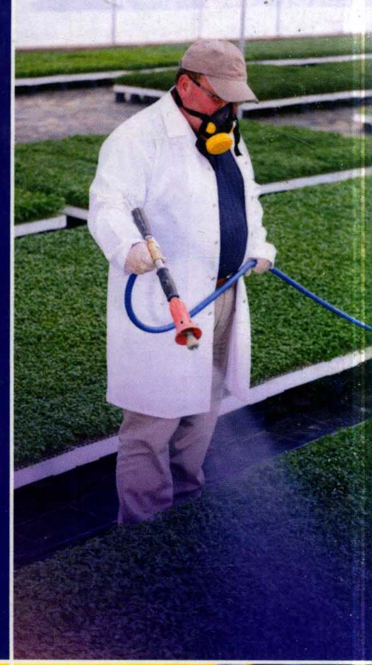
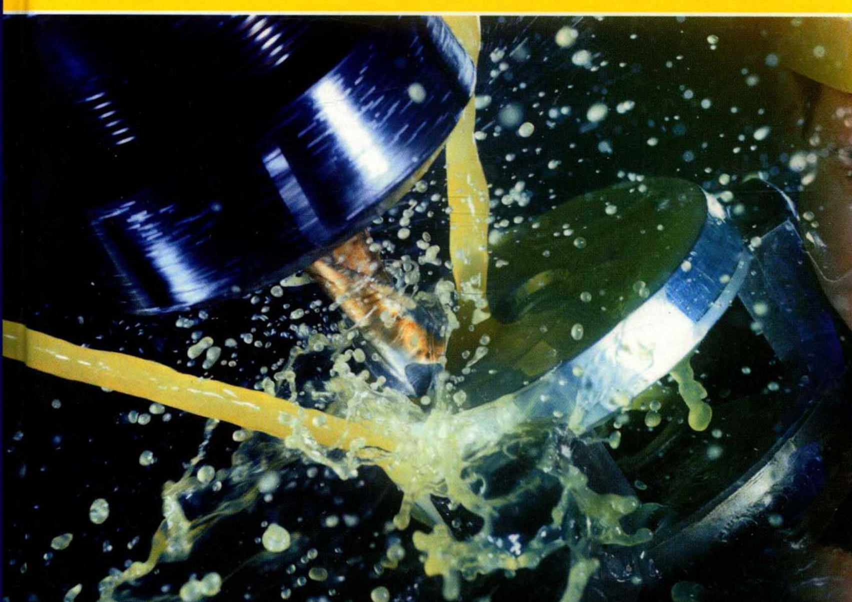
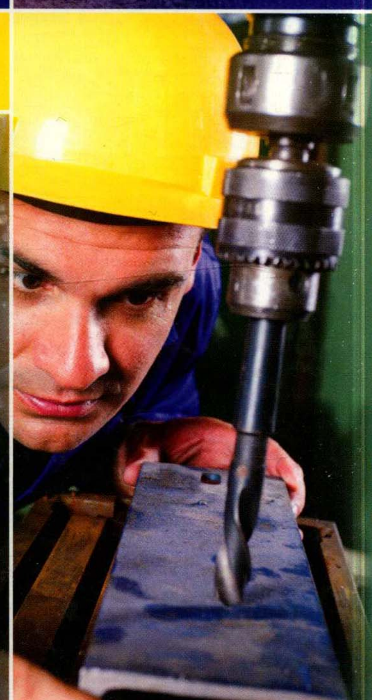
MICHAEL D. COLEMAN



Expert Report Writing in Toxicology

Forensic, Scientific & Legal Aspects





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Expert Report Writing in Toxicology

Forensic, Scientific and Legal Aspects

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This book is dedicated to Walter Drozd and Brian Odell

Preface

Most of us at one time or another have complained about issues relating to our workplace. It might be too hot or too cold; perhaps the chairs are uncomfortable and our colleagues and line managers are too annoying, aggressive, passive or uncaring. Perhaps the majority of us feel undervalued and under-rewarded for our efforts. However, one issue that relatively few of us in the developed world are likely to be worried about currently is whether our occupation might lead us to an early and unpleasant death due to a disease or condition brought about by our work and its environment. This is partly because of the vast changes in work patterns which have occurred over the past half-century in developed countries. Many of our great-grandparents and grandparents toiled in hard physical work, which might have meant jobs in areas such as heavy industry, manufacturing, farming, fishing, mining or construction. Many of these occupations caused severe and long-term impact on health, and in many cases the individuals concerned did not even live to retirement age. We still need the products of industry such as steel and aluminium for our cars, and we use myriad manufactured goods, eat fresh produce and fish, burn coal, move into new houses and use new roads. However, as a society, we have effectively 'outsourced' many of these difficult and hazardous occupations to other, usually developing countries.

