Chapter 2. An uphill struggle and a missed discovery

The uphill struggle

In chapter 1, we saw some early attempts at control. By 1800, the obvious methods of controlling dust by ventilation and crude masks were in use, and there had been at least one successful attempt to reduce dust at source by replacing a dry method by a wet one, which had meant that the very dusty and dangerous process of crushing calcined flint for the pottery industry became practicable.

But by that date, anyone attempting to control workplace disease had to run to stay in one place. In real terms, Britain's Gross Domestic Product grew 30% between 1700 and 1750, 80% between 1750 and 1800, and 140% between 1800 and 1850.[1] The factory system was growing fast, with more workshops and mills and greater concentrations of workers. Then as now, new machines can mean faster production, but also more pollutant in the air, more noise, and no doubt other stressors as well, so more people are exposed to poorly-controlled hazards.

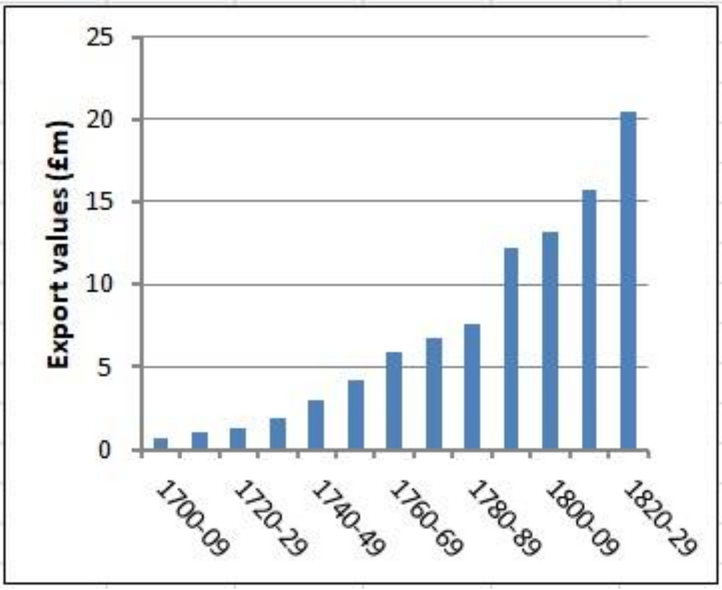

Fig 2.1. The growth of industrial production in Britain from 1700 to 1830, illustrated by the exports of iron and steel, including machinery, cutlery, and hardware. Figures are decade totals in millions of pounds. They allow for inflation, so give a measure of the growth in the amount exported. Up to 1790, figures are for England and Wales; thereafter for Great Britain. Figures from Mitchell BR, Deane P. *Abstract of British Historical Statistics*, as quoted by Mathias, P, *The first industrial nation,* 2nd edn 1983.

The iron and steel industry was an example of growth, and also a growing source of disease (Fig 2.1).[2] Many processes used grindstones, usually made of sandstone, to clean up castings or to sharpen edges. From contemporary accounts, the results seem to have been carnage. In 1796, a physician named James Johnstone wrote that workers pointing needles by grinding in the industry round Redditch "are very soon affected with pulmonary complaints, such as cough, purulent or bloody expectoration; and being so affected, they gradually waste in flesh and strength, and hardly ever attain the age of forty years." [3] In 1832, CT Thackrah, Town Surgeon of Leeds, wrote that fork grinders usually died at 28 to 32, with the oldest grinder in a group of 80 being aged 36. Fork grinding was done with dry stones; table-knife grinders, who worked wet, were reported to survive to their forties. File cutters, also grinding wet, lived to 45-50.[4]

It is surprising that anyone was found to take such risks, but apparently some were, for money and short-term benefit. Johnstone wrote: "As the business is known to be constantly attended with such fatal effects, the manufacturers find it not very easy to engage persons to work at it; and the who are engaged, as so well paid as to get money to misspend in drink; being, for the most part, in this respect, persons of very irregular manners."

