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ALFRED SWAINE TAYLOR, MD, FRS (1806–1880): FORENSIC TOXICOLOGIST

by

NOEL G. COLEY *

The systematic study of forensic toxicology dates from the end of the eighteenth century. It arose as a branch of forensic medicine concerned with the problem of proving deliberate poisoning in criminal cases. It was often very difficult to distinguish symptoms produced by many common poisonous plants like belladonna (deadly nightshade) and henbane from those of certain diseases. Medicines also frequently involved the use of poisonous substances and most physicians agreed that a better knowledge of the chemical properties and physiological effects of poisons would aid diagnosis and treatment as well as the search for antidotes. Moreover, some physiologists thought that the ability to trace the passage of poisons through the body would offer a new tool for investigating metabolic changes and the functions of the organs. All of these advances would depend on the development of more reliable methods of chemical analysis. The common reagents, such as barium chloride, silver nitrate, hydrogen sulphide or copper sulphate, used by chemists to identify mineral substances had long been known, but from the beginning of the nineteenth century the methods of inorganic qualitative analysis were improved and systematized.[1] New tests were added to those already well-known, new techniques were devised and better analytical schemes for the identification of mineral acids, bases, and salts in solution were drawn up. Chemists like Richard Kirwan[2] in Ireland studied the analysis of minerals and mineral waters while C. R. Fresenius, in Germany, who in 1862 founded the first journal entirely devoted to analytical chemistry,[3] devised the first workable analytical tables. In organic analysis too, there were considerable improvements from

* Noel G. Coley, M.Sc., Ph.D., C.Chem., FRSC, Staff Tutor in History of Science, The Open University (SE Region), St James's House, 150 London Road, East Grinstead, W. Sussex, RH19 1ES.

[1] For an account of the development of inorganic chemical analysis see Ferenc Szabadváry, *History of analytical chemistry*, Oxford, Pergamon Press, 1966, pp. 114–85; Christian Heinrich Pfaff (1773–1852), professor of chemistry and pharmacy at the university of Kiel, wrote one of the first general textbooks of chemical analysis: *Handbuch der analytischen Chemie für Chemiker, Staatsärzte, Apotheker, Oekonomen und Bergwerks Kundige*, Altona, J. J. Hammrich, 1821.

[2] R. Kirwan, *An essay on the analysis of mineral waters*, London, D. Bremner, 1799. Kirwan collected and arranged the analytical methods of others like Klaproth, Westrumb, and Bergman into a system of qualitative analysis for the chemical investigation of mineral waters.

[3] Carl Remigius Fresenius (1818–97) worked with Liebig at Giessen; in 1841 he published an important textbook of analytical chemistry, op. cit., note 58 below, and in 1845 became professor of chemistry at the agricultural college in Wiesbaden. He founded the journal *Zeitschrift für analytische Chemie*, devoted entirely to analytical chemistry, in 1862.

the early years of the nineteenth century, which contributed to the rise of physiological chemistry.[4] These advances also helped to provide solutions to some of the difficult problems in toxicology.

In the criminal courts evidence presented by medical experts was usually based on clinical and pathological observations, interpreted in terms of contemporary notions of the physiological effects of drugs and poisons.[5] The results of chemical analysis were accepted somewhat doubtfully by the courts to clarify the medical evidence when the presence of specific poisons was alleged. Identification of the mineral acids, alkalis and salts, when they were mixed with food and drinks, presented the analyst with problems that became even more difficult when the poison was sought in stomach contents or had been absorbed in tissues and organs. Yet even in these cases, mineral compounds were almost always more easily identified than organic or natural substances.

