ACADEMIA AND INDUSTRY: WHAT SHOULD THEIR RELATIONSHIP BE? THE LEVINSTEIN-ROSCOE DIALOG

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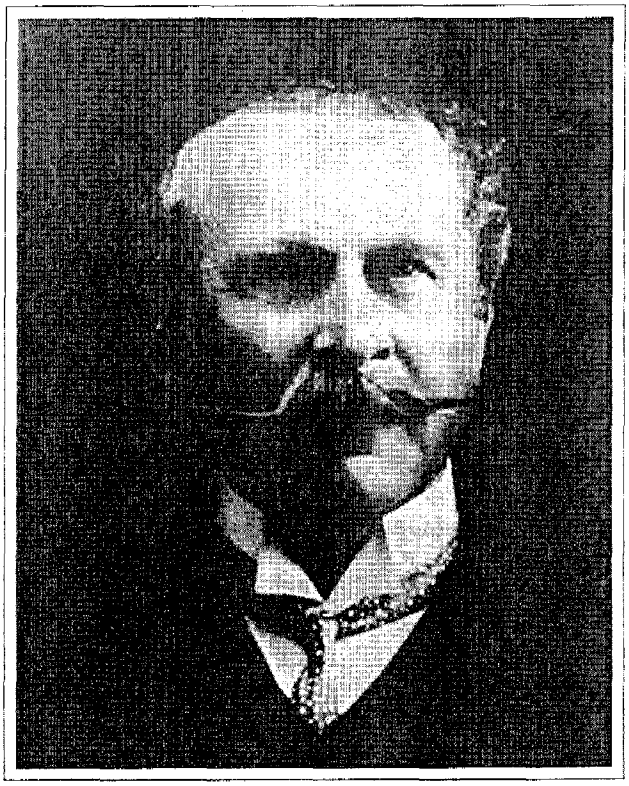
What should be the proper relationship between the practitioners of pure academic science and those involved in the application of science? Should there be an active partnership or should applied science be of no concern at all to the academic scientist? This is an age old question which still has not been satisfactorily answered today. As we enter the 21st century are lessons of the past still relevant? In this context, it is worth considering the first major debate on the relationship of academic chemistry and industrial. This took place at the end of the 19th century and focused on the perceived needs of the British synthetic dyestuff industry, which was then in decline(1). The debate was carried on between Ivan Levinstein (1845-1916)(2) representing applied chemistry and Henry Enfield Roscoe (1833-1915)(3) representing pure chemistry.



Ivan Levinstein

The British synthetic dye industry had been founded in England following the discovery of the aniline dye mauve in 1856 by William Henry Perkin (1838-1907). This also marked the beginning of the modern synthetic organic chemical industry. Yet within two decades it was totally eclipsed by the German chemical industry. What led to this decline? The reasons were complex and many(4), but for Ivan Levinstein, one of the few British survivors (despite his German origins), one of the most important was the lack of cooperation of industry and academia. Some recent observers have seen this as the culmination of a trend that had occurred in Britain with the professionalization of chemistry, begun in the 1840's with the founding of the Chemical Society (1841) and the Royal College of Chemistry in London(1845)(5). Initially there was a very visible connection between pure and applied chemistry. Perkin had studied at the Royal College for three years, and he received training in theory as well as research experience under the tutelage of A. W. Hofmann (1818-1892)(6). This was instrumental in his being able to make his laboratory discovery and successfully commercialize it within a very short time span.

A common theme in chemical instruction as it developed in Britain was that theoretical or pure chemistry had to be taught first, and then more practical or applied chemistry would follow at the end of the course of studies. By the 1870's the academic study of chemistry had almost completely displaced applied chemistry from the curriculum. The commonly accepted wisdom was that the attainment of a knowledge of pure chemistry would be enough to make it possible for anyone to apply it to industrial situations. Academic chemists had developed their own "industry" of training students and teachers and ignored the needs of the chemical industry for the most part. Numerous British chemists obtained Ph.D. degrees at the German research institutes and universities(7) beginning in the 1840's and, on their return, brought an emphasis on pure chemical research to the developing universities. This helped displace any remnants of applied chemistry from the university curriculum. The importance of a continuing relationship between academia and industry seemed to most British academics to be of little concern. Though many served as consultants, few if any connected these activities with their own research program.

