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Textile chemistry and industrial culture in the early nineteenth century. Some historiographic reflections [1]

Summary - How should the history of the industrial chemists be written? This is the main question I address in this paper, using examples of the 'industrial cultures' of textiles, dyestuffs and calico-printings in nineteenth-century England. In particular, the works of John Mercer (1791-1866), a colourist from northern Lancashire, provide an interesting case study of the history of an industrial chemist — a subtle combination of entrepreneurial dynamism, chemical knowledge, and workshop expertise. The leading lights of the period — Gay-Lussac, Berzelius, Davy, and Dalton — made major breakthroughs; but self-taught, provincial chemists like Mercer also made significant practical and theoretical contributions.

My appraisal of Mercer's achievements will, I hope, underline the fact that certain approaches in the history of chemistry and technology (including the study of the relationships between science and technology) are ill-suited to providing a satisfactory account of the complexity of chemical practices such as calico-printing, photography, or the chemical treatment of textile fibres. I will discuss a number of aspects of the new cultural and social history of science and technology, and their possible application to the history of chemistry.

1. *Industrial chemistry in the mid-nineteenth century: the case of John Mercer.*

John Mercer (1791-1866) was a well-known colourist in mid-nineteenth century Lancashire. He was born near Blackburn, north of Manchester, one of the leading areas of the textile industry, into a family of hand loom-weavers. The young Mercer very soon became interested in natural dyes [2] and other chemicals used in

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[1] A full version of my research work on John Mercer has been already published: A. NIETO-GALAN, «Calico-printing and chemical knowledge in Lancashire in the early nineteenth century. The life and 'colours' of of John Mercer», *Annals of Science*, 54 (1), 1997, 1-28. My thanks to the editor of the journal for his permission to reproduce parts of this paper in my lecture to the «VII Convegno di Gruppo Nazionale di Fondamenti e Storia della Chimica», L'Aquila, 8-11 October, 1997.

[2] A. NIETO-GALAN, «The use of natural dyestuffs in eighteenth-century Europe», *Archives Internationales d'Histoire des Science*, 46, 1996, 23-38.

the textile mills in the colouring of the new printed cottons, the calico-printings known as "indiennes". It was in this context of textiles and dyestuffs that John Mercer became 'experimental chemist' in a local factory in 1818, a position in which he was able to produce new colour formulas.[3] In the 1820's, he developed new patents, and organized monthly informal meetings at which he discussed chemical problems with other specialists. Although he spent his life in a single industrial milieu and did not travel abroad, he gained a considerable reputation as an innovator, and intellectual recognition as well, thanks to his inventions in the use of natural colours for cotton.[4]

In 1844, he made a major contribution to the chemical treatment of textile fibres: in all likelihood an accidental discovery,[5] which was reported some years later in histories of calico-printing:[6]

"... [Mercer] first noticed the action of caustic soda on cotton; he was filtering through six folds of fine cambric some 60 T caustic [solution] when he found his filter cloth had undergone a remarkable change; ... He found, as he said in his patent specifications in 1850, that the cotton ... had become [smaller] thicker and closer, and had acquired greater strength and firmness, and had greatly augmented and improved powers of receiving colours in printing and dyeing".

In fact, not only with an alkaline treatment did the cotton undergo this spectacular change. Diluted sulphuric acid, or a solution of chloride of zinc, produced similar effects.[7] The fibre actually became stronger and finer, and acquired a surprising attraction for the natural colouring matter.[8] The advantages could be seen simply by comparing a sample of cloth that had been chemically treated before dyeing with one that had not.

In 1851, the English *Journal of Design and Manufactures*, a review that highlighted the aesthetic quality of the new industrial scale products, published an article on the process of cotton mercerization named after its inventor. The article presented samples of mercerized and non-mercerized cottons; the difference in quality was plain to see.[9]

Mercer displayed some mercerized samples at the Great Exhibition of 1851,

[3] F. Crace-Calvert, «On the Influence of Science on the Art of Calico Printing», *Chemical News*, 1 (1860), 150-151.

[4] John Mercer's Archive. Museum of the History of Science. Oxford. Mss North n. 25. Typescript by E. Houghton, «Pioneers in calico printing».

[5] *Mercerisation. A practical and historical manual*, London 1903, pp. 90-94.

[6] John Mercer's Archive. Museum of the History of Science. Oxford. Miss North n. 25. E. Houghton, «Pionnes of calico-printing» s.d.

[7] Ch. O'Neil, *Dictionary of Dyeing and calico-printing*, London 1862, pp. 152-153.

[8] F.H. Bowman, *The structure of the Cotton Fibre in its relation to technical application*, Manchester 1881, pp. 53-53.

[9] J. Mercer, «Mercer's Patent: Improvements in the preparation of cotton and other fabrics amd fibrous materials», *Journal of Design and Manufactures*, 5, 1851, pp. 100-103.

where he was awarded a prize.[10] But despite this success, his treatment of cotton fibres remained controversial, and the cost if the process deterred many calico-printers from using it.[11] Mercer's biographers, for the most part, agreed that the process:[12] "seemed to promise great results but, unfortunately, it has not turned out so valuable or useful as was expected".

Others questioned the originality of Mercer's process, declaring that before Mercer's experiments specialists were already aware of the action of alkaline lyes on cotton.[13] Johann Carl Leuchs, the chemist-entrepreneur of a German firm in Nuremberg claimed that his company had discovered mercerization, and several articles appeared to this effect in the famous periodical *Dingler's Politechnische Journal* in 1847. Nevertheless, eventually even the German press acknowledged that Mercer's experiments had begun long before, in 1844.