Regarding those physical occupations in hazardous environments that remain in the developed world, the suffering of previous generations has led to the creation of an effective, complex, yet sometimes ridiculed Health and Safety apparatus which has greatly diminished, but sadly not eliminated, the risks of ill-health arising from occupation. Chapter 1 of this book outlines some of the historical milestones in the evolution of our occupational health knowledge, awareness and practice. This chapter also charts the rise and fall of various industries, as they created wealth, but also human misery, in terms of their widespread toxic impact on workers' health and life expectancy. This introductory chapter also outlines the notion that whilst hard-won experience led to detailed frameworks of Health and Safety practice that are now usually adhered to in the developed world, this is far from the case in the emerging manufacturing powerhouses of the Far East.

Despite our progress in Occupational Health in the developed world, there remains a substantial number of individuals whose health has been irreparably damaged by their occupation. The second chapter begins with the main features of the process whereby some recognition can be obtained for their suffering, as well as financial redress for loss of earnings and any necessary support for attainment of some quality of life. Whilst recognition and compensation can arise from some mutual agreement between former employee and employer, court action, or the threat of it, might be necessary for a final settlement. Naturally, much documentation is necessary for such actions to proceed, but expert reports are amongst the most important material needed to propel a case. From the perspective of the claimant, it is as if they wish to communicate to the court initially, *look at me now and my medical impairments*, which are dealt with by the medical report or reports. Subsequently, the claimant wants to establish *how this happened to me*, which is covered by other expert reports, notably on causation. Clearly a medical examination will provide a picture of the claimant's health impairments, which is usually relatively straightforward to describe and justify. Causation, in terms of how a substance or substances led the claimant to his or her current plight, may be much harder to establish, and the main purpose of this book is to provide the aspiring expert report writer with my own experience to illuminate this area.

It is not always easy for solicitors mounting cases to recruit relevant experts to contribute reports on causation. If causation cannot be established, then clearly the court will not be convinced and cases may not proceed because of a shortage of appropriate expertise. This may be particularly important in cases where the claimant is suffering from life-threatening health issues and may not have the luxury of time to pursue a case. Experts might be difficult to recruit due to a general shortage of qualified individuals in a particularly narrow field, or perhaps due to sheer pressure of other commitments. Indeed, an expert's credibility in part stems from validation supplied by their continued employment by their institution so their commitment to their employer's demands is, of course, paramount. It is also possible that prospective experts with the appropriate research interests and experience, as well as the relevant writing and oral skills, may hesitate to offer their services for different reasons. These might include a lack of familiarity with the legal context and framework of report drafting, or insufficient confidence in whether they already possess appropriate skills and knowledge to draft an effective report. Chapter 2 supplies some guidance as to how the expert report fits into the current legal process and how their work is evaluated and employed by the claimant's legal team, as well as the court.

The remaining chapters provide case histories where I have written reports as part of cases in various broadly themed areas, ranging from exposure to solvents and adhesives (Chapter 3), petrochemical-induced cases of bladder cancer (Chapter 4), as well as the impact of herbicides and insecticides (Chapter 5). In contrast, rather than focus on the occupational issues of the manufacturers of imported goods, Chapter 6 features the toxicity of some of the products of Far Eastern economic success. Whilst this book is not intended to be a toxicology text, I have striven to make the toxicological issues as accessible as possible to enable the arguments to be weighed and criticised. In addition, it is hoped that the book may be useful to all interested participants of the process of establishing causation in occupational toxicity proceedings.