By the 1860's the center of the British dye industry had moved from the London area where Perkin had established it, northward to Manchester(8) and Huddersfield, which were closer to the textile industry of Lancashire and Yorkshire. As Manchester had already grown in importance as an industrial center, and an institution of higher learning Owens College had been founded in 1851 to fulfill the perceived need for technical training. Owens would serve as the model for many of the civic colleges founded in the next few decades in major British cities. Chemistry became one of the most important disciplines at Owens, and after a keen competition, Edward Frankland (1825-1899)(9) was chosen as the first Professor of Chemistry. Frankland had impeccable credentials for the appointment, having studied with Robert Bunsen at Marburg and Justus Liebig at Giessen, and already had published a considerable body of research. In his inaugural address Frankland stressed that chemistry was an important mental discipline in and itself and would equip the holder of a certificate of proficiency for many other occupations. Frankland stressed the practical aspects of chemical training with respect to the situation in Manchester(10).

The advantages of chemistry to the chemical manufacturer, the dyer and the calico printer are almost too obvious to require comment...It is now an acknowledged fact that these processes cannot be carried on without some knowledge of our science, yet with the exception

Sir Henry Roscoe

of some few firms who have not the aid and co-operation of distinguished chemists, this knowledge is too often only superficial and sufficient to prevent egregious blunders and ruinous losses, but inadequate to seize upon and turn to advantage the numerous hints which are almost sure to be constantly furnished in all manufacturing processes. It is well known how many valuable discoveries of the highest practical importance have been made by the acute observation of a single minute phenomenon exhibiting itself during a manufacturing process and which would perhaps never have come to the cognizance of any one if the intelligent and scientific conductor of the process had not at once comprehended the reaction and chronicled the fact.

In Frankland's mind pure science and practical chemistry were mutually compatible and not exclusive of each other. Frankland left Owens in 1857 because of the uncertainty of the survival of the college. His successor was Henry Enfield Roscoe, a Liverpool native who had studied at University College, London, and obtained his Ph.D. with Bunsen at Marburg in 1853. Returning to London, Roscoe worked as a part-time teacher and consultant until his appointment to Owens in 1857. Roscoe was probably the person most responsible for the reversal of fortune at Owens in the succeeding years and the evolution of Owens into the

nucleus of the University of Manchester. Roscoe's goals can be best appreciated from this passage from his autobiography(11):

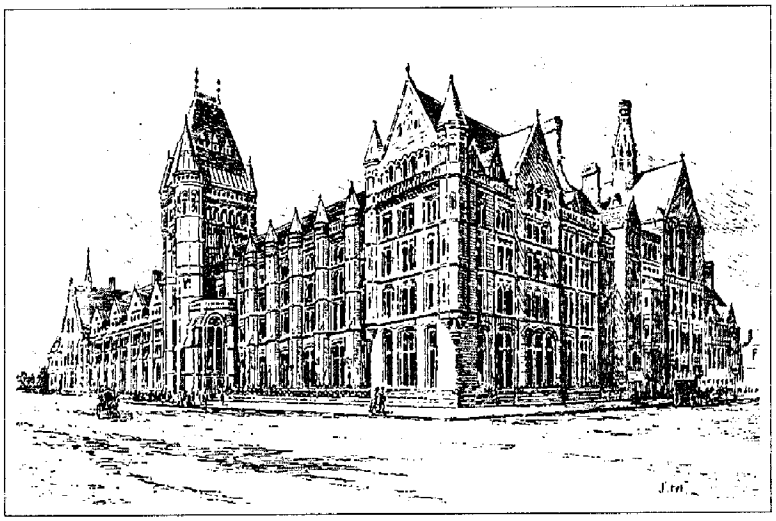
> Public opinion in Manchester at that time did not appreciate the value of the higher education, and it was not understood that science could be made an efficient instrument of education, and that such an education was absolutely necessary for an industrial career. To make a school of chemistry worthy of the great manufacturing districts of South Lancashire was my ambition, and after thirty years of work I think it must be admitted that this was, to some extent at least, realized.

Robert Kargon has written of Roscoe(12):

> Roscoe's own combination of energy, enthusiasm, and political skill which thrust him to the forefront of Owens professors in reviving the College. This energy and enthusiasm rubbed off on his students and the community at large where he acted as a consultant on matters of health and waste management to manufacturers.

