INTRODUCTION

Chemistry, Consultants, and Companies, c. 1850–2000

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In response to the growth of the "entrepreneurial university" and increasing commercialisation of scientific and technological knowledge that has occurred since the 1980s, university-technology transfer has become the subject of multi-disciplinary debate. Over the last 30 years, against the backdrop of globalisation and neoliberal pro-market policies, this debate has intensified. A recent special issue of *History and Technology* added to the expanding literature on the subject by addressing what the editors, Joris Mercelis, Gabriel Galvez-Behar and Anna Guagnini, saw as an imbalance, namely the over-emphasis on institutions, at the expense of the individuals at the heart of the commercialisation of academic science and technology.[1] They identified three kinds of commercial activities which scientists engaged in: consulting, patenting, and full-blown business entrepreneurship, and argued that focusing on individuals and their activities was far better suited to addressing issues of continuity and discontinuity than focusing on institutions. Such an approach proves better able to question the models that have hitherto been proposed, and that are often skewed by their preoccupation with the US and efforts to challenge the – allegedly recent and somewhat unhealthy – alliance between academic science and the economic sphere.[2]

With the quantitative study carried out by Robin Mackie and Gerrylynn Roberts, this issue of *Ambix* answers Mercelis *et al*'s call for more systematic surveys, before following the trajectories of individual consultants.[3] It complements and adds to their work by paying special attention to scientists from a particular discipline, chemistry (broadly construed), who carried out the most common of the three activities: consulting, for a specific sector of the economy: the chemical industry (also broadly construed to include food producers and pharmaceutical

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[1] J. Mercelis, G. Galvez-Behar and A. Guagnini, "Commercializing science: nineteenth- and twentieth-century academic scientists as consultants, patentees, and entrepreneurs," *History and Technology* 33, 1 (2017): 4-22. The special issue was the outcome of a workshop on "Academic entrepreneurship in history" that took place in Ghent in 2015.

[2] Among the models cited are Mirowski's. P. Mirowski, *Science Mart: Privatizing American Science,* (Cambridge, MA: Harvard University Press, 2011).

[3] Mercelis *et al*, "Commercializing science," 9.

companies, among others), over the *longue durée*. Chemical consultants have been neglected as an occupational group in the published literature, especially in the interwar period. Where reference is made, they are usually included as part of general surveys of early industrial development, of biographies of individual scientists, or of institutional histories, in particular those that describe the links between universities and industry.[4] And yet, from the middle of the nineteenth century, not only were chemists prominent as consultants at a time when industrial growth and urban expansion created a special demand for testing the safety and analyzing the quality of air, food, and water, but consultants were prominent among members of the chemistry profession.[5] Although subsequently the proportion of consultants declined, consulting nevertheless endured as a key activity of academic and non-academic chemists, a testimony to the versatility it has offered scientists in different occupations or at different stages in their careers. Indeed, for some, consultancy was an opportunity to carry out independent work, often as a secondary occupation, alongside other remunerated work, while for others it was a stage in their "portfolio careers." As Mackie and Roberts argue, and as the case studies in this special issue illustrate, chemists who worked as consultants tended to have varied careers, and their activities were "diverse, covering a broad range of fields from foodstuffs to metallurgy, and including routine analysis, pioneering research, and advisory work."[6] Several of these are encountered in this special issue, and show that consultancy often went hand in hand with other commercial activities.

Consultants and their activities

[4] J. Donnelly, "Consultants, Managers, Testing Slaves: Changing Roles for Chemists in the British Alkali Industry, 1850–1920,"*Technology and Culture*, 35/1 (1994): 100–128; C.A. Russell and J. Hudson, *Early Railway Chemistry and Its Legacy*, (Cambridge: Royal Society of Chemistry Publishing, 2011); P. Lucier, *Scientists and Swindlers. Consulting on Coal and Oil in America, 1820–1890*, (Baltimore: The John Hopkins University Press, 2008), 278–285T; G. E. Webb, "The Chemist as Consultant in Gilded Age America," *Bulletin of the History of Chemistry*, 15/16 (1994): 9–13; W. Reid, *Memoirs and Correspondence of Lyon Playfair, First Lord Playfair of St. Andrews* (London: Cassell & Co., 1899), 61–3; W.H. Brock, *William Crookes (1832–1919) and the Commercialization of Science* (Aldershot: Ashgate, 2008); K.D. Watson, "The Chemist as Expert: The Consulting Career of Sir William Ramsay," *Ambix*, 42/3 (1995): 143–159; M. Sanderson, "The Professor as Industrial Consultant: Oliver Arnold and the British Steel Industry, 1900-14," *Economic History Review*, 31/4 (1978): 585–600; H.E. Roscoe, *Life and Experiences of Sir Henry Roscoe* (London: Macmillan and Co. Ltd., 1906), p. 141–2.