The spread of Mercer's invention was not helped by the progressive improvements in the mechanical operations of spinning and weaving, and by the emergence of new artificial colours in the second half of the century. Mercerization with acid or basic treatment was not indispensable; the 'spinning-weaving-finishing' technological system could progress without it. In late nineteenth-century histories of textile chemistry, accounts such as the following were common:

"The cost of this mercerizing process seems, however, to have hindered its adoption in practice, and the results which were anticipated to flow from the discovery have not been realized to the extent which seemed probable when it was first announced, while the improvements of spinning, which enable finer and fuller yarns to be produced, have in some measure rendered it unnecessary in a large class of goods".[14]

The raw materials required in mercerization were also expensive. Caustic soda was vital to Mercer's process, and since it was not mass produced at that time, its cost was prohibitive. Nonetheless, when the price of soda eventually fell, a number of modifications were introduced in Mercer's process, which were applied and developed in the industrial setting up to the twentieth century.

In spite of the problems it encountered, Mercer's discovery stimulated considerable theoretical debate among chemists and dyers on the chemistry of textile fibres;[15] it led to a great increase in chemical analyses of cotton, linen, silk

[10] *Reports by the Juries on the Subjects in the Thirty Classes into which the Exhibition was divided*, London 1852.

[11] F.H. Bowman, *The structure of the Cotton Fibre in its relation to technical application*, op. cit., p. 53.

[12] Ch. O'Neil, *Dictionary of Dyeing and calico-printing*, op. cit., p. 89.

[13] *Mercerisation. A practical and historical manual*, op. cit., pp. 5-6.

[14] F.H. Bowman, *The structure of the Cotton Fibre in its relation to technical application*, op. cit., p. 53.

[15] Idem, p. 196.

and wool,[16] and microscopic observations of the fibres, and fuelled the controversy surrounding the search for a convincing theory for the complex relations between fibre and colour.[17] Mercerization thus became one of the cornerstones of the flourishing textile chemistry in the science-based industry of the second half of the nineteenth century, and the name of Mercer has been associated ever since with the foundation of a new discipline.

There is no doubt about Mercer's achievements with practical problems in cotton and calico-printing; but what can we say of his contributions in papers and meetings on 'difficult' subjects such as atomic weights, chemical catalysis or molecular arrangements? Lyon Playfair (1818-1898), a pupil of Justus von Liebig, stayed in the Lancashire area as a chemist for two years and became Mercer's friend; he recognized his merits, but left no doubt about the intellectual superiority of the well educated academic chemist.[18] Mercer learned elementary chemical procedures only from reading popular chemistry books, and had no conventional training.[19] Nonetheless, he developed a chemical analysis of the composition and behaviour in solution of a bleaching powder, and studied various oxides and peroxides for generating different colours.[20] He also commented on some results on diffusion[21] in an attempt to link chemical hydration with mobility, viscosity and capillarity. He often applied these concepts to the relation between colours and fibres in the dyeing and printing processes.[22]

In spite of his practical uses of chemical equivalents in some analytical experiments, Mercer was also aware of different atomic problems of matter. He presented some conclusions on the possible empirical formulas of nitrogen oxides in 1843,[23] and often discussed atomic and molecular aggregation with his academic friend, proposing a set of two dimension arrangements for different metallic oxides.[24] His theoretical concerns even touched on the problem of atomic weights

[16] A. Ure, *The Philosophy of Manufactures*, London 1835, pp. 96-97.

[17] P.E. King, «The Present State of Development of the Theory of Dyeing, with special reference to colloidal and electrical hypotheses and phenomena leading thereto», *Journal of the Society of Dyers and Colourists*, 35 (1919), 171-177, 190-195; B. Bensaude-Vincent, A. Nieto-Galan, «The theories of dyeing in Europe (1750-1900): A view on a long-standing controversy through the works of Jean-François Persoz», paper presented to the workshop *Natural Dyestuffs in Europe, 1750-1870*, Oxford, January 1996 (in print).

[18] John Mercer's Archive. Museum of the History of Science. Oxford. Miss North n. 27. Lyon Playfair's notes on Mercer.

[19] J. Parkinson, *The chemical Pocket Book or Memoranda Chemica, arranged in a Compendium of Chemistry*, London 1803.

[20] E.A. Parnell, *The life and labours of John Mercer*, London 1886, pp. 115-124.

[21] R.A. Smith, *The life and works of Thomas Graham*, Glasgow 1884.

[22] E.A. Parnell, op. cit., pp. 176-177.

[23] Mercer-Playfair Correspondence. Manchester Central Library. MF 887. Letter 9, 19-I-1843.

[24] Mercer-Playfair Correspondence. Manchester Central Library. MF 887. Letter 10. n.d., Letter 15, 8-II-1842.

as a criterion for classifying chemical elements.[25] In 1846 Mercer complained of his heavy involvement in manufacturing, and his lack of time to think about 'elemental chemistry';[26] however, these demands on his time did not stop him expressing his ideas on theoretical problems, which made a large contribution to his practical tests in the factory, and enhanced his public reputation.

2. New chemical practices: photography.

Mercer's actual contribution to the new field of photography is unclear, but there is some evidence that he began experimenting as early as the 1820s. Nevertheless, his name never appears in histories of the subject, not even in studies of the forerunners of the official history (which began in 1839, with the first exposures to light of copper plates covered with a layer of silver sensitized with vapour iodine crystals, by Louis Daguerre).[27]

Unfortunately, there is no further information about Mercer's early chromatic experiments, but the majority of the samples preserved were produced using a procedure described by Mercer himself in a letter to the chemist Lyon Playfair some years later, in 1847:

"I found that if a paper or cotton cloth is smeared with a solution of pernitrate or persulphate of iron [III] with certain quantities of oxalic and tartaric acids, dried in the dark, than exposed to the light (solar) and immediately dipped in solution of red prussiate [iron III] containing a little free sulphuric acid ... where the light has caused de-oxidation [iron II], the blue is fixed, and where the peroxide remains unchanged there is no colour. The cloth or paper must be washed immediately in water ... The picture is a reverse blue print ... An exposure of 20 seconds on a dull rainy day sufficed to produce a good blue when the paper was passed through the red prussiate bath".[28]

This method was based on the chemical and photochemical properties of a family of blue dyes, Prussian Blue and Turnbull's blue, colouring matters that were widely used in dyeing and calico printing. These dyes contain iron in its two main

[25] John Mercer, «[Note] On the relation of the Atomic Weights of the Families of the Elements», *Reports of the British Association for the Advancement of Science. Leeds, September 1858*, (1959), pp. 57-59.