In theory at least Roscoe maintained a strong belief that there must be a union between the science of chemistry and the practice of chemistry. However, this was not to be construed to mean that Owens College was to be a vocational school(13):

> .....to the practical man the youths trained in the Chemical School of Owens College were able not only to take a more intelligent part in the operations of the various manufacturers than those who had not had such advantages, but that this education had given insight into these processes such that those thus trained were able to effect improvements or even to make discoveries of importance.



Victoria University of Manchester

Levinstein and the Dye Industry

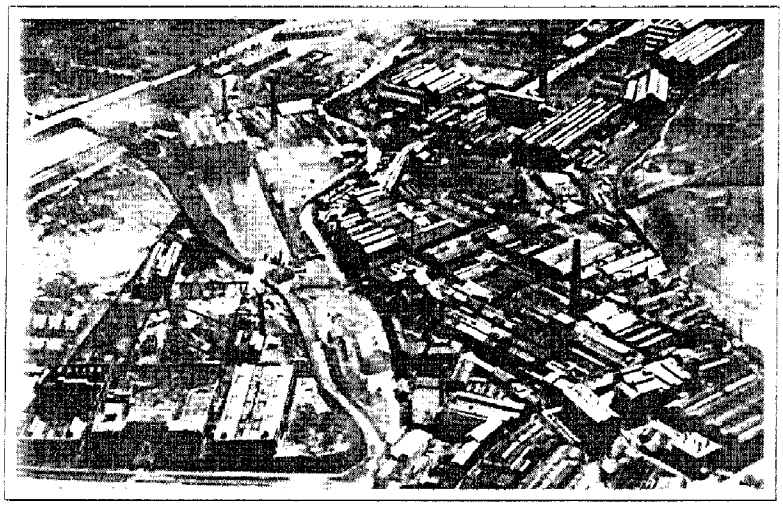
Ivan Levinstein was the eighth son of Levin Jacob Levinstein (1803-1865), a Berlin merchant. Four of his sons, Hugo (1832-1878), Gustav (1842-1910), Alexander (1843-?), and Ivan would become involved in the dye business in some capacity in England during their lifetimes. Of all the sons, only Ivan had any formal chemical training. After completing secondary school studies at the Royal Prussian Gymnasium in Berlin, he studied applied chemistry at the Gewerbeinstitut Berlin. Ivan's older brother Hugo was the first to emigrate to England in 1858. In London he founded the firm of Hugo Levinstein & Co. for the purpose of manufacturing and selling natural dyes and later manufacturing aniline dyes. The family's entrance into the dye business in England may have been the result of the father's declining fortunes in Germany. Greater opportunities existed now in England and in the newly developing dye industry.

By 1864 when Ivan left Germany for England, the English dye industry was probably at its zenith, although it was about to enter into a period of very rapid decline. Ivan is supposed to have remarked that his father in 1864 had already sensed that the English dye industry was going to be challenged by competition from the continent and would not likely survive this challenge. Putting his father's advice aside, Ivan established a chemical works first in Salford in 1864, and one year later he moved to the Blackley section of Manchester. This was to become the manufacturing site of Levinstein & Co during its existence(14). The initial products manufactured by Levinstein were aniline dyes, such as aniline red or magenta and aniline blue.

As the fortunes of the British chemical industry began to fade rapidly in the late 1870's as because of continental competition, Levinstein spoke out whenever he could as to the causes of this decline and ways to arrest it. The media used by Levinstein were his own journal *Chemical Reviews*, which he published from 1871-1891, the Society of Chemical Industry, founded in 1881(15) and its journal, and the Society of Dyers and Colourists, founded in 1884., In addition, Levinstein was an active member of the Manchester Chamber of Commerce. Levinstein

analyzed the reasons and offered solutions for the problems of the synthetic chemical industry as well as the declining competitiveness of British industry in general.

The reasons for the decline were, according to Levinstein, a combination of several factors. Germany, using the pioneering models of Liebig and Wöhler, had produced numerous first-rate centers for the training of chemists. Since there was little opportunity for many of these German chemists in the fatherland, it was only natural for many of them to migrate to Britain in the 1860's. As the dye industry grew there was the need for specialized technical trained personnel which were not readily available in Britain(16).



Aerial view of British Dyestuffs Corporation, Blackley, 1921

German chemists had made significant strides in developing structural organic chemistry and aromatic chemistry in particular, which was at the heart of the dye industry in the nineteenth century. Chemists such as Heinrich Caro (1834-1910), Carl Martius (1838-1920), August Leonhardt(1827-99), and Otto Witt (1853-1915) returned to their homeland with the experience and expertise learned in Britain. They joined dye-making firms—in particular Hoechst, Agfa, BASF, and Bayer.

