Developments in Electrochemistry
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Science Inspired by Martin Fleischmann

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A group of electrochemists whose lives were enhanced by their contacts with Martin Fleischmann have joined together to produce this book; it is intended to celebrate the legacy that he has left to modern electrochemistry. Martin was an outstanding scientist with a great vision that allowed him to initiate a number of fields of activity. His detailed grasp

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1Figure reproduced from http://en.wikipedia.org/wiki/File:Fleischmann-cf.jpg
of chemistry, physics and mathematics provided a background for a continuous flow of new approaches and experiments. Martin was essentially “an ideas man.” Indeed, often his ideas were ahead of the ability of equipment to carry out the experiments, and it was only a few years later that the ideas came to fruition and it became possible to obtain high-quality experimental data. As can be seen by the authorship of the following chapters, this ability to be ahead of “the state-of-the-art,” combined with inspirational leadership, made him a reliable stepping stone to successful careers for many of his coworkers. His enthusiasm for science, combined with a very warm personality and a lifetime’s interest in the arts, skiing, food and wine, led him to have a large group of friends, ex-students and other coworkers, throughout the world. Stories about Martin abound, and a few of these are set out below. Indeed, the affection with which Martin is held can be seen in all the following chapters. All authors have, however, been asked to concentrate on the developments from the work of Fleischmann that are important now, and hence to produce a book that is relevant to “Electrochemistry in 2014.” This would surely have been the wish of Martin Fleischmann.

Martin Fleischmann FRS was born in Karlsbad, Czechoslovakia in March 1927 to a wealthy, German-speaking family. His father was a well-known lawyer and his mother the daughter of a senior Austrian civil servant whose family traced its roots back to the thirteenth century in Prague. In Martin’s own words, he was born into a castle with a fantastic collection of paintings. All this was to change dramatically, however. His parents were vocal opponents of the Nazi regime and, inevitably, they were forced to flee their home and leave behind all their possessions. They arrived in England after a lengthy and dangerous journey by taxi and train through Germany and Holland with a total of £1.30 in their purse! Following a period living in a “chicken hut,” and the death of his father resulting from injuries received during a period of imprisonment by the Nazis, the family circumstances began to improve. Support from a refugee committee led to the lease of a cottage in Rustington (Sussex), where his mother was to start a business making dolls (that was to continue for more than 30 years, http://www.oldcottagedolls.co.uk) and Martin went back to education at Worthing High School for Boys. During the war he served in the Czech Air Force Training Unit. Martin was both an Undergraduate and Postgraduate in the Department of Chemistry at Imperial College London. During these student days he courted – and married – Sheila, who was to be his wife and support for 62 years. Together, they brought up three children, Nicholas, Vanessa and Charlotte, and Martin was always a devoted and stimulating father. He died on August 3rd, 2012 at the age of 85 after an extended illness.

His introduction to electrochemistry was as a PhD student with Professor Herrington at Imperial College. His own project concerned the diffusion of electrogenerated hydrogen through thin palladium foils! Importantly to his later career, he became part of a larger group that included John Bockris, Brian Conway and Roger Parsons, all to become leading figures in the world of electrochemistry. These contacts led to a stimulating environment for discussion and catalyzed broad interests in electrochemistry. After graduation in 1951, Martin went to the University of Newcastle where he was to interact with Lord Wynne-Jones, Reg Thirsk, Alan Bewick, Ron Armstrong and Frank Goodridge, amongst others. He was quickly promoted to a Readership before, in 1967, being appointed to the Faraday Chair of Chemistry at the University of Southampton where, with the support of Graham Hills, he was to establish a large Electrochemistry Group that soon had a worldwide reputation and still flourishes today. Key colleagues included Alan Bewick, Pat Hendra, Bob Jannson,
Laurie Peter, Derek Pletcher, Jim Robinson and David Schiffrin. His work in Newcastle and Southampton led to numerous contributions in:

- Electrochemical nucleation and phase growth
- Surface-enhanced Raman spectroscopy
- In-situ X-ray techniques
- Potentiostat design
- Microelectrodes
- Theory and development of electroanalytical techniques
- Organic electrochemistry
- Electrolytic cell design and electrochemical engineering
- Corrosion
- Electrodes in biological science.