[26] Mercer-Playfair Correspondence. Manchester Central Library. MF 887. Letter 3, 16-6-1846.

[27] A.V. Simcock, «Essay Review: 195 years of Photochemical Imaging 1794-1989», *Annals of Science*, 48 (1991), 69-86; A.V. Simcock, *Photography 150 years. Images from the first generation*, Oxford 1989; H. Gernsheim, *The Origins of Photography*, London 1982; H. Gernsheim, *A Concise History of Photography*, New York 1986; F.T. Hardwich, *A Manual of Photographic Chemistry including the Practice of the Colloid Process*, London 1855.

[28] R. Broughton, «John Mercer's Experiments in Photography», *The Observer*, 20-11-1920. Lancashire Record Office. John Mercer's papers. UDCl 8/19.

degrees of oxidation Fe(II)/Fe(III), depending upon their exposure to light, as Mercer was well aware.[29] The importance of the fastness of colours fixed on cloth and the routine of repeated experiments with exposures to sunlight were probably influential in linking Mercer's interest in photography with dyeing and printing. With the application of the so called "discharge-resist" process, widely used in the everyday work in the calico-printing factories, he was also able to exchange colours on the cotton prints to provide a huge range of monochrome photographs through dyeing.

Mercer also saw photographical experiments as a way of measuring light. He took great pleasure in testing different colours and exposures,[30] as he wrote in 1857:

"for the last two or three years I have occasionally amused myself with making photographic experiments, not as an artist, but rather as a chemist. Some of my results are interesting. One is a simple method of measuring the chemical power of the solar rays ...".[31]

But probably Mercer's most original contribution — the one which would earn him a place in the history of photography — was his experimental study of various metals that provide different colours depending upon their degree of oxidation and their combinations with different natural dyestuffs. Some 'metallic bases', or mordants, of lead, zinc, tin, mercury, silver, gold or manganese were combined after exposure to sunlight to natural dyestuffs such as madder, cochineal, logwood, murexide, quercitron bark, prussiates, chromates, etc. These were clear examples of the connection between photography and dyeing and calico-printing.[32] Mercer's chromatic prints are evidence that similar skills and chemical knowledge converged in technical branches of the production of colour, such as photography and textile dyeing and printing in the first decades of the nineteenth century.

3. *The social status of the industrial chemist.*

Mercer's rise from humble origins to social and scientific eminence is not without parallels in early Victorian Britain, a society in which certain individuals were able to improve their social position due to their scientific discoveries.[33] "... George Stephenson, inventor of the locomotive, was taught in the mine, the engine house and the tramway, Hargreaves of 'Spinning Jenny' fame was a cotton weaver,

[29] G.B. Kauffman, *Inorganic Coordination Compounds*, London 1981.

[30] E.A. Parnell, op. cit., pp. 220-230.

[31] Mercer compared his method with another developed by the German chemist Robert Wilhelm Bunsen. See E.A. Parnell, op. cit., pp. 220-230.

[32] Idem, p. 226.

[33] J.B. Morrell, «Individualism and the Structure of British Science in 1830», *Historical Studies in the Physical Sciences*, 3 (1971), 183-204; *Gentlemen of Science. Early Years of the British Association for the Advancement of Science*, edited by J.B. Morrell, A. Thackray, Oxford 1981.

Arkwright of the circular carding machine was a barber, Crompton inventor of the Mule was a weaver, Mercer was [also] a weaver ...".[34]

Mercer's social ascent probably began in 1841, when Lyon Playfair came to Lancashire to broaden the 'chemical life' of the district.[35] Although Playfair was not in the area long — only two years — he advocated closer connections between chemistry, dyeing and printing, and gathered togheter a group of some thirty people interested in the subjet in monthly meetings at his home, at Whalley, a small town near Great Harwood, and later in the pub, the 'Whalley Arms'. In this way, the practical knowledge of the factories was linked with chemical experts trained in cities in the forefront of science.[36]

In Section II of the programme at the Great Exhibition of london in 1851, which focused on innovations in different chemicals, almost half of the exibits were connected with printing and dyeing processes.[37] Mercer showed his own samples in Section IV (textile fibres), and acted as a juror in Section II (chemicals). Queen Victoria received a collection of Mercer's printed handkerchiefs; [38] and at this public celebration of the nation's prosperity, he was introduced to academic and political circles. Lyon Playfair, the Special Commissioner of all the Jurmenties, was again largely responsible for Mercer's social recognition.[39] In 1852 Mercer was elected Fellow of the Royal Society;[40] in 1849, he had become a member of the Literary and Philosophical Society of Manchester, and some years later, he also joined the Glasgow Philosophical Society. In 1862, now in the last years of his life, he took charge of the Jury of the new International Exhibition held in London.

Mercer's figure and personality exercised a notable influence on other chemists, industrialists and manufacturers, during his lifetime, and even more so after his death. The process of mercerization itself was mentioned in most textile chemistry books published in the late nineteenth century and the first decades of the twentieth century.[41] In spite of the difficulty of making mercerization a commercial success, the chemical modification of textile fibres was studied by later chemists,[42] and samples of 'mercetized' cotton were distributed among textile factories.

[34] John Mercer's Archive. Museum of the History of Science. Oxford. Miss North, n. 25. Typescript by E. Houghton, «Pioneers in calico printing».

[35] R. Kargon, *Science in Victorian Manchester. Enterprise and Expertise*, Manchester 1977, p. 89; A. Robson, *The History of William Blythe Limited* (unpublished typescript), p. 4.