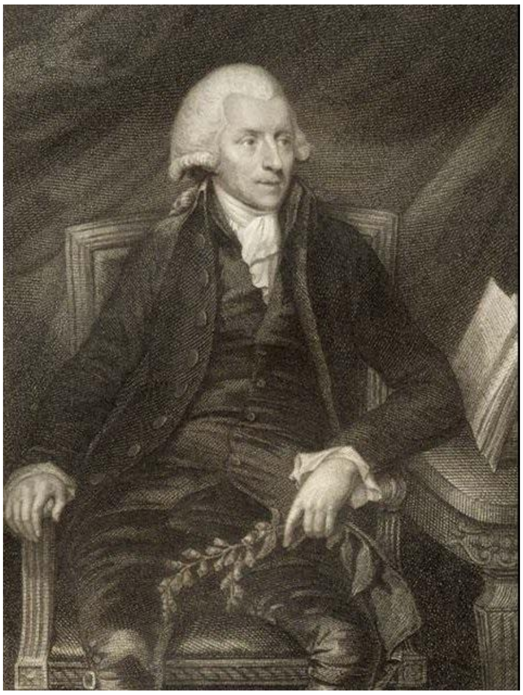

Fig. 2.2. William Withering, who came close to an important discovery about a cause of occupational disease. He is holding a foxglove – the medicinal properties of this plant were one discovery he did make. (Public domain)

Three diseases, but one cause?

A few years earlier, in 1793, the fate of the needle grinders had been debated by two other well-known physicians, William Withering (Fig. 2.2) and Thomas Beddoes.[5] Withering said that the needle grinders were suffering from the same disease as that was seen in the potteries from the use of calcined flint, which he described as consumption. As occupational hygiene has developed, we have learned that identifying the causative agent is often an important stage in control, so Withering's observation was potentially an important insight. In his 1726 patent on controlling dust from calcined flint, Benson said that the process "had proved very destructive to mankind, occasioned by the dust sucked into the body, which, being of a ponderous nature, fixes so closely upon the lungs that nothing can remove it".[6] Also, Beddoes quoted a 1772 thesis by a student of Carl Linnaeus at the University of Uppsala in Sweden, mentioning fatal lung disease in those mining sandstone grinding wheels, so that "before 30 years old the greater part of them die of phthisis".[7] It seems that Beddoes and Withering both suspected that it was the stone dust which was the common cause of the diseases in three processes which did not look very similar – flint pounding, sandstone mining, and needle grinding.

We now know that flint and sandstone are both very high in crystalline silica, but with the minerals looking very different, their similarity was not at all obvious to 18th century observers. However, the science of mineralogy was developing at about the same time, and it was known by 1801 that flint and sandstone were almost the same mineral.[8] This was probably discovered by Tobern Bergman, an Uppsala scientist like Linnaeus, in the 1780s.

Scientific communication was nothing like as well organised then as now of course, so how did Withering and Beddoes know the calcined flint story, or about the work of Linnaeus' student on grindstones, and did they connect this with the other Uppsala work on mineral analysis? A likely route is the Lunar Society of Birmingham, a group of 14 or 15 people interested in the progress of science, medicine, industry, and society as a whole, who met once a month to enjoy other's company and to discuss developments in their fields.[9] Withering was a member, and so was Josiah Wedgwood, who ground calcined flint for his pottery in Stoke on Trent. Another was Erasmus Darwin, grandfather of Charles Darwin. In about 1790, Darwin wrote a long poem, *The Botanic Garden*, which included a clear description of Wedgwood's use of Benson's mills, grinding the calcined flint under rotating chert rollers to produce a white slurry (Chapter 1; Fig. 1.5).

> "Gnomes! as you now dissect with hammers fine;
> Grind with strong arm, the circling cherts betwixt
> The granite-rock, the nodul'd flint calcine;
> Grind with strong arm, the circling chertz betwixt,
> Your pure Kaolins and Petuntses mixt:…
> And pleased of WEDGWOOD ray your partial smile,
> A new Etruria decks Britannia's isle.-
> Charmed by your touch, the flint liquescent pours
> Through finer sieves, and falls in whiter showers…"

Erasmus Darwin was an admirer of Linnaeus, whose work inspired much of *The Botanic Garden.* This complicated network, of Withering, Beddoes, Wedgwood (with Benson's mills), Erasmus Darwin, and the Uppsala scientists, is charted in Fig 2.3.