In nineteenth-century Britain many poisons were readily available for ordinary household use. Rat poison containing arsenic, "lysol"—a proprietary mixture of phenols and cresols dissolved in caustic alkali—strong hydrochloric acid (spirit of salt), oxalic acid crystals, and some other common poisons were on open sale in hardware shops and pharmacies. Compounds of arsenic were widely used in medicine[6] as were preparations containing mercury salts. Prussic acid was sometimes prescribed as a treatment for pulmonary diseases.[7] Opium and its derivatives, like laudanum, were increasingly given to ease pain or induce sleep, and even to quieten young children. Nux vomica, a highly poisonous natural substance, was also prescribed for some nervous diseases. The active constituents of such natural medicines were the vegetable alkaloids, morphine, strychnine, and brucine, isolated by organic chemists in the early nineteenth century,[8] though their chemical and physiological properties remained obscure. The fact that they could legitimately be obtained increased the difficulty of proving their deliberate use as poisons in the criminal courts.[9]

Forensic medicine had been studied in several European countries from the seventeenth century, though not in Britain. It was generally called medical jurisprudence or legal medicine, and included detailed studies of the many forms of violent death, including poisoning. All the early works on the subject published in this country relied extensively on European sources.[10] In France, *médecine légale* was

[4] F. L. Holmes, 'Elementary analysis and the origins of physiological chemistry', *Isis*, 1963, **54**: 50–81.

[5] M. P. Earles, 'Early theories of the mode of action of drugs and poisons', *Ann. Sci.*, 1961, **17**: 97–110.

[6] John S. Haller Jr., 'Therapeutic mule: the use of arsenic and the nineteenth century materia medica', *Pharm. in Hist.*, 1975, **17**: 87–100.

[7] A. B. Granville, *An historical and practical treatise on the internal use of the hydrocyanic [prussic] acid in pulmonary consumption and other diseases*, London, Longman, 1811, 2nd ed., 1820; by 1836 a preparation containing a 2 per cent solution of prussic acid was included in the *Pharmacopoeia Londinensis*, see Melvin P. Earles, 'The introduction of hydrocyanic acid into medicine; a study in the history of clinical pharmacology', *Med. Hist.*, 1967, **11**: 305–12, on p. 311. In 1845 the Quaker John Tawell was convicted of murder by prussic acid, G. Latham Browne and C. G. Stewart, *Trials for murder by poisoning*, London, Stevens & Sons, 1883, pp. 16–49.

[8] Strychnine was discovered in nux vomica by Pelletier and Caventou, *Ann. Chim.*, 1818, no. 8, p. 323. They discovered brucine the following year, ibid., 1819, no. 12, p. 113.

[9] Many examples of such problems are cited by C. J. S. Thompson, *Poison mysteries in history, romance and crime*, London, Scientific Press, 1923; *idem, Poison and poisoners*, London, Harold Shaylor, 1931.

[10] Samuel Farr, *Elements of medical jurisprudence, or a succinct and compendious account of such tokens in the human body as are requisite to determine the judgement of a coroner and courts of law etc.*, London,

intensively pursued after the Revolution and a survey of contemporary knowledge in the field was made in 1797 by the French physician F. E. Fodéré, whose work received official approval by the French National Institute.[11] Fodéré classified poisons into six groups according to their physiological effects, namely septic, narcotic, narcotico-acrid, acrid, corrosive, and astringent.[12] Most later toxicologists followed some similar system of classification, including M. J. B. Orfila, professor of chemistry and natural philosophy in the Medical Faculty of Paris, who is generally regarded as the true founder of toxicology.[13] Orfila carried out experiments on animals and was able to detect and recover from the organs and tissues most of the organic and mineral poisons then known. His most significant discovery was that poisons are absorbed selectively in different organs. Thus, if a suspected poison was not found in the stomach, it might be present in the liver, kidneys, brain, blood or other parts of the body. By examining separately all the organs and fluids of the body, the chances of detecting the presence of poison were greatly increased. Yet despite improvements in analytical techniques and the growing number of well-documented case histories, toxicology remained an empirical science well into the present century.[14]