[36] *Metropolis and Province. Science in British culture, 1780-1850*, edited by I. Inkster, J. Morrel, London 1983.

[37] *Reports by the Juries on the Subjects in the Thirty Classes into which the Exhibition was divided*, London 1852.

[38] E.A. Parnell, op. cit., p. 204.

[39] D. Knight, *Ideas in Chemistry*, London 1992, pp. 107-108.

[40] John Mercer's Archive. Museum of the History of Science. Oxford. Miss North, n. 25. Typescript by E. Houghton, «Pioneers in calico printing».

[41] F.H. Bowman, *The structure of the Cotton Fibre ...*, op. cit., p. 53.

[42] *Mercerisation. A practical and historical manual*, op. cit., pp. 3-10.

Mercer's ability to amass practical and theoretical knowledge was especially admired (even by Playfair, in spite of his feelings of superiority). Edward Baines, the English chemist who wrote a famous *History of the Cotton manufacture in Britain* in 1835, saw Mercer "as an ingenuous individual possessing a store of knowledge and facts unknown to scientific chemists".[43]

Others saw Mercer's life and achievements as "the history of a man, whose name as a calico printer, industrial chemist, and inventor, is known to scientific men throughout Europe. There is nothing in his life which is not at least a subject of laudable emulation to you. He was simple, sober, pious and genial in his personal intercourse".[44]

Even as late as 1944, the Manchester Section of the British Society of Dyers and Colourists, founded sixty years before,[45] inaugurated the "John Mercer Lecture". In a meeting at the Grand Hotel of Manchester, on 19 May, under the title "Science in an Old Industry", Mercer's figure was taken as a model for dyers and printers in their search for an ideal balance between science and industry. The authors of the first John Mercer lecture, McCulloch and Hibbert, were members of a company with a direct descendant of the firm of which Mercer was an employee, and later a partner. During the speech they declared:

"... again we can turn to Mercer, for the broader lessons of his experience lie open to us, and they embody nearly all we need to know as industrialists in order to gain and hold premier place. Today we are being pressed from all quarters to recognize the benefit that comes when scientific theory is allied to industrial practice ... Why are we slow to learn the lesson fully? Is it that the British are practical people and that the history of the last one hundred and fifty years confirms them in their belief in their own outlook?".[46]

Mercer represented the dream of the industrialist: to assimilate academic science as a way of obtaining social prestige and broader possibilities to improve the efficiency of technical process at a time in which a second chemical revolution and the synthetic dyes industry had transformed the old picture of the early Victorian years. Dr. Cronshaw, the president of the Society of Dyers and Colourists, introduced the speakers, and paid tribute to Mercer as an example of a deep involvement in industry combined with significant contributions to science. It was again a sort of mythology of the humble, now applied to dignifying the professional status of the

[43] Cited by C.A. Russell, N.G. Coley, G.K. Roberts, *Chemists by profession. The Origins and the Rise of the Royal Institute of Chemistry*, Milton Keynes, 1977, p. 32.

[44] E. Houghton, «Pioneers in calico printing» n.d. John Mercer's Archive. Museum of the History of Science. Oxford. Miss North n. 25.

[45] M. Tordoff, *The Servant of Colour. A History of the Society of Dyers and Colourists; 1884-1984*, Bradford 1984.

[46] N.G. McCulloch, G.S. Hibert, «Science in an Old Industry», *Journal of the Society of Dyers and Colourists*, 60, 1944, 258-263, p. 260.

twentieth-century industrial chemists. During the Second World War,[47] Mercer's example was evoked when "... the word research ... [was] on everybody's lips, and the potential influence of sciene and scientists on industry [was] ... receiving general recognition". Mercer was perceived as a sort of mythical British pioneer of the application of scientific research to industry.

Even later, in 1950, during the Jubilee of the British Cotton and Wool Dyers Association, Mercer was formally remembered as a great contributor to textile chemistry, and, in spite of the increasing production of artificial fibres,[48] mercerization was praised as one of the association's major endeavours. Indeed, one of the pioneers of the history of chemical technology, Dr. Sidney Edelstein, worked with the U.S. army on the eve of World War II on the development of a chemical test for mercerized cotton fibres, reviewing Mercer's original patent a century later.[49]

The German coal-tar dyestuff industry, which flourished in the last decades of the nineteenth century, provided professional experts to give technical assistance to the British textile firms for the finishing process. This blocked the entrance of academic chemists into the British factories, as already stated in the 1944 speech in Manchester (I quote): "the need foreseen by Mercer and others for scientific personnel within the industry was thus partially satisfied from outside, and may well have prompted hard-pressed industrialists of the time to allow this to suffice, so contributing to slowing down the employment of scientists within industry".[50] Science-based industry required new links between academic knowledge and industrial practices, and Mercer was seen again as an ideal bridge.

4. *How should the history of nineteenth-century industrial chemists be written?*

The example of John Mercer will shed light on the social role and involvement of nineteenth-century industrial chemists. Mercer worked in a context in which common problems were shared in the Whalley meetings, and in trips to other countries; foreign experts were invited, and great attention was paid to scientific developments in cities such as Glasgow, London or Manchester. He was one of those emblematic individuals who embraced a concept of 'chemist' that was a combination of theory, practice and social recognition, a combination that is difficult to generalize or standardize.[51] Mercer was not an entrepreneur, nor a

[47] R. MACLEOD, «The chemists go to War: The mobilization of civilian chemists and the British War effort, 1914-1918», *Annals of Science*, 50, 1993, 455-481.

[48] *Jubilee. The British cotton and wool dyer's association Limited 1900-1950*, Bradford 1950, p. 6.

[49] See Melvin Kranzberg in his Introduction to: *Biblioteca Tinctoria. Annotated Catalogue of the Sidney M. Edelstein Collection in the History of Bleaching, Dyeing, Finishing and Spot removing*, edited by M. RON (Jerusalem 1991).

[50] N.G. MCCULLOCH, G.S. HIBERT, «Science in an Old Industry», op. cit., p. 259.