Martin was a consummate mathematician and liked nothing better than a model leading either to “back-of-the-envelope calculations” or many pages of equations; those who worked with him were regularly presented with 20 pages of mathematics, scribbled the evening before and often requiring one to learn about new mathematical transforms or functions! The idea was always to fit experimental data to the resulting equations, and hence to gain insight into the fundamentals of the electrode reaction mechanism. Martin already had the interpretation and conclusions fully worked out and ready for discussion!

During the late 1960s and throughout the 1970s, Southampton was an exciting place for electrochemists. Lectures and longer visits by the world’s most distinguished electrochemists were frequent, while Martin was always full of ideas for new experiments and would discuss them energetically. The Electrochemistry Laboratory was bigger than many entire Chemistry Departments at the time, and it had many diverse projects. The atmosphere at Southampton at the time is captured in Jim McQuillan’s recollection: “From June 1972, I was a postdoctoral fellow at Southampton with Martin Fleischmann and Pat Hendra. Both Martin and Pat were innovative scientists who enjoyed competing with each other in scientific brainstorming and both were excited by the prospect of audacious experiments. I well remember those sessions when ideas were flying.”

Pat Hendra’s view was that Martin used him as an intellectual “punch bag.” Pat particularly remembers one morning (and there were many like it) when he was giving a tutorial to a small group of undergraduates. Suddenly, the door crashed open, unseating a secretary whose desk was behind the door, and in advanced the “Great Man,” as Pat always called him. With the oh so familiar words, “I’ve had an idea,” he started to outline it! He was, of course, bearing a coffee cup in his left hand and spilling some on the floor! Several minutes later, after repeated reassurances that Pat would find him after the end of teaching, Martin left to acquire another coffee while Pat returned to his students. No more tutorial – they were speechless. “Who was THAT?” Pat was left to explain that they had been privileged to see a genius at work!

Martin was involved in the early years of the International Society of Electrochemistry, and served as both its Secretary/Treasurer (1964–1967) and President (1973–1974). He was for a period Head of Chemistry in Southampton, and also served on Research Councils and National Committees, duties that he carried out in his own particular style. Again, his lasting contributions were ideas. He was not a detailed administrator; Derek Pletcher describes how Martin’s office was always covered with stacks of reports/correspondence
and so on, and if your particular interest dropped below a certain level in the piles you
were wise to sneak in and return it to the top of the stack. Martin’s then secretary, Kate,
had a system where piles were regularly moved to boxes in a cupboard and then destroyed,
if MF had not noticed, in two years! Derek also commented that he used to tease Martin:
“The only admin that you do efficiently is to book your skiing holidays.” Despite these
shortcomings, Martin was an effective leader with a great talent for inspiring novel research
activity.

Martin’s work led to a large number of publications in scientific journals (see the list
below), many plenary lectures at conferences, and also invitations to visit laboratories
throughout the world. Recognition peaked with the election to Fellowship of the Royal
Society in 1985. He was also awarded several medals, perhaps the most prestigious being
the Electrochemistry and Thermodynamics Medal (1979) of the Royal Society of Chemistry,

Martin Fleischmann took early retirement from Southampton in 1983 but, despite some
serious health problems, he was to remain a very active scientist for a further 25 years.
He continued to collaborate with colleagues in Southampton but spent extended periods
at Harwell, the University of Utah, and the Laboratories of IMRA (part of Toyota) in the
South of France. David Williams remembers first meeting Martin on a staircase during
a scientific meeting and asking whether he would like to think about applying stochastic
modeling to the problem of pitting corrosion; this topic piqued Martin’s interest and led to
a longstanding collaboration. The period with Stan Pons in Utah led to a large volume of
publications related to the theory and practice of microelectrodes. Also, of course, Salt Lake
City saw the early experiments that led to the birth of “Cold Fusion,” and these continued in
France. Later, Martin became a more itinerant scientist working with several laboratories,
especially in the USA and Italy; he remained a focus for work on “cold fusion” but his
interest in nucleation, biological systems and microelectrodes was undimmed. He also
developed an enthusiasm for the applications of quantum electrodynamics to explaining
scientific observations, but because of ill-health many of these ideas never matured into the
published literature.

