Marsh's Mirror
James Marsh (1794-1846)

James Marsh, artificer and inventor of a delicate test for arsenic.

When I was a student I stumbled across a copy of Thomas de Quincey's "On Murder Considered as one of the Fine Arts". It is a hilarious satire, in places of Swiftean savagery, that considers the aesthetic merits of different murders. It has often come to my mind when people have jokingly said to me that surely, I, a chemist, could come up with the ultimate, perfect, and untraceable poison. Yet surely murder will out. It is hard for us to imagine a material that vanishes completely; could there really be a poison that leaves no spoor that a resourceful chemist could not track, given time and ingenuity?

Among the earliest and most delicate forensic tests is that for arsenic, the fashionable poison of the 19th century, a test so legendary that a positive result could consign a suspect to the gallows. Its inventor, James Marsh, was born in Woolwich on the southern bank of the Thames to the East of London in 1794. Nothing is known of his parents, nor about his education, but he is first recorded in 1822 working as a lowly "practical chemist" at the Royal Arsenal not far from where he was born. The Royal Arsenal was the main munitions factory for the British military establishment in the 19th century, and included research labs that later in the century would attract some of the best young chemists graduating from August Hofmann's Royal Institute of Chemistry (see CK 29 January 2010).

I suspect, however, that Marsh did not benefit from a formal education but rather was trained by apprenticeship, eventually securing a permanent position. The Arsenal was attached to the Royal Naval Academy and Marsh began working with Peter Barlow, the professor of mathematics who also taught physics and is remembered for a device called "Barlow's wheel". Marsh improved on a related apparatus invented by Ampère and developed a portable electromagnetic device – an early dynamo – for which the Royal Society of Arts would award him a silver medal and a prize of 30 guineas (a substantial sum perhaps equivalent to 20 weeks wages).

In 1829, Michael Faraday became professor of chemistry at the Naval Academy, a position that paid him £200 to give 25 lectures a year. The money supplemented his modest wages at the Royal Institution and allowed him to devote the rest of his time to his own research. James Marsh became his assistant, paid 15 shillings (three-quarters of a pound) a week. Marsh would not only have prepared lecture demonstrations for Faraday, but also been the primary contact with students in the teaching laboratory; he did so for the rest of his life.

He must have made a name for himself as a problem-solver because in November 1833 he was called upon to investigate a murder that was thought to have involved arsenic. A young man, John Bodle was accused of poisoning his grandfather, George, by adding arsenic (arsenic oxide, a common rat poison) to his coffee. At the time, arsenic was detected using a test, ironically invented by Samuel Hahnemann, the father of homoeopathy, that is still familiar today to undergraduates doing qualitative inorganic analysis: hydrogen sulphide passed through an ammoniacal solution containing arsenic produces a yellow precipitate of the sulphide. It was probably straightforward to test this with ground coffee, and Marsh confirmed the presence of the metal. But it would have been quite a different matter to establish the presence of arsenic in, for example, the stomach contents of a murder victim.

Two years later Marsh had developed a beautifully elegant solution. In 1775, the Swedish chemist Scheele had discovered that if zinc was added to arsenic dissolved in sulfuric acid, a colourless gas that smelled weirdly of garlic was evolved alongside the hydrogen. The gas, "arseniuretted hydrogen" or arsine (AsH_3), developed an unsavoury reputation after the German chemist Alexander Gehlen inhaled it and died . Indeed some have commented that Scheele must have had a charmed life, having discovered both hydrogen cyanide and arsine in an age before labs were equipped with fumehoods.

Marsh constructed a miniature Kipp's apparatus (CK 3, Nov 2007): an unsymmetrical glass U-tube the shorter arm of which was surmounted by a small valve with a nozzle. A piece of zinc was suspended in the short side and the device was then filled with sulfuric acid. When a sample was added to the other arm and stoppered, hydrogen and arsine would build up in short arm of the tube. The gas could then be released through the nozzle and ignited. On playing a piece of glass into the whitish flame, a brownish/black spot of arsenic metal would appear. An alternative device, for use with larger samples was a modification of the Döbereiner lamp (CK 79 March 2014) with a vertical nozzle, with the zinc suspended on a wire. Marsh reported satisfactory results with "three pints of very thick soup, … port wine, gruel, tea, coffee, etc. etc".

When Marsh published his method it drew every chemist's attention. The Society of Arts again awarded him a medal, large and gold this time. In Germany Mohr (CK6 February 2008) said it was a game-changer and proposed using porcelain rather than glass. Justus Liebig (CK 25 September 2009) instead passed the escaping gas through a heated glass tube leaving a silvery cylinder of reflective arsenic metal on the walls, perhaps the earliest example of chemical vapour deposition. When I have recreated this version of the test, the appearance of the little mirror is a magical moment that causes everyone present to gasp in unison. Ironically however, the heated tube method is often called the Marsh-Berzelius test, a mistaken reference to the Swedish chemist's later use of heated copper filings to capture the arsenic quantitatively.

In 1840, the beautiful Marie-Fortunée Lafarge was accused of murdering her much older husband Charles with arsenic. The tabloid press were agog as a flamboyant French forensic chemist, Mathieu Joseph Bonaventure Orfila, used the Marsh test to establish the presence of the poison in the old man's body. Mrs Lafarge only escaped the guillotine because she was a woman; she was sentenced to life imprisonment and Marsh's test was publically acclaimed as the would-be poisoner's nemesis.

But for all the lurid excitement, and, of course the medal, for Marsh there was little advancement. Although he seems to have been widely respected, Marsh remained based at the Arsenal focused on his explosives work. He was awarded another Society of Arts medal for inventing a new percussion cap in 1837. In January 1844 he published a long paper in *The Chymist* describing the formulation of gunpowders and signal rockets used not only by the British Arsenal but also covering those of the French, American, Russian and Chinese governments. In 1845 the Times reported that experiments were to be conducted at Portsmouth to compare shells equipped with fuses of different design, including 80 developed by Marsh. Whatever the outcome, Marsh probably never heard about it. He died suddenly in the autumn.

Surprisingly for such a prominent and young scientist, his death got only a fleeting mention in The Times, which drew attention to his salary – a mere 30 shillings a week, little more than that of a foreman. His death left his wife and two daughters destitute. When his widow applied to the Board of Ordnance for a pension, they magnanimously awarded her twenty pounds, less than 10 weeks of his salary. The sum was so derisory that a week later the Times printed a letter from a gentleman in Brussels, proposing a subscription to raise money for Marsh's family. Whether anything came of this is a mystery – there is not word about it in the Times or in the Chemical Society's Journal.

Marsh is remembered today for his delicate test that helped to catch the most vicious of murderers. Arsenic may be old hat, yet the quest for the perfect poison remains. In the shadowy world of espionage, natural products like ricin and radioisotopes like polonium have been detected almost by accident; recent events in Moscow make one think that the classic quest continues. What, I wonder, would de Quincey have made of those who took his witty essays literally?

Reference:

J. Marsh, "An Account of a Method of Separating Small Quantities of Arsenic from Substances with which It May Be Mixed," *Edinburgh New Phil. J.*, **1836**, *21*, 229-236.

J. Marsh, "Beschreibung eines neuen Verfahrens um kleine Quantitäten Arsenik von den Substanzen abzuscheiden, womit er gemischt ist," *Ann. Chem.*, **1837**, *23*, 207-227

J. Marsh, "Arsenic; nouveau procédé pour le découvrir dans les substances auxquelles il est mêlé,"

FIG. 2. FIG. 1.