[51] G. DODD, *The Textile Manufactures of Great Britain*, London 1844, p. 85.

traveller in search of international innovations in calicoes; nor was he an academic chemist like Playfair with a university degree and outstanding professors to work with and imitate. He did not have bourgeois tastes, or bourgeois ideas of refinement.

As James Donnelly mentioned in his recent paper on the History of the British alkali industry,[52] in the years before 1850 complex, private routes of training were widely developed, but there was little standardization, institutional protection, or division of functions. In contrast, many professionals in the second half of the century were trained in new institutions able to standardize the practice of chemistry, which became increasingly routinized.

Mercer's context was still a world of 'amateurs'; [53] the scientific arena of early Victorian Britain was made up by a complex mix of late professionalism, active social groups, people of humble origins, manufacturer-scientists, religious dissenters, local elites, and political radicals.[54] Mercer, like the other figures in the circle of calico-printers in Lancashire, presents problems to historians tempted to take simplistic 'photographs' of the past, or to define excessively broad categories in which to classify ideas, people and practical achievements.

The example of John Mercer may reflect some of the problems facing historians of chemistry in their attempts to write the history of 'second class' figures of this kind. The leading nineteenth-century chemists have aroused great interest among scholars, but the majority of the famous names of the history of chemistry are mainly known as the authors of new chemical theories and ideas. There is always a danger of writing tunnel history, which describes industrial chemists as the agents of the application of academic knowledge to industries and workshops, often ignoring contributions from those on the periphery.

In 1983, the British historian of chemistry William Brock provided a historiographic review of the discipline in his collaboration to the book *Information sources in the history of science and medicine*, edited in Oxford by Pietro Corsi and Paul Weindling. Brock devoted only a short paragraph at the end of his chapter to industrial chemistry, citing some classical works from the 1970s (Idhe, Clow, Musson and Robinson, Multhauf, J.G. Smith, Gillispie, Beer, Haber, Campbell).[55] Other more recent histories of chemistry also reflect the lack of a strong

[52] J. DONNELLY, «Consultants, Managers, Testing Slaves: Changing Roles for Chemists in the British Alkali Industry, 1850-1920», *Technology and Culture*, 35 (1994), 100-128. See also D. KNIGHT, op. cit., pp.110-111; W.H. BROCK, *The Fontana History of Chemistry*, London 1992, p. 310.

[53] R. KARGON, *Science in Victorian Manchester*, op. cit.

[54] S. SHAPIN, A. THACKRAY, «Prosopography as a Research Tool in History of Science: the British Scientific community 1770-1900», *History of Science*, 12 (1974), 1-28; S. SHAPIN, «The Pottery Philosophical Society, 1819-1835: an Examination of the Cultural Uses of Provicial Science», *Science Studies*, 2 (1972), 311-336.

[55] W. BROCK, «History of Chemistry» in P. CORSI, P. WEINDLING (eds.), *Information sources in the History of Science and Medicine*, London 1983, pp. 317-346.

historiographic framework for industrial chemistry, in comparison with the relatively good health of other topics such as alchemy, Paracelsian chemistry, Newtonian affinities, the chemical revolution at the end of the eighteenth century, or chemical nomenclature.

The history of soda production from Leblanc to Solvay, the developments in agricultural chemistry and the central role of Justus von Leibig, and the rise of artificial dyestuffs in the second half of the nineteenth century are told as more or less standard accounts in Bernadette Bensaude's and Isabelle Stengers' *Histoire de la chimie*, and in Brock's *Fontana history of chemistry*.[56] In spite of the increasing number of studies on the history of chemical industries,[57] neither the classical history of chemistry nor that of business and economics provide a complete genuine framework for the understanding of the role of the industrial chemists, in the nineteenth century at least.[58]

As Bernadette Bensaude and Isabelle Stengers pointed out in their *Histoire de la Chimie*, the categories of 'pure' and 'applied' chemistry are unable to provide a full explanation of the complex relations between science and industry in the nineteenth century. The large scale production of artificial goods can be explained by a group of different factors (economy, technology, industrial organization, patents, trade, national rivalries, etc.), a framework in which professional academic chemists progressively involved in industry played only a minor role.[59]

In 1958, with the creation of the Society for the History of Technology in the United States, and the appearance of the journal *Technology and Culture*, the history of technology, as an independent domain of interest among historians and historians of science, was beginning to grow. And, even before the rise of this new community of American scholars, earlier classic histories of technology already included chapters on the development of chemical industry.[60] In 1954, Singer, Holmyard and Hall edited a five-volume History of Technology sponsored by Imperial Chemical Industries (ICI), and by Dr. Cronshaw, the president of the Society of Dyers and Colourists. The book focused on the history of the chemical industry in the general framework of the history of technology, and covered subjects such as heavy chemicals, dyestuffs, explosives, fine chemicals, textiles, rubber, metals.

Some years later, these detailed chronological descriptions of the main technical

[56] W. Brock, *The Fontana History of Chemistry*, op.cit., B. Bensaude-Vincent, I. Stengers, *Histoire de la Chimie*, Paris 1993.

[57] J.F. Sturchio (ed.), *Corporate history and chemical industry*, Philadelphia 1985.

[58] J. Donnelly, «Industrial recruitment of chemical students from English Universities: a revaluation of its early importance», *British Journal of the History of Science*, 24, 1991, 3-20.

[59] B. Bensaude-Vincent, I. Stengers, *Histoire de la Chimie*, op. cit., pp. 136-137.

[60] Ch. Singer, E.J., Holmyard, A.R., Hall, J.A., Williams, J.A., *History of Technology*, Oxford 1954-1958 (5 vols.).

achievements in history were followed by outstanding books like Bertrand Gille's *Histoire des Techniques* (1978). Its definition of "technical system" (a technological analogy to Thomas Kuhn's paradigm) contributed to the construction of a more substantial theoretical framework for the history of technology as an emerging discipline, and for the explanation of the technological change in history. A technical system, as a tool to study the mechanisms of the consistency of a set of objects and operations that coexisted at any particular time, provides an interesting pattern for the study of complex chemical processes in industry.