[5] See for example R. Bud and G. K. Roberts, *Science versus Practice. Chemistry in Victorian Britain* (Manchester: Manchester University Press, 1984); C.A. Russell, N.G. Coley, and G.K. Roberts, *Chemists by Profession: The Origins and Rise of the Royal Institute of Chemistry* (Milton Keynes: Open University Press, 1977).

[6] R. Mackie and G.K. Roberts, **"**Consultancy as a Career in Late Nineteenth and Twentieth Century Britain," this issue.

We begin with Robert Warington (1807-1867), a central figure in the mid-nineteenth century chemical community, who enables Anna Simmons to shine a light onto the nature of consultants' work during a key period in the development of the chemical profession. In his position at the Society of Apothecaries he fulfilled a variety of roles but, as a consulting chemist, providing chemical services for industrial and commercial clients represented the largest part of Warington's work. In this period few firms employed full-time chemists, hence his expertise was sought for chemical answers to commercial questions about manufacturing, waste, standards, competitors' activities, and intellectual property. He was a patent holder himself, including one of the first patents for the use of chromium salts in tanning. However the diversity of his otherwise highly successful – and lucrative – career led the authors of his obituary to comment on the somewhat dispersed nature of his research. In Simmons' s view, his obituarists felt that, had he not been so committed to his numerous consultancies, Warrington's research might have been more fully developed.

Then comes George Davis (1857-1906), who from 1870 was closely associated with the chemical industry in the Northwest of England, by then a major centre for chemical manufacturing. He was first employed in several different sectors before working for the Alkali Inspectorate. Over the course of his career, he took out patents, a sizeable number of which were concerned with the coal gas industry, and not only tackled issues such as river pollution and waste management, but also designed plant and advised companies about the most economic methods of production. He did so often through experimentation, and was a strong believer in the use of continuous research to "ensure solutions to manufacturing inefficiency built on the very latest knowledge and understanding."

Crossing over from Britain to Norway, and moving forward in time, Annette Lykknes argues that Peder Farup (1875–1934) and Sigval Schmidt-Nielsen (1877–1956), professors of chemistry at the newly founded Norwegian Institute of Technology (NTH), both succeeded in "bridging, even mixing the industrial and academic realms," thus building "hybrid careers," albeit in different ways. As a consultant for the electrochemical industry, Farup carried out experiments to find new titanium white pigments, and developed new apparatus and processes, for which he obtained a number of patents. Schmidt-Nielsen, who spent most of his career at NTH, and consulted for both industry and the state, identified more as an academic scientist than Farup, publishing articles and carrying out research, and acting as expert witness in court cases. Like

Farup however, his work as consultant would be closely associated with a particular product, in this instance margarine from whale oil developed during World War One.

As well as an individual consultant, a very special product, the breast cancer drug tamoxifen, is the subject of the last paper in this issue. Craig Jordan, who in his own words was "the First Tamoxifen Consultant," at first tapped into, and later added to ICI's extensive research networks and R&D effort in cancer. His work involved devising laboratory tests, carrying out research, and liaising with clinical trial groups on behalf of the company in order to establish the translational strategy for tamoxifen. It helped to transform the drug into a treatment of choice, not only in the UK, but also in the US, its largest potential market, thus paving the way for a new therapeutic approach to cancer: chemoprevention. The relationship between ICI and Jordan was therefore mutually beneficial, bringing in huge profits to the company, whilst laying the foundations for Jordan's academic career.

Despite the diversity of functions and experiences described above, chemical consultants shared a number of key features: first, their consultancy work remained largely "invisible;"[7] second, personal connections and professional networks played an important role in this work, and consulting attracted some of the most highly qualified scientists, often in central locations, either capital cities or university towns near major industrial hubs. If consultancy continued to flourish, it was not only because of the need for external knowledge and expertise, but also because this need brought something to consultants that exceeded the more direct benefits of their consultancy. This conclusion highlights the need to explore the motivations behind the different activities involved in consulting, which – as observed by Mercelis *et al*, and confirmed by our case studies – often went well beyond simple financial gain.

Motivations and stimuli for consulting

The examples of Warington and Davis show that consultancy went hand in hand with scientists' discipline building efforts. In Warington's case, the connections he formed, and the organizational skills he acquired in the early part of his career, which included a period of independent work as a chemical consultant, stood him in good stead when establishing the Chemical Society of London in 1841, of which he would be Vice-President twice from 1851-1854, and 1862-1865. In return, his consultancies benefited from his main institutional base at

[7] Quoted in Jonathan Aylen, Viviane Quirke and Peter Reed, "Hireling Shepherds or Knowledge Brokers? The Changing Role of Consultants in Industry, 1850-2000," *Newcomen Links* 250 (June 2019): 16-19.

Apothecaries' Hall, as well as the connections generated by his employment, although as Simmons comments "these extended far beyond the trade's customer base."