A major problem that accelerated the decline in Britain from about 1865 was the fragmentation of the industry following patent litigation and growing imports of German-made coal tar dyes. Levinstein remarked in 1906, "German manufacturers were in the happy position that they had the brains of the world at their disposal without paying for them...It was therefore no wonder that the German competitors, who were unfettered and unrestricted by patents or monopolies, soon made headway by selling goods at lower prices than those charged by the patent(17)." German dye companies benefited greatly from the transfer of technology from England which allowed them to get off to a very fast start in the dye business. Coupled with the intimate relationship between academia and industry as well as a supply of chemists trained in the British dye industry spelled inevitable doom for the British. In addition British patent laws did not require foreign companies to work their patents in Britain nor were German chemical companies compelled to license their patents to British manufacturers. Thus German dye companies patented their new products in England and freely exported them to the textile centers. Patent law would only be reformed in the beginning of the 20th century, when it was too late for the chemical industry.

Levinstein attributed much of the technical advantage the Germans enjoyed to the close cooperation between academia and industry. This is clear in the dialog between Levinstein and Roscoe carried out for the most part at meetings of the Society of Chemistry and Industry. The dialog was recorded in the pages of the *Journal of the Society of Chemical Industry*. The first annual meeting of the Society was held July 5, 1882, at Owens College. Roscoe was elected the first President of the Society. In his presidential address he related his observations on a recent visit to several of the German and Swiss dye companies. In particular, he described the organization of one of the Swiss firms, Bindschedler and Busch of Basel. His point was to show that on the continent the first principle that guided the management was(18):

> The absolute necessity of having-trained scientific chemists, not only at the head of the works but at the head of every department of the works where a special manufacture is being carried on. In this respect this method of working stands in absolute contrast to that too often adopted in chemical works in this country, where the control of the processes is left in the hands of men whose only rule is that of the thumb, and whose only knowledge is that bequeathed to them by their fathers.

Roscoe further stated that English chemists had been just as successful as their continental opposites in the initial stages of the synthetic organic chemical industry. The real reason he attributed to the decline of the dye industry was the lack of appreciation of training in pure chemistry as a prelude to its practice in the industry(18):

The Germans and Swiss, however, have been and still are distinctly before us, not only in the facilities which they possess of obtaining the highest technical training in their numerous Universities and Polytechnic Schools, but what is even more to the point, before us is the general recognition of the value and importance of such training for the successful prosecution of any branch of applied science. it is only the highest and most complete scientific training that can insure commercial success.

Levinstein became Chairman of the Manchester Section of the Society of Chemical Industry in 1883. In his inaugural address he focused on the subject of technical education and the state of the dye industry. After stating that most of the British chemical industry had managed to do very well despite difficult conditions, he then added that..."it is only that special part which deals with the production of aromatic hydrocarbon derivatives that has been neglected, and in which this country has allowed itself to remain behind others(19)." The dye industry was only in its infancy; yet it was generating enormous profits. Levinstein indicated that the three largest German dyestuff companies in 1882 had a profit of one million pounds sterling! (in today's terms over one hundred million dollars at least). Levinstein then posed a rhetorical question(19):

> You will also agree with me that it is a perfect anomaly that England, the largest manufacturing nation, possessing immense accumulated wealth, with general manufacturing facilities superior to those of any other country, situated geographically in the most favored position, and, above all, possessing the necessary raw material in quantities sufficient to supply both its own wants and the needs of the world, should be altogether beaten in an industry which had its original development in its own borders, and of which it was indeed the founder. What, then, is the cause of the fact that this country has lost and is still losing ground as regards this special industry?