Things were therefore in place in the 1790s to link lung disease in three processes that did not look very similar, and even to identify dust containing silica as the causative agent. However, the chance was missed, and silica was not firmly identified as the culprit for many decades. It was unfortunate because although some controls do not require the causative agent to be identified, they can be more effective and efficient if the real agent is known. Needle grinding, which we have already mentioned, provides an example of this, as we shall now see.

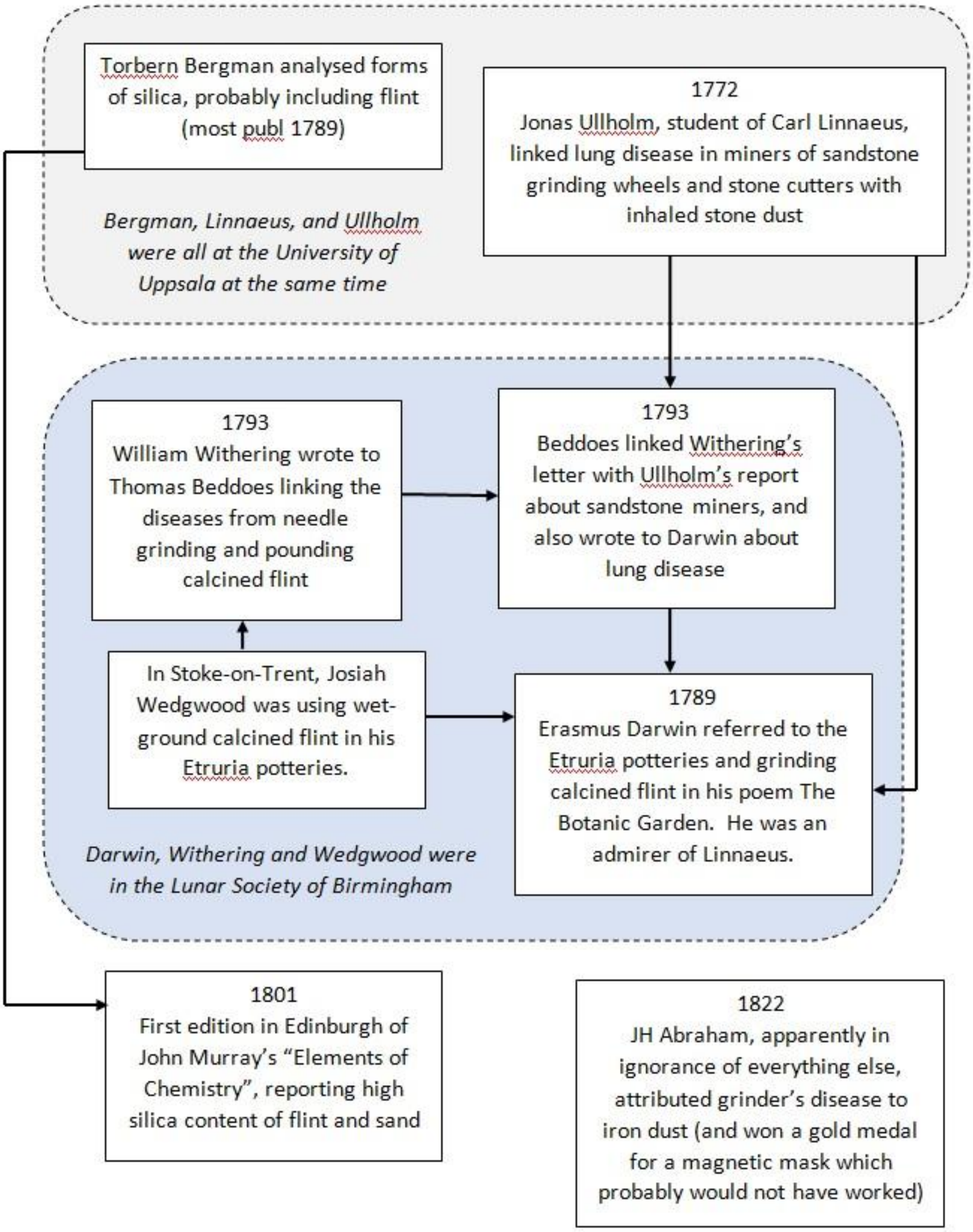

Fig. 3. How the cause of silicosis was nearly identified, but not quite. Links were made around 1770-1790 between diseases from sandstone mining, calcined flint, and needle grinding. It was known about then that flint and the sandstone were almost pure silica, but the step identifying silica as the cause of the disease was not made. For the work of Bergman and Murray, see:

Bergman T, *Essays physical and chemical.* Anonymous translator. Edinburgh, Mudie, 1791. https://books.google.co.uk/books?id=BsiVgNpaYrUC

Murray J, *Elements of Chemistry,* Vol 2. Edinburgh, Maccliesh, 1801. https://ia801409.us.archive.org/28/items/elementschemist04murrgoog/elementschemist04murrgoog.pdf

A gold medal for trying