The case histories are taken from some of the reports I prepared and submitted from 1997 to 2009. Indeed, depending on the reader's own expertise and experience, they will form their own opinion of the quality of the reports I compiled, and they may well feel that they could have constructed considerably better drafted and more convincing arguments, given the same starting information. If this is the case, then this book will have achieved one of its aims, which is to encourage those who could 'assist the court' to do so and to do a better job than I could do. Of course, in any given case, neither the medical experts nor the court or the causation report writing can restore the health of the individual concerned. However, contributing one's expertise towards achieving justice for a claimant is not only worthwhile, in terms of bringing recognition for their plight and others in the same position, but it also contributes to the evolution of the developed world's knowledge of Health and Safety. In addition, the publicity which sometimes surrounds cases also highlights the impact of old and hazardous industries, but also the effects of new processes on health which were not anticipated or expected.

My only personal experience of the damage occupation can do to health was the impact on my father of his service as a Wireless Telegraphist in the Royal Navy in World War II. Aside from surviving four years of Arctic weather, he had many lucky escapes, such as watching a torpedo from a U-Boat pass under his ship, a bout of persistent friendly fire by a US Air Force Lightning fighter, as well as a perilously close small arms attack whilst at anchor in Norway after the Germans had officially withdrawn. Ironically, it was his day-to-day work of high-frequency radio signalling, as well as using rifle fire to 'pot' mines during sweeping processes, that caused lifelong and severe impairment to his hearing, which deteriorated to virtually nothing towards the end of his life. Whilst he was, of course, grateful to survive, his deafness often made his personal and professional lives profoundly difficult, although he bore it with fortitude.

Chapter 6 considers the developing world's extremely uneven awareness of occupational health damage, albeit indirectly, through the toxicity of their products which have reached the United Kingdom. The Epilogue reflects on the gradual improvement of developing world Health and Safety, through advances in education and prosperity. Having spent the last few decades using manufacturing to generate wealth to attain Western living standards, it is to be hoped that developing countries will also see the necessity of adopting Health and Safety structures and practices, as well as improving existing ones, so that future manufacturing can be as safe for their workforces, as it should be sustainable and profitable. Every effort has been made to make this book as accurate as possible, but nothing and nobody is perfect. I am grateful to my wife Clare, my mother Jean and my family for their support during the preparation of the manuscript, and I hope that the book will be of use.

M.D. Coleman, D.Sc.
September 2013

'If I am given six hours to cut down a tree,
I will spend four hours sharpening the axe'

Abraham Lincoln (1809–1865)

Contents

1

A brief history of occupational toxicology

1.1 Occupational toxin exposure in antiquity

There are several activities essential to a civilised society, such as reliable food production as well as some provision for manufacturing and processing goods and foodstuffs. Whilst farming came comparatively late in human evolution, perhaps 8000–10,000 years BC, manufacturing of some recognisable sort appeared even later, when humans started to mine and process various metals. Of course, recovering metal ores from underground exposes the individual to many physical dangers, such as rock falls, floods and toxic gases. However, the significant energy input required for the extraction and processing of pure metals presented new hazards, such as the hot gases and dangers of the molten product. Many ancient cultures soon developed what we might recognise as a production process, where metals were mined, smelted and processed, including copper and tin, which were eventually combined to make bronze, which was more durable than either metal alone.

Whilst the process of smelting is inherently dangerous, neither copper nor tin is especially directly toxic to man. Indeed, the metal that replaced both of them in tool and weapon manufacture, iron, was also not particularly toxic to process in itself. These metals do not tend to accumulate in the body and cause acute or chronic toxicity during normal processing techniques. Lead, however, is very toxic, and the mining and smelting of this malleable and useful metal were probably the first activities where there were significant acute and chronic toxic hazards encountered during its handling. Lead is usually found as its sulphide (galena), which contains silver, so lead production at first was a by-product of silver recovery. Lead usage was fairly widespread before the ascendancy of the Romans, with many ancient peoples such as the Egyptians, using it for a variety of tasks; these included fishing weights, water piping and the basis of a form of early mascara.