The blame according to Levinstein lay squarely on the shoulders of British academics. Since the departure of Hofmann in 1865, the study and application of aromatic chemistry which was so fruitful in the early developing stages of the industry had been neglected. W.H. Perkin and E. C. Nicholson, students of Hofmann and early leaders of the dye industry, had continued their research on problems related to dyestuffs as the industry developed. However, these two chemist-entrepreneurs, who had become very wealthy, abandoned the industry while still in their prime. Continuing his Presidential address Levinstein stated(19):

> But then these gentlemen, though even great organic chemists, are none of them specialists in this particular department of science, and if you desire further confirmation of my statements, I invite you to look through the literature of the last ten years, and to compare the researches and investigations undertaken by the German with those of the English professors bearing on this subject, when you will be quite as much astonished at the overwhelming amount done by the former as at the insignificance of the work done by the latter. Indeed, gentlemen, unless my memory plays me false, I do not remember, during the period referred to, with perhaps few exceptions, any important original research bearing on this subject undertaken by the English professors, and I certainly cannot call to mind any work done by them which has been of practical utility to this industry.....and whilst the Germans are constantly developing this department of chemistry, and are thus extending and cultivating year by year the ground taken from this country, the British are content with simply acknowledging the ever-increasing amount of experimental research in Germany, without making the slightest effort to overtake their opponents, save perhaps by the demand for increased expenditure on technical education or endowments for research.

The dyehouse of Levinstein's works in Blackley, 1912

Levinstein argued for the appointment to professorships of men willing to work on research that would benefit the color industry. In Germany, science and prac-

tice were intimately related, and Levinstein would have liked to see this also occur in Britain.

In the following year, Roscoe became Chairman of the Manchester section of the SCI and in his remarks he sought to reply to the criticisms put forward by his predecessor. Roscoe stated that the purpose of any course in chemical technology in his view was not to train persons so completely that they could immediately manage an alkali or alizarin works(20):

> All that instruction can with any degree of success attempt is to lay a scientific foundation upon which the pupil is afterwards to build...In our case the first thing to ensure is that the student has obtained a careful and systematic grounding in the principles of the science, the application of which it will be his business to carry out.

Roscoe further stated his belief that one must know the theory, and then and only then can the student make full use of any lectures in the practice of chemistry(20):

> Above all, train him in habits of precise scientific thought, thus giving him the power of...initiating improvements or new processes by a complete understanding of the old one.

The period of anyone's formal education is brief as compared to the whole of a working career. Practical knowledge can be adequately acquired during this second stage of one's life. Original laboratory research, Roscoe argued, better equips the chemist to analyze and solve the problems encountered in the works. Roscoe was fully aware that under the most ideal circumstance teachers should be employed who had both a thorough grounding in theory as well as some practical experience. In Roscoe's view this practical training became outdated fairly quickly(20):

> We may indeed be well content if our students are brought so near the harbour for which they steer, that they can recognize and appreciate the value of the new lights which by degrees open out to them in practice. We may be satisfied if by careful training they are brought to know the principles of their calling, though their knowledge of detail be deficient, and even somewhat antiquated.

In concluding his remarks, Roscoe made the following plea(20):

> But the great difficulty which meets us on every hand is the proneness of the English mind to look for immediate results. We are proud of being called a practical nation; let us take care that with this we unite theory or scientific knowledge, and all will be well with us; whilst if we continue to be content with practice alone, we shall find ourselves outstripped in our industries by those who see more clearly than we do in what the real strength of a manufacturing nation lies.

This was to be Roscoe's last statement as a member of the Owens College faculty; he was elected in 1885 to Parliament as the member for the South Manchester constituency and would never return again to academic life. These remarks of Roscoe ring as pertinent today as they were in his time in the continuing debate over funding pure versus applied science and the need for academia to become more involved in practical research.

In 1886 the present state of the British chemical industry was analyzed again by Levinstein before the Manchester section of the SCI. This was a wide ranging analysis of the industry as a whole and particularly of the dye industry. With respect to the question of pure versus applied science, Levinstein again returned to his theme that teachers of technical chemistry must have practical experience to be effective(21):

> .....when Professors are placed at the head of our largest technical colleges who have never in their life done an hour's practical work in any manufactory or works, and whose only qualification appears to be purely scientific attainments...Industry and science must work hand in hand, for each can learn from and benefit the other.

Levinstein further lamented the lack of training available in Britain in what would become the discipline of chemical engineering. Mechanical engineers had long been a fixture at chemical plants as they were needed to run the steam engines and pumps. The problem of scaling up a chemical process was a challenge they were not equipped to handle. So much of the industrial chemist's time was taken up with learning the mechanics of running a chemical plant, that the application of their knowledge of chemistry was greatly hindered. From 1880 to 1907 at the Manchester Technical Municipal School, an institution that Levinstein helped to found, George Davis presented a series of lectures that became the core of chemical engineering programs in Britain. Degrees in chemical engineering were not offered until 1909, however. Judging from the discussion after the paper, Levinstein had struck a very responsive note with the audience. Speaker after speaker arose to agree with the conclusions of Levinstein concerning the thrust of his argument for technical education and the lack of appreciation of scientific education in Britain as a whole. Watson Smith of Owens College stated that the managers of chemical works argue, "Give me an

ounce of practice and you can keep your ton of theory"(22). This completely subverted the role of the chemist.