In 1822, almost thirty years after Withering's letter, a needle-grinding workroom in Sheffield was described as having "an immense quantity of iron and grit-dust hourly produced, [which] rolls slowly about the rooms, till the atmosphere has become so fully impregnated that the men are scarcely visible on entering at the door; it then begins to be deposited on the floors and timbers from which it is again disturbed by the motion of the machinery." This was from J.H Abraham and colleagues, who reported these conditions and described arrangements to improve them by separating the operator from the dust.[10] One device was a canvas hung from wall to wall over the horizontal axis of the grindstone, leaving a small gap over the part of the wheel where the needle grinding took place. The air movement induced by the rotating wheel moved the dust to the area behind the screen. Similar screens were used in Sheffield for other grinding tasks.

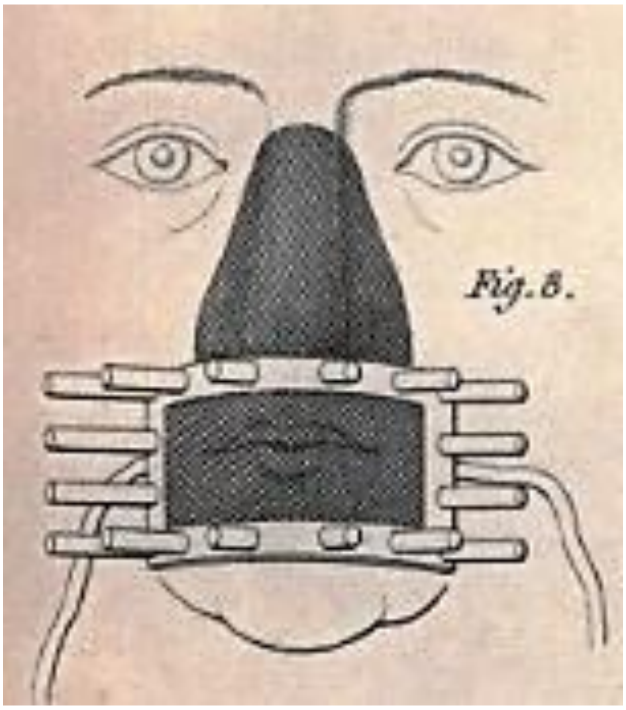

Fig 1.4. Abraham's magnetic "muzzle", for protecting needle grnders. A wooden frame holds "two or three thicknesses of crape or muslin, and is studded with 16 magnets". The cloth is held over the nose by bent wire. The magnets are intended to collect much of the iron dust before it reaches the cloth. Illustration from https://www.jstor.org/stable/41325961?seq=30#metadata_info_tab_contents .
(Public domain; electronic version reproduced courtesy of JSTOR)

