refers to ELF, RF or other frequencies. A possible way of working this out is to refer to the original source materials, which are provided in the extensive Notes and Bibliography (169 pages).

Regardless, the writing style is pleasant, the arguments are laid out in a clear and concise manner, and the book is aimed at the general public. So as a work of popular science it deserves a place on the shelves. It is, of course, not just a work of popular science. *The Invisible Rainbow* is also a call to arms. It is a call to recognise that biology is not just about chemistry, but also about electricity, it is a call to recognise that electrification of society could have effects on humans, animals and the environment more general, and most of all it is a call to arms for the recognition of electro hypersensitivity and to study this more and better. And in these calls to arms, Firstenberg has been very successful.

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