Levinstein did have some success in improving technical education in Manchester since he was the driving force behind the merger of the Faculty of Technology at Owens with Manchester Municipal College to form the foundation of the present University of Manchester Institute of Science and Technology.

Well into the present century Levinstein continued his attack on the general state of education in Britain as a whole. His 1902 Presidential address to the SCI was entitled, "Education and Legislation: Their Influence on Trade and Industry." After reviewing the litany of reasons for the decline of British commerce, he made the following remarks concerning legislation(23):

> Under our present system, questions of the highest commercial importance receive but scant attention either from the Board of Trade or the House of Commons. Parliament is indifferent because it is largely constituted of lawyers and of men who, having been fortunate in the choice of a father, disdain anything appertaining to trade or commerce. They regard the House as a first-class club where one meets good society; and without the most strenuous efforts from the outside, it is difficult to get the House to consider any commercial question of national importance. The Board of Trade consists of a number of distinguished officials, often overworked with routine, and hence by no means anxious for changes which mean more work still. The appointment of a Minister of Commerce, able to command the attention of the House and to organize his own department, selected especially on account of an intimate knowledge of commercial affairs, would be an immense boon to the country.

Levinstein would be greatly pleased at how the emphasis on commerce and its importance has become a key element of national policy today. The Department of Trade and Industry in the UK and the US Department of Commerce as well as Japan's Ministry of Trade and Industry are examples of what Levinstein had hoped to accomplish. Levinstein saw the need to reform general nonspecialized secondary education. What good was there in a system of technical education if the proper groundwork was not laid in prior education? He went on to cite impressive statistics concerning secondary education in Germany as compared to England(24):

> The millions of money spent on technical education in this country had been in the main sadly wasted. Of 54 so-called technical schools 22 had practically no day students, and the total number of day students taking technological courses in Technical Schools and University does not equal the number of students in one single German Technische Hochschule—that of Charlottenburg.

To restore British competitiveness Levinstein advocated a system of modern comprehensive education instead of the classical education that had existed in Britain for so long. Students in Germany obtained an education that prepared them to deal with the complexities of modern businesses. The real deficiency, however, was in general secondary education and until this was remedied, all the magnificent facilities for higher education would not be adequately used(24):

> What we really want is a large number of men who have enjoyed the highest scientific training. To attain this end, the first condition is not by any means to erect an additional number of technical high schools, but to have a very large number available who have been thoroughly trained in general knowledge and are ready to benefit from the existing facilities for higher education. It is here that the "shoe really pinches." Establish a system of high-class secondary education accessible to all grades, give sufficient inducement for the boys to stay long enough at school, and you will find that efficient scientific and technical education will follow here just as it did in Germany.

These remarks again have much contemporary application in the current debate over secondary school education in the United States as compared to other parts of the world.

In many ways Levinstein can be likened to the Biblical prophets of old whose warnings were not heeded. The deficiencies that Levinstein saw in the chemical industry in his adopted country were dramatically shown during the Great War, the first conflict in which science, especially chemistry, played an important role. The inadequacies of the British chemical industry became very evident by 1915, the cause being the lack of investment in research and the failure, as Levinstein had so well documented, training of chemists for applied work by the universities. The lesson seemed to be learned to some extent, since the British were in a much better position in 1939 than in 1914. At the time of his death in 1916 Levinstein must have been saddened to see how true his prophecies had become. Without the continuous dialog between opposing viewpoints concerning the role of pure and applied science, however, change would never have occurred.

