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# ELIZABETH FULHAME AND THE DISCOVERY OF CATALYSIS: 100 YEARS BEFORE BUCHNER

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Catalysis is certainly the foundation of enzymology, and enzymology may well be the foundation of biochemistry; at least, enzymologists think so. In a commemoration of the centenary of Eduard Buchner's classic experiment it is interesting to speculate whether Buchner himself might have written about the origins of our ideas of catalysis if he had been contributing to a centenary volume in the 1890s. Probably he would not, because like most people today he would probably have thought that these originated with the work of Jöns Jakob Berzelius in 1836 — too recent to be the subject of a centenary in 1897. However, classic ideas in science rarely spring from nowhere, and catalysis is no exception, because Berzelius had a distinguished antecedent who has become almost completely forgotten.

More than 40 years before Berzelius, on the 5th November 1794, Elizabeth Fulhame published a remarkable book entitled *An Essay on Combustion*. Noting this date and the title of the book, readers familiar with what happens in England each 5th November might be tempted to speculate that either the book or this chapter about it were an elaborate practical joke; however, Mrs Fulhame's book is no joke but a major step in the history of chemistry. In it she set out

> to show that the hydrogen of water is the only substance, that restores oxygenated bodies to their combustible state; and that water is the only source of the oxygen, which oxygenates combustible bodies.*

*Quotations in this chapter are from Fulhame (1794) unless indicated otherwise.

In modern terms, we can interpret this as an expression of the rather extreme view that all oxidation-reduction reactions require water as a catalyst.

To prove her case, Mrs Fulhame carried out what Davenport and Ireland (1989) called "numerous, meticulous and numbingly tedious experiments", adding that they could vouch for the tediousness as they had repeated many of them: they obtained essentially the same results apart from trivial differences that could be attributed to the indeterminate purity of Mrs Fulhame's reagents.

Mrs Fulhame's experiments led her to believe that many oxidation reactions occur only in the presence of water, and that water participates directly in them, being regenerated at the end of the reaction. However, her contribution went further than this, because she was probably the first to propose recognizably modern mechanisms for the reactions that she studied. For example, to explain the combustion of charcoal she suggested that

> the carbone attracts the oxygen of the water, and forms carbonic acid, while the hydrogen of the water unites with oxygen of the vital air, and forms a new quantity of water equal to that decomposed.

The starting point for Mrs Fulhame's work was her hope that she could find a satisfactory way of staining cloth with heavy metals under the influence of light, and she begins her book with the words

> The possibility of making cloths of gold, silver, and other metals, by chymical processes, occurred to me in the year 1780: the project being mentioned to Doctor Fulhame, and some friends, was deemed improbable. However, after some time, I had the satisfaction of realizing the idea, in some degree, by experiment.

Schaaf (1989, 1992) has considered her book as a landmark in the birth and early history of photography; however, that is more remote from biochemistry than the origins of catalysis and we shall not discuss it in any detail here. It is salutary to recall, however, that only today is silver chemistry being displaced from its overwhelmingly predominance in photography; until the invention of xerography there was no commercial alternative to silver chemistry, and even now it remains a strong competitor.

The little that is known of Mrs Fulhame's life is described by Wheeler and Partington (1960) and by Laidler (1993): she appears to have been the wife of a Dr Thomas Fulhame, and was in contact with the great scientists of her time, most notably Joseph Priestley. Her work was widely known and discussed in the late 18th and early 19th centuries. For example, Coindet (1798) took no fewer than 28 pages of *Annales de Chimie* to review her book; unfortunately, however, he had nothing of interest to say either about her or about her ideas, but simply gave a blow-by-blow account of the book. Subsequently it was almost forgotten, but not as completely forgotten as

> those who are radically stupid, and malicious, who are the beasts of prey destined to hunt down unprotected genius, to stain the page of biography, or to rot unnoted in the grave of oblivion.

Clearly Elizabeth Fulhame was no stranger to hostile criticism, nor to the idea that scientists do not always welcome the contributions of women:

> But censure is perhaps inevitable; for some are so ignorant, that they grow sullen and silent, and are chilled with horror at the sight of any thing, that bears the semblance of learning, in whatever shape it may appear; and should the *spectre* appear in the shape of a *woman,* the pangs, which they suffer, are truly dismal.

She was also a determined woman, however, and as shown by the opening paragraph quoted earlier she did not allow the scepticism of her husband and friends about her project to prevent her from pursuing it. She ends her preface with comments on the status of a scientific theory and the value of the opinions of great men that could hardly be more modern:

> Finding, the experiments could not be explained on any theory hitherto advanced, I was led to form an opinion different from that of M. Lavoisier, and other great names. Persuaded that we are not to be deterred from the investigation of truth by any authority, however great, and that every opinion must stand or fall by its own merits, I venture with diffidence to offer mine to the world, willing to relinquish it, as soon as a more rational appears.

Unhappily, Lavoisier never knew of Mrs Fulhame's ideas; he died under the guillotine on 8th May 1794, just six months before her book was published.

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**NOTE** (*added 3 October 2014*). Mrs Fulhame's book was essentially unobtainable for many years. However, various facsimile reprints have recently become available at very reasonable prices. See for example `http://tinyurl.com/qjhx8yj`