In Britain the first university chair in medical jurisprudence and police was established at Edinburgh in 1807, with Andrew Duncan the younger[15] as its first incumbent. From 1822 this chair was held by Robert Christison, who in Paris had studied chemistry with Robiquet and attended the chemical lectures of Orfila and Fourcroy's colleague L. N. Vauquelin. Christison, whose interest in toxicology was aroused by these studies in France, introduced many refinements in analytical techniques.[16] In 1829 he was appointed medical adviser to the Crown in Scotland and for the next thirty-seven years he served as a medical witness in almost every

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J. Callow, 1788. This, the only work on medical jurisprudence in English before 1800, was little more than an abstract of such foreign works as J. J. Plenck, *Elementa medicinae et chirurgiae forensis*, Vienna, R. Graeffer, 1781; German ed., *Aufangsgrunde der gerichtlichen Arzneywissenschaft*, 3 vols, Vienna, R. Graeffer, 1793. The first full-length original work on medical jurisprudence in English was by George Edward Male, *Epitome of juridical or forensic medicine*, London, T. & G. Underwood, 1816; B. T. Davis, 'George Edward Male MD—the father of English medical jurisprudence', *Proc. Roy. Soc. Med.*, 1974, **67**: 117–20.

[11] François Emmanuel Fodéré, *Les lois eclairés par les sciences physiques; ou traité de médecine-légale et d'hygiène publique*, 3 vols, Paris, Croullebois & Deterville, 1799. In 1813 an expanded second edition appeared in six volumes, *Traité de médecine légale et d'hygiène publique ou de police de santé adapté aux codes de l'empire Français et aux connaissances actuelles*, 6 vols, Paris, Impr. de Mame, 1813. On Fodéré see Bernard-Pierre Lécuyer, 'L'Hygiène en France avant Pasteur 1750–1850', in Claire Salomon-Bayet (ed.), *Pasteur et la révolution pastorienne*, Paris, Payot, 1986, pp. 67–139, on pp. 121–4.

[12] Foderé, op. cit., note 11 above, 1813, vol. 4, p. 2.

[13] M. J. B. Orfila, *Traité des poisons tirées des règnes minéral, vegetal et animal, ou toxicologie général considerée sous les rapports de la physiologie, pathologie et de la médecine légale*, 2 vols in 4, Paris, Crochard, 1814–15; *idem, A general system of toxicology, or a treatise on poisons drawn from the mineral, vegetable and animal kingdoms, considered as to their relations with physiology, pathology and medical jurisprudence*, transl. J. A. Waller, 2 vols in 3, London, E. Cox, 1816–17, p. viii.

[14] C. P. Stewart and E. Stolman (eds), *Toxicology: mechanisms and analytical methods*, 2 vols, New York, Academic Press, 1961, vol. 2, p. 2.

[15] For Duncan see G. T. Bettany in *DNB*, 1908, vol. 6, p. 163.

[16] *The life of Sir Robert Christison, Bart.*, ed. by his sons, 2 vols, Edinburgh, 1885–6; obituaries, *Lancet*, 1882, i: 207–9; *Br. med. J.*, 1882, i: 214–15; *Edinb. bot. Trans.*, 1883, **14**: 266–77; G. T. Bettany in *DNB*, 1908, vol. 4, p. 290.

important murder trial in Scotland and many elsewhere.[17] In London, J. G. Smith was appointed to a chair of medical jurisprudence in 1829 at University College London.[18] Educated in Edinburgh, where he later came in contact with Christison, Smith had published a book on forensic medicine in 1821[19] and lectured on the subject at the Royal Institution in 1825–26. About the same time, Humphry Davy's biographer, J. A. Paris, was also writing on medical chemistry and medical jurisprudence.[20] In his inaugural lecture Smith criticized most of his contemporaries for their lack of interest in forensic medicine.[21] Physicians called to give medical evidence in court often failed to agree and were unable to make any well-founded statement which would assist in reaching a verdict.[22] To avoid such embarrassments Smith argued that forensic medicine should be treated as a distinct speciality, but as no medical licensing body then required evidence of instruction in forensic medicine, he attracted hardly any students. After two unsuccessful years he resigned in 1831, although by this time the Society of Apothecaries had recognized the importance of forensic medicine and most medical schools in Britain had established lectureships in the subject to satisfy the new requirements of the Society's Licence.[23] Among these appointments was that of Alfred Swaine Taylor, who, in 1831, became lecturer in medical jurisprudence at Guy's Hospital in London.