Hippocrates (460–379 BC) [1] was the iconic founder of modern medicine, and it has been thought that he was the first to describe occupational lead poisoning; however, this is not actually true [2] as his description was not as precise as some

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authors would have it. The first detailed surviving description of lead intoxication appeared (in verse, apparently) around the second century BC, in the physician and poet Nicander of Colophon's *Alexipharmaca*. As the reach of the Roman Empire extended, by the beginning of the first century AD, lead usage increased dramatically. Indeed, the impact on health of any toxic process is directly related to its scale, and the Romans used vast amounts of lead in their grandiose, but impressively durable building projects. For instance, thousands of tonnes of lead were involved in the construction of a siphon unit in the great aqueduct at Lyon [3]. To supply lead on such a scale meant processing which we would even now recognise as 'industrial'. Consequently, it is not surprising that several Roman figures described the appalling environmental impact of lead processing, as well as the toxicity of the actual processes used for purifying the metal. Towards the end of the first century BC, the architect known today as Vitruvius (Marcus Vitruvius Pollio; ~75 BC to ~ AD 15) described the severe impact on local water supplies of metal processing, and he stated his opposition to the use of lead piping because of its toxicity to the lead workers, as he noticed how pale they looked. The philosopher and scientist Pliny the Elder (Gaius Plinius Secundus; AD 23–79), writing around 70 years later, commented that lead produced 'noxious and deadly fumes' when it was heated and processed. Pliny also designed masks that could be worn by workers to protect them from fumes. Interestingly, as with many toxins, although the dangers of lead were well documented, it continued to be used on a large scale for centuries after the deaths of its early critics. As we know, lead was used in piping and paints until well into the twentieth century and remains in many houses today, carrying drinking water all over the United Kingdom. Whilst it remains useful as a roofing material, perhaps most remarkably, lead was employed in its tetraethyl form for more than 80 years as an anti-detonation agent in fuels, such as petrol (gasoline); unfortunately, vast amounts were released into the atmosphere via this route. Since its removal from fuels in most countries before the year 2000, this source of lead pollution has declined dramatically in developed economies. Currently, lead is much less of a toxic threat than before, although human exposure in foodstuffs will probably never entirely be eradicated.

1.2 The Middle Ages and the Renaissance: The beginnings of modern occupational toxicology

Although always a crucial part of metal industries, mining in general broadened in scope up to the Middle Ages and beyond, as many more materials were actively recovered from deeper and deeper pits. The mining of coal for energy began in earnest after the thirteenth century, and by the end of the fifteenth century, metal mining to support the armaments industry was growing rapidly, as cumbersome cannon evolved towards more intricate hand-firearms. All this increased demand for iron, lead and copper, along with other metals. In 1473, the German physician Ulrich Ellenbog (1435–1499) wrote the landmark paper *Von den gifftigen Besen Tempffen* *un Reuchen* (On the Poisonous Wicked Fumes and Smokes), where he described the various toxic processes found in the gold mining industry, which involved fuming acids, as well as lead and mercury vapours. A more systematic exploration of mining and its hazards was then made by another German physician *Georgius Agricola* (Georg Bauer; 1494–1555), who developed a lifelong fascination with these subjects. He even bought a share of a silver mine and published several books on mining and various minerals, including *De Re Metallica* [4], which took him more than 20 years to write and was only published after his death. Although the book's main focus is its extraordinary detail of the methods of mining and metal processing of the time, he did investigate and document many of the occupational hazards of mining, including the various types of pneumoconiosis, such as silicosis, as well as other mining health dangers. Agricola is regarded now as a particularly able and methodical scientist, whose enthusiasm (Section 1.11) and understanding of the value of the observation of phenomena in making appropriate deductions were far ahead of his time.

A contemporary of Agricola was the much better known *Paracelsus*, and variations of his ubiquitous quote "All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy" have adorned many a text and student submission over the centuries. Philippus Theophrastus Aureolus Bombastus von Hohenheim was born in Zurich in 1493. His physician father, Wilhelm Bombast von Hohenheim, became an expert in occupational medicine in much the same way as Agricola, through researching his mining patients' experience. Strongly influenced by his father, young Philippus nevertheless began his studies with the controversial subject of alchemy. Today, the idea of making gold and silver from base metals in an ordinary laboratory sounds as quaint as it is impossible, without the aid of a Nuclear Research Facility. However, as late as the seventeenth century, it was taken deadly seriously, and most of the front rank of scientists at that time, such as Isaac Newton and Robert Boyle, considered themselves alchemists, although in secret.

Philippus Von Hohenheim travelled widely and studied surgery and, through his alchemy activities, chemistry. He began to pioneer the role of chemistry in medicine, rejecting various contemporary 'cures', in favour of a more systematic approach to the use of remedies such as opium, as well as metals such as lead and antimony. He advocated the use of small doses of mercury for syphilis, which was essentially the right idea with the wrong agent, as mercury was eventually proven ineffective for syphilis in the 1940s.

