

studies. What she reveals is a very complex mixed economy of care from the 1870s to the 1920s, with hospital provision often costing mid-sized UK towns more than larger ones, a case study of Liverpool underlining how policy varied geographically.

While this might easily have become simply another book on twentieth-century health care in the UK and Ireland, this book, like the topic it covers, is a far more complex entity. The various chapters of this well-edited collection offer an extremely useful and refreshing introduction to students interested in the field of regional health care, summarising a rich seam of historical research. For this alone, I recommend it highly. However, the authors also, collectively, set an agenda for future research, which promises to guide the field, not only by addressing critical gaps in our knowledge, but by encouraging comparative, even multidisciplinary, approaches to voluntarism and regional health care in history.

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Robert G. McKinnell, *The Understanding, Prevention and Control of Human Cancer: The Historic Work and Lives of Elizabeth Cavert Miller and James A. Miller* (Leiden and Boston: Brill, 2016), pp. xvi, 196, \$50, hardback, ISBN: 9789004286795.

By the 1940s, it had been inferred that dozens of chemicals caused cancer in people or had been shown to do so in experimental animals. These chemicals came from a bewildering array of structural classes, including polycyclic hydrocarbons, aromatic amines, and others. A seminal paper¹ authored in 1947 by Elizabeth C. Miller (1920–87) and James A. Miller (1915–2000) provided the first clue to an underlying common mechanism for the biological activities of chemical carcinogens. They observed that feeding rats a carcinogenic dye resulted in a chemical bond between a metabolite of the carcinogen and liver proteins. Over the next twenty-five years, this extraordinary scientific team of husband and wife ‘discovered and developed the important unifying concept that most carcinogenic and mutagenic chemicals are not carcinogenic or mutagenic per se but that these compounds must undergo metabolism to reactive electrophilic metabolites that exert their effects by covalently binding to critical sites on cellular macromolecules (DNA, RNA, and protein).’² In addition to its importance as one of the foundations of modern cancer biology, this unifying concept has had broad societal implications for how we identify cancer-causing chemicals and how we protect people from them. The Millers’ discovery is so widely accepted that it is often cited without attribution and they have received relatively little recognition for their contributions outside the field of cancer research. Robert G. McKinnell has recently published an excellent biography of James and Elizabeth Miller, motivated in part by his desire ‘that the Millers should be recognised by the myriads of ordinary people whose lives have been impacted for the better.’

The first half of McKinnell’s book focuses on the arc of key discoveries made by the Millers and the context in which that research took place. Although this section is written in a clear and accessible style, it is likely to be challenging for readers who are not scientists or students of medical history to follow in detail. McKinnell discusses many

¹ Elizabeth C. Miller and James A. Miller, ‘The Presence and Significance of Bound Aminoazo Dyes in the Livers of Rats Fed p-dimethylaminoazobenzene’, *Cancer Research*, 7 (1947), 468–80.

² Allan H. Conney, Miriam C. Poirier, Young-Joon Surh and Fred F. Kadlubar, *Elizabeth Cavert Miller (1920–87) and James A. Miller (1915–2000): A Biographical Memoir* (Washington, DC: National Academy of Sciences, 2009).

of the important discoveries made by the Millers and their students and fellows following the 1947 paper and leading to the overarching concept cited above. As examples, they generalised the observation of covalent binding of carcinogen metabolites to cellular components to other chemical classes of carcinogens; made fundamental discoveries related to the enzymatic machinery responsible for the biotransformation of foreign chemicals; showed that, in many cases, these same chemicals could induce their own metabolism by the host; and demonstrated the DNA binding and mutagenic activities of many ultimate, carcinogen metabolites. Implications of this research outside the field of chemical carcinogenesis also receive significant attention from McKinnell, in particular in a chapter titled 'Serendipity: How the Millers Unintentionally Revolutionized Biology'. The Millers' discoveries related to biotransformation of foreign chemicals has, for example, great relevance to pharmacology and our understanding of the activities of drugs.

The second half of McKinnell's book, based on archival sources and interviews with family members, friends and colleagues, will be of broader interest because it focuses on James and Elizabeth Miller as people: how they grew up and came to science, how they came together and how they lived and worked, 'like the two strands of DNA', for forty-five years. For example, we learn that Elizabeth Cavert and James Miller came from very different backgrounds. She was raised in and around St. Paul, Minnesota, in an academic family. Her mother was a Vassar graduate with graduate training at Columbia and her father was an instructor at the University of Minnesota who later obtained a PhD. in agricultural economics from Cornell and became the Director of Research for the Farm Credit Administration. There was never any question in the Cavert household that the two daughters (Elizabeth and her sister Jane) should receive the same first-rate education as their son (Henry). Elizabeth's love of science was fostered by mentors in both high school and at the University of Minnesota. After receiving her degree there in 1941, she chose to do graduate work in biochemistry at the University of Wisconsin-Madison. James Miller grew up in more difficult circumstances in a suburb of Pittsburgh. His father lost his job at the Pittsburgh Press at the beginning of the Great Depression and was largely absent while James grew up. He lost one of his three older brothers and his mother to illness by the time he was 13 years old. His two remaining older brothers recognised James' strong intellect and love of science, and supported him through high school and his efforts to study chemistry at the University of Pittsburgh. James payed for much of his college education through working in a welding shop and later in student jobs at the university. Fortunately, he obtained a lab job with the biochemistry professor Charles Glen King during his second year, and Dr King's mentoring led James to pursue graduate work in biochemistry following his graduation in 1939. A close relationship with a former postdoctoral fellow of King led James to the University of Wisconsin-Madison. For further fascinating details on how Elizabeth and James met and led their lives together, read McKinnell's book.

The contributions of Elizabeth and James Miller were well recognised by others in the field of cancer research, and they received many honours, including their simultaneous election to the U.S. National Academy of Sciences in 1978. However, at several points in his biography of this remarkable pair of scientists, McKinnell expresses regret that their story is not more widely known and their accomplishments did not receive broader recognition. One is left with the sense, based on McKinnell's reporting, that the Millers would be fine with that state of affairs, given the deep humility and grace that was an essential part of both of their characters. It was, after all, only ever about the science.

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