Born at Northfleet, Kent in 1806, Taylor entered the Medical School of the United Hospitals (Guy's and St Thomas's) as a student in 1823. At Guy's chemistry had featured in the medical curriculum since 1770, when William Saunders was appointed as a physician and lecturer in chemistry. Since then many physicians had worked to establish the role of chemistry in medicine, most notably William Prout and Richard Bright.[24] Taylor became interested in the applications of chemistry in medicine and in 1825, when the hospitals separated, he joined Guy's as a pupil of Astley Cooper. In Paris three years later he attended lectures by Orfila, Dupuytren, the surgeon, and the

[17] M. Anne Crowther and Brenda White, *On soul and conscience: the medical expert and crime*, Aberdeen University Press, 1988.

[18] For Smith see D'Arcy Power in *DNB*, 1908, vol. 18, p. 491; ibid., *Lond. med. surg. J.*, 1833, no. 4, p. 287.

[19] J. G. Smith, *The principles of forensic medicine systematically arranged and applied to British practice*, London, T. & G. Underwood, 1821, 2nd ed., enl., 1824; *idem, An analysis of medical evidence: comprising directions for practitioners, in the view of becoming witnesses in courts of justice; and an appendix of professional testimony*, London, T. & G. Underwood, 1825.

[20] J. A. Paris and J. S. M. Fonblanque, *Medical jurisprudence*, 3 vols, London, W. Phillips, 1823, New York, Collins & Hannay, 1823; J. A. Paris, *The elements of medical chemistry*, London, W. Phillips, 1825.

[21] J. G. Smith, *The claims of forensic medicine: being the introductory lecture delivered in the University of London, Monday May 11, 1829*, London, T. & G. Underwood, 1829, p. 20.

[22] Thomas Rogers Forbes, *Surgeons at the Bailey: English forensic medicine to 1878*, New Haven, Yale University Press, 1985, p. 3.

[23] W. S. C. Copeman, *The Worshipful Society of Apothecaries of London: a history 1617–1967*, Oxford, Pergamon Press, 1967.

[24] W. H. Brock, 'The life and work of William Prout', *Med. Hist.*, 1965, **9**: 101–26; *idem* in C. C. Gillispie (ed.), *Dictionary of Scientific Biography (DSB)*, 16 vols, New York, Charles Scibner's Sons, 1970–76, vol. 11, 1975, pp. 172–5; *idem, From protyle to proton: William Prout and the nature of matter, 1785–1985*, Bristol and Boston, H. Hilger, 1985; Steven J. Peitzman, 'Bright's Disease and Bright's generation: toward exact medicine at Guy's Hospital', *Bull. Hist. Med.*, 1981, **55**: 307–21; Pamela Bright, *Dr Richard Bright, 1789–1856*, Oxford, Bodley Head, 1983; N. G. Coley, 'Medical chemistry at Guy's Hospital, 1770–1850', *Ambix*, 1988, **35**: 155–68.

chemist, Gay-Lussac. He then travelled in Europe, visiting medical schools in Italy, Germany, and The Netherlands before returning to Guy's in the winter of 1829. In the following summer he returned to Paris where, during the insurrection of July 1830, he studied the appearance and treatment of gunshot wounds received in the street fighting. It was during these visits to Paris that his interest in forensic medicine was aroused[25] and in the following year, when the lectureship in medical jurisprudence was established at Guy's, he was the young physician best prepared for the post.