Abraham did not know about the Withering and Beddoes insights of the 1790s, and believed that it was the metal dust which caused the harm, and tried to control the danger based on this belief. His hanging curtain did not depend on the type of dust, of course, but in another device, he placed a semicircular frame of magnets over the needle grindstone to collect the steel dust. He also made a magnetic dust mask. This was a wooden frame which held a piece of fine cloth over the nose and mouth, and also carried 16 magnets which were intended to catch much of the iron dust before it reached the cloth, The frame was held by ribbons tied behind the head (Fig.1.4). The workmen, said a supporter, "adopted it with alacrity and gratitude". The Society of Arts awarded Abrahams their Gold Medal for this device, although 80 years later they said that it appeared never to have come into practical use because the workers feared that "the lessened risk attached to their employment would lower their wage".[11] This was not the last time that this fear got in the way of improved working conditions.

However, although Abraham might have deserved a gold medal for trying, his magnetic devices surely would not have made much difference even if people had used them. It seems unlikely that the magnets would have been powerful enough to capture many metal particles as the air swept them past, but in any case, it was aiming control at the wrong component of the dust. Siderosis, the pneumoconiosis caused by inhalation of iron, is now usually considered non-progressive. As Beddoes and Withering nearly realised, it was the crystalline silica dust from the sandstone grindstones which was causing the problem.

In his 1796 letter, James Johnstone had suggested that needle grinders should be protected by "a crape hood or gauze helmet, to receive the head and rest on the shoulders". If Abrahams had known about this, he might have made something practicable and effective out of this suggestion.

As already mentioned, Thackrah in 1832 thought that wet grinding was safer than dry, because the dust particles "do not rise to enter the air tube". But he seems to have been uncertain about the causative agent. He wrote about "sand and dust, which are baneful both to the respiratory and digestive systems, and would, if the employ was constant, produce the most serious results". However, he regarded the iron particles as dangerous too, and promoted Abraham's magnetic mask. Thackrah knew that mining in sandstone was more injurious than mining limestone, but he thought it was because the sandstone was usually drier. He reported too that masons, who "inhale sand and dust" generally die "before they attain the age of 40".

Lessons for today?

It is dangerous for historians to point out lessons from history, but fortunately I am not one and this is not a formal history, so I can take the risk. This is an early example of how identifying the causative agent could lead to better control. Abraham's dust curtain did not depend on this knowledge, but his respirator did, so would not have given much protection. We will see more examples of the importance of knowing causes in later articles in this series. The British Occupational Hygiene Society (BOHS) was founded with a Latin motto, a line from Vergil which meant roughly "Happy are those who understand why things happen". Ignoring the time gap, it is a shame that Withering and Johnstone, who had ideas about causes, could not have pooled skills with Abrahams, the practical man, who might have made an effective hood or respirator. This illustrates the value of organisations like BOHS which can bring together people with a common interest in a problem, but different backgrounds and skills.

However, despite these misunderstandings and lost opportunities, we can see that by the 1830s people were trying to use ventilation and personal protection, and there were also examples of control of dust at source by using a wet process, separation of the workers from the dust by screens, and attempts to make respirators on a more logical basis, and to understand what were the causative factors of the diseases and to target control. In the next chapter we will get some fresher air than the workshops of Sheffield and Redditch, and look at changes in an industry which in 1800 still employed far more than iron and steel, namely agriculture.

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[3] Johnstone J (1796) Some account of a species of phthisis pulmonalis, peculiar to persons employed in pointing needles in the needle manufacture. Memoirs of the Medical Society of London 5:89-93.

[4] C. Turner Thackrah, *The Effects of Arts, Trades, and Professions, and of Civic States and Habits of Living, on Health and Longevity: with Suggestions for the Removal of many of he Agents which produce Disease, and shorten the Duration of Life.* London, Longman, Rees, Orme, Green and Longman; 2nd Edn 1832. https://books.google.co.uk/books?id=ennv5jq4FbEC A modern review of this book by J Tim Carter and Anne Spurgeon is at Occupational Medicine, 67(6), 500–501 (2017). https://academic.oup.com/occmed/article/67/6/500/4095227

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[11] 1902 Annual Report of the Chief Inspector of Factories, p xxviii