The economic pressures of the period due to intense competition, regulation of pollutants, waste management, and trade tariffs were the backdrop for Davis's "framework for chemical engineering," which addressed the fundamental nature of process operations rather than the specifics associated with any one industry sector. Through his editorship of the *Chemical Trade Journal,* launched in 1887, a series of lectures he delivered in 1888, and finally in his *Handbook of Chemical Engineering* (1901 and 1904) Davis sought to establish the chemical engineering profession as something more than what had previously been the "melding of some mechanical engineering with some chemistry." His Permanent Chemical Exhibition promoted both the framework and the consultancy services of the Partnership (formed with his brother in 1890) among those working in the chemical and allied trades. Others would later take up the framework, "revise it and mould it afresh in the light of new manufacturing challenges and technical advances."

Although our case studies come mainly from Britain, Norway provides a useful counterpoint to the British examples. If preoccupations with national performance and standing were not absent from Davis's work as a consultant or his efforts to establish a framework for chemical engineering, the Norwegian chemists discussed by Lykknes show how consulting for industry played an important part, in both institution and nation building, at a crucial moment in the country's history. Indeed, "when Farup and Schmidt-Nielsen served industry, they served the state, either directly by giving the state expert advice, like Schmidt-Nielsen did, or by contributing to innovations that could bring about industrial development, as was the case for Farup."

All the consultants discussed in the special issue applied their expertise, at one time or another, to areas concerned with public health and/or medicine, but none more so than the last consultant examined here, Craig Jordan. Although his first passion was for chemistry, he became a pharmacologist, since this branch of science offered him the best way (using his own words) to "save women's lives." To achieve this ambition, his research was carried out in collaboration with industry. Yet, although he referred to himself as a "consultant," he chose not to earn a fee, but rather to use the consultancy to fund his research at university. His example

reflects the flexibility of the term, which is to some extent is an "actors' category."[8] It also reflects the increasingly central place of research within consultants' activities, and as research became more expensive, the outsourcing from industry to universities that occurred in the last quarter of the twentieth century. As Mercelis *et al.* have highlighted in their article, this prompts the question of the continuities and/or discontinuities in the history of consulting.

Continuities and discontinuities in the history of chemistry, consulting and companies, c. 1850-2000

By focusing on case studies of chemists as consultants between 1850 and 2000, we are not only able to identify the different types of activities and motivations that consultancyentailed, but also to identify a number of historical shifts, although of course it is difficult to make wide generalizations from these few examples. By 1861 Warington defined himself as a "professional chemist," and his consultancies were central to this professional identity. While Warington had been an important player in the rise of the chemical profession, George Davis (1850-1907), experienced – and, through both his consultancies and his framework for chemical engineering, contributed to – another shift, this time in the chemical industry, to make chemical manufacture more economic and competitive. Farup and Schmidt-Nielsen exemplify the transnational circulation and influence of models of scientific practice (including consulting practice) over time, for Norwegian chemists drew much of their inspiration from Germany. They show how such models were internalized, and hybrid careers such as theirs were embodied within institutions like NTH.

These shifts were accompanied by the increasingly central role of laboratory research in consultants' activities, a trend accentuated by the two World Wars. The global conflicts of the twentieth century presented scientific and technological opportunities that have been well recognized, and chemical consultants responded not only to the military, but also the public health needs of nations at war. At a time of embargoes and limited resources, Schmidt-Nielsen answered his country's demand for food substitutes, in this instance margarine. However, by helping to drive home the realization that science was essential to the modern state as well as industry, war led to a relative downturn in the numbers of consultants, as noted by Mackie and Roberts. Yet, chemical consultants did not disappear. They continued to serve industry, even if

[8] "Consultancy UK" defines the consultant as someone "who provides professional or expert advice [...] As there is no legal protection given to the job title 'consultant', in theory, anyone can on a day wake up and decide to adopt the consultant title." https://www.consultancy.uk/career/what-is-a-consultant (accessed 17/06/20).

consulting became their secondary rather than primary occupation. By the 1970s, with research costs soaring, industrial research was increasingly outsourced, whilst universities and other public research institutions increasingly relied on external sources of funding for research. Through their collaborations with industry, consultants like Craig Jordan continued to bridge the gap between the two domains, and their careers thrived in the process.

The latter shift happened in the wake of the Cold War, on which Robert Bud reflects in his Epilogue. Consultancy threatened the ideal of “free science,” and its cultural boundaries, which became more sharply delineated during the Cold War. This explains why consultancy has tended to be overlooked in the history of science, which has its roots in that period. In Bud’s words, by exploring the fluid roles and values of individual chemists, the articles in this special issue therefore help historians of science move “beyond the rigidities inherited by our discipline from its Cold War infancy.”

The special issue is not intended to provide the final word on chemical consultants but rather to offer some insights into the changing nature and enduring appeal of consultancy which, as our case studies suggest, has been a source of historical continuity as well as a driver of scientific and technological change. We hope these articles will encourage other researchers to seek out the nature and context of other chemists working in a consultant role, and thus develop a more complete understanding of the distinctive roles played by consultants as an occupational group, and of how the work of consultants advanced chemical knowledge and know-how over the last 150 years.

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