From the beginning Taylor included forensic toxicology in his lectures on medical jurisprudence and he also lectured in chemistry during the same period. After Arthur Aikin's retirement in 1850, Taylor taught chemistry at Guy's single-handed, assisted until 1863 by his pupil William Odling, as demonstrator and director of the chemical laboratory.[26] He was undoubtedly fortunate to have been in a hospital with a long tradition of medical chemistry where he was able to call on colleagues like Odling and Rees,[27] whose analytical skills were superior to his own. Guy's Medical School lectures were also open to interested outsiders and this gave Taylor the opportunity to reach an audience beyond the confines of the hospital.[28] As a lecturer he was said to be lucid, interesting, and accurate and although he lacked the attainments of Orfila in theoretical chemistry and was not noted for skill in research like the German forensic physician, Johann Ludwig Casper,[29] he contributed more than either to the *professional* establishment of medical jurisprudence. Taylor's public reputation was built upon his appearances in court as an expert witness. He took account of legal as well as scientific criteria and by diligence in combining the great mass of legal precedents and judicial rulings with chemical and anatomical data he established forensic toxicology as a medical specialism. This was his main achievement, but he

[25] For Taylor see S. Wilks and G. T. Bettany, *Biographical history of Guy's Hospital*, London and New York, Ward Lock, Bowden & Co., 1892, pp. 392 ff.; Bettany in *DNB*, 1908, vol. 19, p. 402; *idem, Br. med. J.*, 1880, **i**: 905–6; *idem, Anns Hyg. publ. Méd. légale* (Paris), 1881, **5**: 59–61; *idem, Eminent doctors: their lives and work*, 2 vols, London, John Hogg, 1895, vol. 2, p. 291; Obituary, *Med. Times & Gaz.*, 1880, **1**: 642, 653, 671; L. Rosenfeld, 'Alfred Swaine Taylor (1806–80), pioneer toxicologist—and a slight case of murder', *Clin. Chem.*, 1985, **31**: 1235–6; Richard O. Myers, 'Famous forensic scientists—Alfred Swaine Taylor (1806–1880)', *Medicine, Science and the Law*, 1962, **3**: 233–40.

[26] For Odling see J. E. Marsh, *J. Chem. Soc.*, 1921, **119**: 553–64, (portr.); H. B. Dixon, *Proc. Roy. Soc.*, 1922, **100A**: i-vii, (portr.); K. R. Webb, *J. Roy. Inst. Chem.*, 1957, **81**: 728–33; John L. Thornton and Anna Wiles, *Ann. Sci.*, 1956, **12**: 288–95; P. J. Freeman, 'The life and times of William Odling (1829–1921), Waynflete Professor of Chemistry 1872–1912', B.Sc. thesis, University of Oxford, 1963; W. H. Brock in C. C. Gillispie (ed.), *DSB*, vol. 10, 1974, pp. 177–9. Odling wrote a laboratory manual of practical chemistry for the medical students at Guy's; W. Odling, *A course of practical chemistry, arranged for the use of medical students*, London, Samuel Highley, 1854, 2nd ed., 2 parts, 1863–5; 3rd ed., 1865.

[27] N. G. Coley, 'George Owen Rees, MD, FRS (1813–89): pioneer of medical chemistry', *Med. Hist.*, 1986, **30**: 173–90.

[28] A. S. Taylor, *Syllabus of a course of lectures on medical jurisprudence annually delivered at Guy's Hospital*, London, Wilson & Ogilvy, 1850.