Philippus's ideas were revolutionary for his time, and he is credited with not only 'inventing' pharmacology, through his concept of dose and how its related to response, but also toxicology and even the idea of the 'target organ' for toxicity [5]. Sadly, he managed to combine aggression, certainty, excessive fondness for alcohol, flamboyance and arrogance in his personality and even styled himself *Paracelsus*, or greater than Aulus Cornelius Celsus (~25 BC–AD 50; the Roman author of the medical treatise *De Medicina*). This, combined with contempt for accepted wisdom and a theatrical and sometimes incendiary lecturing style, he ensured that he surpassed all his peers in his ability to make seriously powerful enemies. His drinking led to fatal liver cirrhosis at only 48 years of age, having spent his life challenging and usually failing to defeat medical orthodoxy. However, although he remains controversial to this day, I think it can be said that he made a significant contribution to occupational medicine, not least through his ideas on the specific mechanisms whereby toxins impact the body, as well as a book on miners' diseases. Perhaps it is characteristic of his personality and ambition that he entitled his last major work, *Die Grosse Wundartznei* (*The Great Surgery Book*) of 1536, which restored his fortunes and public image.

As mining became more industrialised, many more debilitating conditions emerged, not least vibration 'white finger' and noise-related deafness, which were linked with cutting and boring machinery, as well as toxicity associated with the fumes of explosives and more recently, underground vehicles. In recent times, whilst mining has all but disappeared in the United Kingdom, it remains a major industry in more than 50 countries worldwide, although fatality rates and occupational disease remain several fold higher than other industries [6, 7]. In the United Kingdom, the legacy of 'black lung', which is the form of pneumoconiosis caused by coal dust, continues to blight and shorten the lives of retired miners. As there remains several hundred years of supply of coal under the United Kingdom, it is likely that this energy will be exploited in the future, not by manual labour, but with the application of new technology applied to underground coal gasification (UCG), which can be carried out from the surface using bore holes. Interestingly, the concept of UCG is far from new; one of its early proponents was Lenin (Vladimir Illych Ulyanov; 1870–1924), who sought in 1913 to make presumably irony-free political capital out of the possible benefits of UCG, in claiming that it would free the proletariat from the dangers of working underground in Tsarist mines [8].

The individual who is regarded now as the father of occupational medicine was the Italian physician and Professor of Medicine at the Universities of Modena and subsequently Padua, Bernadino Ramazzini (1633–1714) [9]. He was the first physician to devote his career to a systematic investigation of over 50 occupations, involving visiting places of work and questioning workers. He exhorted his fellow physicians to routinely enquire after occupation, as well as symptoms. His career culminated in *De Morbis Artificum Diatriba* (*Discourse on the Diseases of Workers*; first edition, 1700, second edition, 1713). This work described many different occupations, their consequences and ideas for alleviation of the damage and the processes that caused it. Importantly, he not only understood that the various noxious materials, gases and vapours to which workers were exposed were actually responsible for their health problems, but also that unusual specific movements and postures required by the occupation contributed to morbidity and mortality. In this latter area, he was the first to recognise repetitive strain injuries, which remain a workplace hazard today. His work anticipated the Industrial Revolution, where manufacturing grew in scale beyond anything that preceded it, involving large numbers of individuals, vast amounts of processing and long periods of exposure to noxious agents, particularly those related to polycyclic aromatic hydrocarbons (PAHs) from coal and petrochemicals.

1.3 The Industrial Revolution

Whilst it is generally accepted that the Industrial Revolution began in Britain, industrialisation and mining expansion occurred in many other countries, and several scientists around Europe made notable contributions to the emerging science of occupational health in the eighteenth century. Gradually, very early concepts, such as Pliny's ideas on protective measures in the workplace, became re-discovered and reinforced, whilst the understanding of specific links between certain toxins and particular conditions and their mechanisms of toxicity, pioneered by Paracelsus, also gathered pace. The brilliant Russian polymath Mikhail Vasilyevich Lomonosov (1711–1765) outlined measures to be taken to ensure occupational safety in mining in a 1763 treatise, although he could be of a similar disposition to Paracelsus and was imprisoned for eight months for abusing his University's administrators (sounds harsh) and was even briefly forcibly retired by the personal order of Catherine The Great. In England, a major step forward in the understanding of how pollutants from a specific occupation can cause permanent and even lethal injury was made by Sir Percivall Pott (1714–1788). Dr Pott was an extremely well-liked, industrious and technically proficient surgeon, who among many other achievements gave his name to a particular type of compound fracture. The image of eighteenth-century medicine is somewhat tarnished by its obsessions with bleeding, purging and, of course, amputation, for a surprisingly wide range of conditions. However, Dr Pott did his very best with what he had, made highly significant additions to medical knowledge and worked tirelessly right up to his death, which was actually hastened by his devotion to his patients.