In the 1970's, and probably in response to the growth of the history of technology as an independent discipline, together with a reaction against the Marxist influence in academic circles, a very lively debate about the relationships between science and technology broke out. It was the controversy about the "role of science in the industrial revolution". Leading historians of modern industry and chemical technology argued that new scientific theories and methods, from the seventeenth century revolution of knowledge onwards, were key factors in the development of the industrial revolution. This was, for example, the position of Musson and Robinson, *Science and Technology in the Industrial Revolution* (1969), Clow, *The Chemical Revolution* (1952), Smith, *The Origins and Early Development of the Heavy Chemical Industry in France* (1979), etc.[61]

Others argued that science, especially chemistry, had little or no influence on the promotion of industrial technology, at least until the first decades of the nineteenth century: Among these authors were Charles Gillispie in "The natural History of industry" *Isis*, 48, 1957; Rupert Hall in a famous paper "What did the industrial revolution in Britain owe to Science?" (1974), Homer Legrand, with his study of the role of chemistry in provincial French cities like Montpellier, etc.[62] They presented a number of case studies in which technical improvements appeared to have little to do with the new chemical theories. The production of mineral acids, or Leblanc's artificial soda[63] obtained from sodium chloride, were commonly used examples.

Whatever conclusions may be reached on that debate, the development of

[61] A. Clow, N. Clow, *The Chemical Revolution*, London 1952; A.E. Musson, E. Robinson, *Science and Technology in the Industrial Revolution*, Manchester 1969; G.J. Smith, *The Origins and Early Development of the Heavy Chemical Industry in France*, Oxford 1979; Ch. Perrin, «Of theory shifts and industrial innovations: the relations of J.A. Chaptal and A.L. Lavoisier», *Annals of Science*, 43, 1986, 511-543.

[62] H. Le Grand, «Chemistry in a provincial context: The Montpellier Société Royale des Sciences in the eighteenth century», *Ambix*, 29, 1982, 88-105; Ch. Gillispie, *Science and Polity in France at the End of the Old Regime*, Princenton 1980; Ch. Gillispie, «The natural History of industry», *Isis*, 48, 1957, 398-407; R.A. Hall, Rupert, «What did the industrial revolution in Britain owe to Science» in N. McKendrick (ed.), *Historical Perspectives: Studies in English Thought and Society in Honour of J.H. Plumb*, London 1974, pp.129-151.

[63] Ch. Gillispie, «The Discovery of the Leblanc Process», *Isis*, 48, 1957, 152-170.

various chemical technologies during the Industrial Revolution,[64] and the applications of chemistry in workshops and factories deserve further examination. It is a topic which is particularly relevant to an understanding of the complex interplay between theory and practice in the early decades of the nineteenth century, a period in which the progressive social recognition of 'chemists' as new professionals emerging from medical and artisan backgrounds, played an increasing role in the practical world of manufacture,[65] and the usefulness of the new chemistry was proclaimed from numerous academic forums across Europe. The interest of artisans and new industrialists in the possibilities of the new science for practical applications in the factory also began to grow.[66] Chemical manufacturers published books on the theory and practice, mixing 'pure' and 'applied' chemistry.[67] Some of them attended lectures at universities, private laboratories or scientific societies,[68] and often followed them up with bold industrial experiments. Practical men, proud of their mechanical and manual skills, approached abstract concepts in an attempt

[64] The main contributions to the history of chemical technology in the early industrial times mainly date from the 1960s and 1970s: A. Clow, N. Clow, *The Chemical Revolution*, op. cit.; A.E. Musson, E. Robinson, *Science and Technology in the Industrial Revolution*, op. cit.; J.G. Smith, *The Origins and Early Development of the Heavy Chemical Industry in France*, Oxford, 1979; W.A. Campbell, *The Chemical Industry*, London 1971; H. Guerlac, «Some French antecedents of the chemical revolution», *Chymia*, 5, 1959, 73-112; R.P. Multhauf, *Neptune's Gift. A History of Common Salt*, London 1978; R.P. Multhauf, «Salt Ammoniac: A case history in industrialization», *Technology and Culture*, 6, 1965, 569-586. For the case of dyeing B.W. Keyser, «Between Science and Craft: The Case of Berthollet and Dyeing», *Annals of Science*, 47, 1990, 213-260.

[65] R.F. Bud, G.K. Roberts, *Science versus Practice. Chemistry in Victorian Britain*, Manchester 1984, pp. 15-17; C.A. Russell, et al., *Chemists by Profession*, op. cit.

[66] For example, Ch.E. Perrin, «Of theory shifts and industrial innovations: the relations of J.A. Chaptal and A.L. Lavoisier», *Annals of Science*, 43 (1986), 511-543; H.E. Le Grand, «Chemistry in a provincial context: The Montpellier Société Royale des Sciences in the eighteenth century», *Ambix*, 29 (1982), 88-105; Ch. Gillispie, *Science and polity in France at the End of the Old Regime*, Princeton 1980; R. Fox, «An Uneasy Courtship: Rhetoric and Reality in the Relations between Academic and Industrial Chemistry», in *IV National Meeting «Storia e Fondamenti della Chimica. Venezia, 7-9 novembre 1991» (Venice 1991)*, pp. 1-5; Ch. Meinel, «Theory or practice? The eighteenth-century debate on the scientific status of chemistry», *Ambix*, 30, 1983, 121-132.