Details of all his scientific endeavors can be seen both in the following chapters and
the list of his publications. Here, we will only summarize some highlights. During the
early 1950s, Martin Fleischmann recognized the importance of “potential” in determining
the rate of electrode reactions, and set out to design instrumentation that was capable of
potential control and variation in a programmed way. These potentiostats and function
generators were large, unreliable and often temperamental (literally, sparks could fly!) but,
when working, they allowed new experiments. Later generations of such instrumentation
remain essential to all electrochemical experiments in laboratories throughout the world.
At the same time, Martin started to study the early stages of the deposition of conduct-
ing materials on electrode surfaces. The theory of nucleation and growth of such phases
remained an interest throughout his life, and this is reflected in recent papers. Martin was
one of the first to recognize the need for spectroscopic methods capable of interrogating the
interface between electrodes and solutions. In particular, he developed surface-enhanced
Raman spectroscopy (SERS), and in 1974 published the first such spectrum. Later, it was
shown that SERS could provide new insights into many systems. The application of ultra-
microelectrodes was another topic developed in his laboratory that was to become a routine
laboratory technique. Martin also championed the use of electrolysis for the manufacture of
chemicals and started an electrochemical engineering group charged with the development and study of novel flow cell designs, including cells with three-dimensional electrodes.

Martin had a career-long interest in the palladium/hydrogen system, piqued by his PhD studies and stimulated by further results from experiments performed by one of his students during the late 1960s that he could not “fully explain.” This eventually led to the experiments that were to claim “excess heat” and the birth of “cold fusion.” The concept promised a final solution to meeting the need for energy generation, thereby creating enormous interest. The concept of “cold fusion” was, however, totally contrary to accepted wisdom, and the experiments could only be reproduced in some laboratories. Overall, the response of most scientists was extremely hostile and often very personal, and not helped by the unfortunate way that the effect was announced at a news conference in Salt Lake City. This was all a great sadness to Martin, and contributed to his poor health. Certainly, to the end Martin remained willing to defend the underlying concepts as well as his experiments; he believed that there was an unusual phenomenon that deserved further study. It is inevitable and appropriate that this book contains a chapter on cold fusion that takes a positive view. Whatever one’s opinion about cold fusion, however, it should not be allowed to dominate our view of Martin Fleischmann as a remarkable and outstanding scientist. Even those who were amongst his critics would agree. David Williams, heavily critical of cold fusion, remembers Martin as a kind personality full of energy and enthusiasm as well as a quirky humor and, most importantly, with a deep insight into scientific problems.

Laurence Peter recalls: “Martin was a real European intellectual with broad interests in the arts (and wine) as well as science. I first met him in 1966; needless to say I was absolutely captivated by Martin, his Central European accent and dynamic personality and this led me to a career in electrochemistry.” Those who have worked with him all agree that Martin was a formative influence on a whole generation of electrochemists. We remember those wonderful ideas sessions in and around the laboratory; Martin taught that science is great fun, and his love of skiing, food, good wine and a good joke were never far from the surface. He was also a generous and kind man. Marco Musiani remembers being a visitor to Southampton for a summer and reporting to Martin that his family’s apartment had been burgled. The immediate response was that Marco’s wife and daughter could not stay in the flat; Martin’s house and car were offered as Martin and his wife were to be in the USA. In consequence, the Musiani family were to enjoy a memorable month in an English country house and village.

Another abiding memory of Martin Fleischmann is the ending of a BBC documentary on “Cold Fusion.” He appears purchasing cream cakes from a patisserie in the South of France with the accompaniment of Edith Piaf singing “Je ne regrette rien”!

The Publications of Martin Fleischmann

Electrochemical Nucleation and Phase Growth


6 Developments in Electrochemistry


(33) Fleischmann, M., Lax, D.J. and Thirsk, H.R. (1968) Electrochemical studies of the Ag₂O/AgO phase change in alkaline solutions. Transactions of the Faraday Society, 64, 3137.


Developments in Electrochemistry


Surface-Enhanced Raman Spectroscopy

(1) Fleischmann, M., Hendra, P.J. and McQuillan, A.J. (1973) Raman spectra from electrode surfaces. Chemical Communications, 9, 80.


**In-Situ NMR**

In-Situ X-Ray Techniques


Equipment Design


Microelectrodes


12 Developments in Electrochemistry


Theory and Development of Other Electroanalytical Techniques


Organic Electrochemistry


**Cell Design and Electrochemical Engineering**