Today, in the developed world, many developing countries are criticised for allowing dangerous child labour practices; however, from the end of the seventeenth century in England, after being sold to master chimney sweeps by their parents, boys as young as seven years old were sent up naked into extremely cramped chimneys to clean them. They were sometimes 'encouraged' by the sweep lighting a straw fire beneath them [10]. It was not uncommon for these children to die of asphyxiation, and survivors were treated appallingly, with no access to washing facilities. Hence, they would develop scrotal soot warts, which they would sometimes remove by themselves with a knife. These warts would sometimes become cancerous, usually many years later. The idea of employing children in this way was actually considered repugnant even by the end of the eighteenth century, but was not outlawed until 1842 due to the resistance of the master chimney sweeps. Whilst Dr Pott was not the first person to describe the tumours, he made the link between the soot exposure and the tumours, so becoming first to recognise that a malignant disease was caused by a specific occupation [11]. One interesting and important perception he also made was that because the signs of the disease appeared after puberty, it was commonly ascribed by doctors to venereal disease and thus treated with mercury, which of course made things worse. Such understandable misdiagnosis continues today in areas such as idiosyncratic drug reaction, as well as in occupational health, and it still costs the patient time, allowing the disease to progress whilst increasing suffering. As the nineteenth century progressed, it became apparent that scrotal cancers usually presented decades after exposure had finished and although such long lag-times in cancer presentation are still studied even today we do not understand all the processes involved. Interestingly, it was realised as early as the 1890s that chimney sweeps' scrotal cancer was very much an 'English Disease' because in every other country in Europe (even in Scotland), sweeps wore effective protective clothing. Tragically, it took more than a century from the discovery of this cancer towards some means of alleviating it, and right up to the end of the nineteenth century, English sweeps were at an eightfold greater risk of scrotal cancer than other males.

1.4 Petrochemicals: The beginnings

Up to Potts's time, human exposure to PAHs was restricted to environmental coal fire pollution of various sorts, such as in chimney sweeping. As the second half of the nineteenth century progressed, the growing industry of coal distillation produced a variety of different products, ranging from thick, tar-like pitch, to paraffin waxes and various solvent mixes, such as naphtha, creosote and anthracenes. These agents were used as fuels and lubricants of various kinds in many emerging light and heavy industries in England and Europe. It gradually became apparent that workers exposed to these agents, either through their extraction, combustion or usage as lubricants, were suffering from the same scrotal cancers as chimney sweeps. A report by von Volkmann in 1875 [12] revealed that men working with tar distillates were at risk of these cancers. Over the next 25 years or so, many other workers, such as mule spinners in the Lancashire and Yorkshire Cotton Industry, as well as Oil shale workers, were seen to be at risk of petro-chemically induced cancers. The Oil shale business became uneconomic in the 1870s when oil imports began to grow, and only the appearance of modern processing technology and the high price of oil have made shale extraction viable today. The coal tar and oil distillation industry continued to grow from the turn of the century and was particularly well established in Germany, where by 1913 just one factory at Elberfeld run by Bayer employed 8000 workers. It is also worth noting that the number of technically advanced spin-offs of the tar-distillation industry, such as the dye, fuel and tyre industries, was also growing; indeed, the Elberfeld factory employed 330 skilled chemists with university-level educations.

The plight of the mule spinners, however, is a good example of how a combination of specific working practices, environment and toxin exposure can cause an unusual neoplasm. A 'mule' was a long machine invented by Samuel Crompton in the late 1770s that could spin cotton (or other fibres) into yarn, and it was operated by a 'minder' and usually two boy 'piecers' who acted to repair threads when they broke. Each cotton mill might have up to 60 mules, and the basic design did not change until the 1970s when the industry died out in the United Kingdom. From