[67] S. Parkes, *Chemical Essays principally related to the Arts and Manufactures of the British Dominions*, (5 vols), London 1815; E. Bancroft, *Experimental Researches Concerning the Philosophy of Permanent Colours; and the Best Means of Producing Them, by Dyeing, Calico Printing*, London 1794; J. Haigh, *The Dyer's Assistant in the Art of Dyeing Wool and Woolen goods*, London 1800; Ch. O'Neill, *Dictionary of Dyeing and Calico-Printing*, London 1862; A. Ure, *The Philosophy of Manufactures*, London 1835; E.A. Parnell, *Applied Chemistry in Manufactures, Arts and Domestic Economy*, (2 vols), London 1844; W.T. Brande, *A Manual of Chemistry*, London 1819.

[68] J.E. McClellan, *Science Reorganized: Scientific Societies in the Eighteenth Century*, New York 1985; *Enseignement et diffusion des sciences en France au XVIIIè siècle*, edited by R. Taton, Paris 1964.

to broaden their knowledge in an industrial milieu undergoing rapid transformation towards new ways of organization and production.

In spite of a certain inevitable reluctance to 'scientify' old artisan procedures, and occasionally disparaging attitudes towards large scale industrial operations on the part of some educated chemists, the fact is that in the early nineteenth century the distinction between science and technology, or between the theory and practice of chemistry linked to industry, became blurred. Cases such as Mercer's are difficult to classify under the sweeping historical categories like 'science' and 'technology' that characterized much of the debate during the 1970s.

In the concluding remarks of the 1995 ESF workshop "Lavoisier in European context. Negotiating a New Language for Chemistry", organized by Bernadette Bensaude and Ferdinando Abbri, Frederick L. Holmes introduced an interesting concept in his examination of the varied reaction to the new French Nomenclature at the end of the eighteenth century, a new theoretical framework for the chemists. Holmes used the term 'cultures of chemistry' in the following sense:[69] "Those who studied, practiced, or used chemistry can be divided into categories, such as those who taught the subject in medical schools, those who taught it in other contexts ... those who applied it to agricultural or industrial problems, or apothecaries ...". In the industrial and technological domain, metallurgy, glass and pottery making, heavy chemicals, dyeing, distillation, or the practices of druggists, apothecaries, drysalters, etc., were some of those genuine 'cultures'.

Although Professor Holmes is critical of some of the recent approaches of the new social and cultural history of science, I think that his concept of cultures of chemistry is close to a history of contingent chemical practices, in which simple everyday activities, tacit knowledge, spaces of validation, objects, instruments and laboratories take pride of place. In this context, it is perhaps probably better to forego the historical category "science", and talk rather of disciplinary fields, instruments, and cognitive practices.[70] A more symmetrical history, avoiding success and failure as categories, seems better suited to the study of secondary industrial chemists like John Mercer.

I would like to return now to Mercer's blue print photographs and analyze them in accordance with some of the interpretative keys of the new trends in the history of science and technology. First, the making of these photographs (preserved in the Lancashire Record Office in Preston, near Manchester) required

[69] I borrow the idea of the 'cultures of chemistry' from: F.L. Holmes, «Beyond the Boundaries: Concluding Remarks on the Workshop» in *Lavoisier in European Context. Negotiating a New Language for Chemistry*, edited by B. Bensaude-Vincent and F. Abbri, Canton 1995, pp. 267-278.

[70] D. Pestre, «Pour une histoire sociale et culturelle des Sciences. Nouvelles définitions, nouveaux objets, nouvelles pratiques», Annales Histoire, Sciences Sociales, mai-juin 1995, pp. 487-522.

a diversity of skills (the techniques of fixation of natural colours on a cotton cloth, knowledge of the chemistry of light, of the degrees of oxidation of metals, etc.). In addition, Mercer used 'discharge-resist' processes to swap colours on the photographical cotton prints. Light was another chemical element considered to have chemical affinity with other substances (vegetables and metals, in particular).[71]

Photography, then, can be seen as a sort of "mediator" between the cultures of chemistry: parctical dyers and calico-printers, natural philosophers engaged in experiments about the nature of light; drysalters who sold colours and metallic salts; academic chemists who discussed the relationship between the degree of oxidation of metals and the shade of a definite colour; eminent Victorians who controlled the public arena of London, a refined culture of gentlemen of science, whose spaces of validation Mercer joined after his success in the Great Exhibition, in 1851. A photography is here not far from a chemical instrument (like a balance or a calorimeter) another sort of "mediator", following the definition of the American historian Norton Wise.[72] In his view, a "mediator" is an object that materializes scientific, technological and cultural connexions which are not obvious at first glance, and which would never appear in a more traditional tunnel history approach.

It is a question of studying particular objects in a broader technological system, which includes sociological and cultural factors, and which can deepen our understanding of the role of industrial chemists. Taking Gille's original concept of the technical system, the American historian of technology Thomas Hughes added to Gille's scheme actors, institutions, political and economic factors, in his *Networks of Power* (1983), a masterpiece of the history of electrification in Western societies. "Hughes' definition is meant to establish a strong link between technology and the institutional and professional organization that create and sustain it".[73]

Even accepting James Donnelly's hypothesis, and acknowledging that in the first decades of the nineteenth century, industrial chemists (especially British ones such as John Mercer), learnt their field outside any fixed institutional framework, important elements of a very consistent sociology of knowledge in Hughes terms should not be ignored. In my attempts to reconstruct Mercer's routes of learning, I discovered a very complex network of chemists and calico printers, which might explain the great success of this man of humble origins.

[71] M.P. Crosland, *In the shadow of Lavoisier: The Annales de Chimie and the Establishement of a new Science*, Oxford 1994; A.E. Shapiro, *Fits, Passions and Paroxysms*, Cambridge 1993.

[72] N. Wise, «Mediators: Enligntenment Balancing Acts», in P. Horwich (ed.), *World Changes. Thomas Kuhn and the Nature of Science*, Cambridge Mass. 1993, pp. 207-256; N. Wise (ed.), *The values of precision*, Princenton 1995, pp. 3-13.

[73] A. Picon, «Towards a history of technological thought», in R. Fox (ed.), *Technological Change. Methods and Themes in the History of Technology*, Amsterdam 1996, 37-50, p. 38.