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REFERENCES AND NOTES

1. For a comprehensive history of the development of the dye industry see: A. S. Travis, *The Rainbow Makers: The Origin of the Synthetic Dyestuff Industry in Western Europe*, Lehigh University Press, Bethlehem, PA, 1993.
2. The most comprehensive discussion of Levinstein and his company can be found in: M. R. Fox, *Dyemakers of Great Britain, 1856-1976,* Imperial Chemical Industries PLC, 1987.
3. H. E. Roscoe, *The Life and Experiences of Sir H. E. Roscoe Written by Himself,* Macmillan & Co., London, 1906.
4. R. D. Welham, "The Early History of the Synthetic Dye Industry IV-The Reasons for the British Failure," *J. Soc. Dyers and Colourists*, **1963**, 79, 229-237.
5. For a study of the Royal College of Chemistry see: R. W. Bud and G. K. Roberts, *Science versus Practice: Chemistry in Victorian Britain,* Manchester University Press, Manchester, 1984.
6. A. S. Travis, "August Wilhelm Hofmann(1818-1892)," *Chem. Br.,* **1992**, 28, 60-63; A. S. Travis, "Science's Powerful Companion: A.W. Hofmann's Investigation of Aniline Red and its Derivatives," *Br. J. Hist. Sci,* **1992**, *25,* 27-44.
7. P. R. Jones, *Bibliographie der Dissertationen amerikanischer und britischer Chemiker an deutschen Universitaten, 1840-1914*, Forschungsinstitut des Deutschen Museums, Munich, 1983.
8. R. Brightman, "Manchester and the Origin of the Dyestuffs Industry," *Chem. Ind.(London),* **1957**, 86-91.
9. For the most complete biographies of Edward Frankland, see: C. A. Russell, *Lancastrian Chemist: The Early Years of Sir Edward Frankland,* Open Univ. Press., Milton Keynes, UK, 1986; C. A. Russell, *Edward Frankland, Chemistry, Conspiracy, and Controversy in Victorian England,* Cambridge Un. Press, Cambridge, 1996.
10. E. Frankland, "Introductory Lectures on the Opening of Owens College," Manchester, **1852**, 99.(Quote can be found in Kargon, Ref. 12)
11. Ref.. 3, p. 103.
12. R. H. Kargon, *Science in Victorian Manchester: Enterprise and Expertise,* The Johns Hopkins University Press, Baltimore, MD, 1977, 164.
13. H. E. Roscoe, "Record of Work Done in the Chemical Department of Owens College, 1857-1887," Manchester, 1887, p. 3 (as quoted in Kargon, Ref. 12)
14. Salford and Manchester are twin cities separated by the river Irwell. The Blackley site was acquired from Levinstein in 1919 by British Dyestuffs Corporation Ltd., which in 1926 changed its name to Imperial Chemical Industries. ICI in June of 1993 was divided into several new companies. The Blackley site is now part of Zeneca Specialties and serves as the international headquarters for the company. Chemical manufacturing ceased at the Blackley site in 1985 after 120 years.
15. A brief history of the founding of the Society of Chemistry and Industry can be found in: A. S. Travis, "The Meeting of Practical Men," *J. Soc. Chem. Ind. London,* **1990**, 451-456.
16. The argument has been made that the major chemical industry in Britain in this period was the alkali industry. Chemical training was therefore focused on this industry to the detriment of the newly emerging synthetic organic chemical industry. This was a very shortsighted approach for which Britain was to suffer in the future. On the other hand, German dyestuff companies saw that research was the lifeblood of their future prosperity and developed the model of the modern corporate research laboratory.
17. I. Levinstein,"The Decline of the Aniline Color Industry in England," *J. Soc. Dyers & Colourists,* **1906**, 22, 129-130.
18. H. E. Roscoe, "Presidential Address," *J. Soc. Chem Ind. London,* **1882,** *1,* 250-252.
19. I. Levinstein, "Address by the Chairman, November 6, 1883," *J. Soc. Chem. Ind. London.,* **1884,** *3,* 69-73.
20. H. E. Roscoe, "Remarks on the Teaching of Chemical Technology," *J. Soc. Chem. Ind. London,* **1884,** *3,* 592-594.
21. I. Levinstein, "Observations and Suggestions on the Present Position of the British Chemical Industries, with Special Reference to Coal-Tar Derivatives," *J. Soc. Chem. Ind. London,* **1886**, *5,* 51-359.
22. Ref. 21, "Discussion of I. Levinstein's Observations," remarks of W. Smith found on p. 137.
23. I. Levinstein, "Education and Legislation: Their Influence on Trade and Industry," *J. Soc. Chem. Ind. London,* **1902,** *21,* 893-899.
24. I. Levinstein, "Recent Legislation and Other Matters Affecting Trade and Industries," *J. Soc. Chem. Ind. .London,* **1903**, *22,* 843-846.

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