Mercer patented [74] his major inventions with some of the members of the Whalley network. He also worked together, in both theoretical and practical concerns, with the large community of calico-printers offering chemical, mechanical and artistic skills. Their findings were introduced into everyday work in the factory, experiments, large scale production and theoretical speculations.

Chemical skills and practical experience of dyeing evolved in a cosmopolitan or international community of actors, who established strong personal and professional links in their uses of natural colours. The complexity of the procedures, the scientific discussions involved and the need for a huge range of exotic raw materials gradually broke down the secrecy of the old guild system, and the sociology of the 'chemists-dyers' may well shed some light on our understanding of this specific technology. Analogies with the 'savants' of the old 'République des Lettres', are inevitable here, especially since the priority of the relationships between individuals across national borders are in both cases emphasized.[75] In fact, the old "compilateurs" of formulas progressively became compilateurs of the names of the actors involved in this technology in the textbooks.[76]

A closer appraisal of these cultures of chemistry in different historical periods may well challenge the dominance of traditional categories such as 'science' and 'technology', 'pure' and 'applied' science, 'academy' and 'industry'. The experiments in photography mentioned above, and the problem of mercerization illustrate the fact that new historical categories are required.

Moreover, as Ernst Homburg pointed out some years ago in reference to the dyestuffs industry, the craftsman tradition of the small scale dyer progressively became, in the second half of the nineteenth century, a laboratory enterprise in which the colourist,[77] often trained at prestigious chemistry schools, was an emerging new professional. Outstanding figures like Chevreul, Persoz, Bolley or Schutzenberger were renowned teachers in technical schools, as well as writers of

[74] "Late eighteenth century Englishmen believed themselves to be living in an 'inventive age' a 'scientific age' on a 'century ... remarkable for an accumulation of ingenuity. They were proud of their country's technical achievements and a few recognized their potentiality for economic growth". Ch. MacLeod, *Inventing the Industrial Revolution. The English Patent System 1660-1800*, Cambridge 1988, p. 222. H.I. Dutton, *The Patent System and Inventive Activity during the Industrial Revolution 1750-1852*, Manchester 1984.

[75] L. Daston, «Nationalism and Scientific Neutrality under Napoléon», in T. Frangsmyr (ed.), *Solomon's house revisited. The Organization and Institutionalization of Science*, London 1991, pp. 95-119.

[76] The history of synthetic dyes has been studied in recent years: A.S. Travis, *The Rainbow makers. The origins of the Synthetic Dyestuffs Industry in western Europe*, Lehigh 1992; E. Homburg, «The influence of demand on the emergence of the dye industry. The roles of chemists and colourists», Journal of the Society of Dyers and Colourists, 99, 1983, 325-332; J.J. Beer, *The Emergence of the German Dye Industry*, New York 1981.

[77] E. Homburg, «The influence of demand on the emergence of the dye industry ...», op. cit., p. 312.

treatises of 'applied chemistry' on dyeing and printing, and worked in close proximity with the everyday problems of the factory; like Mercer, they became professionals of "textile chemistry", building a kind of bridge between different cultures of chemistry.

It was probably just a step before the German 'industrialization of invention' in which, as Meyer-Thorow stated in the case of Bayer in the last decades of the 19th century: "… the relationship between science and industry changed in a very decisive way … Large company laboratories were set up. The 'consulting scientist' and the 'scientific entrepreneur' were replaced by the salaried industrial research worker".[78] Meyer agreed that only further research could provide a broader overview of the history of the chemical industry and the professional industrial chemist. And there is no doubt that massive changes in organization separate the isolated expert dyer of the eighteenth century and the industrial research teams of the twentieth. Accepting the lack of a broad overview, we should perhaps pursue research in local case studies which might show, as Mercer's case does, the multiplicity of the roads which constitute that ideal bridge between chemistry and industry.

When extending Meyer's study to other German firms, Ernst Homburg shows the importance of management and organization of the industrial research laboratories, and the need we have as historians to open the "black box" of every laboratory and factory. As Peter Morris pointed out in his appraisal of the German dye industry,[79] academic chemists were often invited by industrialists to explain the fundamental principles of an industrial process. Established procedures underwrote this kind of relationship. Nevertheless, the intrusion of industrial chemists into the world of academic research has not usually been so smooth. In any case, when analysing the concrete practices of academic and industrial chemists the distinctions become more vague, and the place of the latter in the black box of the industrial culture is still poorly understood.

Returning to the meeting of the Society of Dyers and Colourists in Manchester in 1944, some remarks made just after the reading of the John Mercer Lecture are of interest. In a vote of thanks to the lecturers, Mr. J.T. Marsh, whose idea the Mercer lectures had been, declared: "A pertinent analogy might be drawn between research organizations and chemical compounds. We had some single elements of very great activity … then we had a few different atoms united in a small compound which may be mobile, reactive and capable of penetrating almost

[78] G. Meyer-Thurow, «The industrialization of invention: A case study from the German chemical industry», *Isis*, 73, 1982, 363-381.

[79] P. Morris, «The technology-science interaction: Walter Reppe and cyclooctadiene chemistry», *British Journal for the History of Science*, 25, 1992, 145-167. On the relationship between academic chemists and industry: P. Morris, *The American Synthetic Rubber Research Program*, Philadelphia 1989; J.L. Sturchio, *Chemists and industry in Modern America: Studies in the Historical Application of Science Indicators*, University of Pennsylvania Ph.D. 1981.

everywhere. Finally we had the high polymer with its elaborate organization of a large number of atoms imparting stability, toughness and strength. All were of value in science and scientific research".[80] Finding their rightful place inside the 'big molecule', in the 'black box' of industry has probably been the main challenge for industrial chemists in the last 200 years, and a fundamental prerequisite for their social recognition as professionals.

[80] N.G. Mc Culloch, G.S. Hibert, «Science in Old Industry», op. cit., p. 262.