[29] J. L. Casper, *A handbook of the practice of forensic medicine*, 4 vols, transl. G. W. Balfour, London, New Sydenham Society, 1861-5. Casper was professor of forensic medicine at the University of Berlin; his work first appeared as *Gerichtliche Leihenoffnungen*, Berlin, Hirschwald, 1850, and was later extended to a *Praktisches Handbuch der gerichtlichen Medizin*, 2 vols, Berlin, Hirschwald, 1857–8. It went through many editions and was translated into French, Italian, and Dutch, as well as English.

was also a prolific writer on medical jurisprudence and toxicology. His books, full of directions about good practice based on his own experience, became standard texts which passed through numerous editions during his lifetime and long afterwards.[30] They were translated into many languages and still have an international reputation in the literature of forensic medicine. Taylor's influence extended far beyond Britain and continued long after his death.[31] Besides his books Taylor also published many papers on toxicology and related subjects in medical journals; from 1845 to 1851 he edited the *London Medical Gazette* and he was a frequent contributor to the *Lancet*. By the mid-nineteenth century he had an established reputation both as an expert witness and as a publicist for forensic medicine and, having appeared in so many criminal trials, he was recognized as the leading medical jurist in England.[32]

His experiences in the criminal courts made him aware of the different perceptions of "proof" in science and the law.[33] In the 1860s there was concern among British scientists about the role of the expert witness, particularly with regard to the effect of the legal constraints on the validity of scientific evidence. It was argued that to put a scientist in the position of an advocate was "far removed from the idea of a man of science"[34] and there was no doubt some truth in this, as the partisan behaviour of some so-called "expert witnesses" showed. Taylor recognized that chemical analysis, no matter how carefully conducted, only provided a certain degree of probability and could never achieve the incontrovertible demonstrations of proof required by the courts. Analytical results were allowed in evidence but only to supplement medical observations. Evidence from chemical analysis was always open to criticism and was seldom, if ever, considered conclusive. Samples could be accidentally or even deliberately contaminated and analytical methods often required a degree of skill well beyond that of the ordinary physician or chemist. This was especially true when body tissues and fluids were involved, as they usually are in cases of poisoning. Only when chemical analysis identified the same poison in the tissues or organs of the body as in food or drink taken by the victim, was the evidence of poisoning strengthened, but even then the *quantity* of poison found was crucial. The expert witness was required to provide the court with a quantitative estimate of the amount of poison involved, relating it to the lethal dose.

[30] A. S. Taylor, *Elements of medical jurisprudence*, vol. 1, (no more published), London, Churchill, 1836; *idem, A manual of medical jurisprudence*, London, Churchill, 1844, 2nd ed., 1846; *idem, On poisons in relation to medical jurisprudence and medicine*, London, Churchill, 1848; *idem, The principles and practice of medical jurisprudence*, London, Churchill, 1865, 2nd ed., 1873.

[31] The most recent edition of Taylor's *Manual* (note 27), the 13th, appeared as *Taylor's principles and practice of medical jurisprudence*, ed. A. Keith Mant, Edinburgh, Churchill, 1984.

[32] In an interview with the journalist Augustus Mayhew in February 1856, Taylor stated that he had been consulted in 20 to 25 cases each year, amounting by then to about 500 cases since his first appointment at Guy's in 1831. *Illustrated Times*, 2 Feb. 1856.

[33] See discussion of the relation between chemical evidence and judicial standards of proof in nineteenth-century Britain in C. Hamlin, 'Scientific method and expert witnessing: Victorian perspectives on a modern problem', *Social Stud. Sci.*, 1986, **13**: 485–513.

[34] R. Angus Smith, *J. Roy. Soc. Arts*, 1860, **7**: 137; for Smith's treatment of the role of the expert witness in relation to sanitary science see, A. Gibson and W. V. Farrar, 'Robert Angus Smith, FRS, and sanitary science', *Notes & Rec. Roy. Soc. Land.*, 1974, **28**: 347–8.

In the 1830s the best study on poisons in English, apart from Friedrich Accum's work on the adulteration of food,[35] was Christison's *Treatise on poisons*.[36] Christison, while drawing on contemporary medical and chemical literature, added many observations from his own experience. The *Lancet* said,

> He [Christison] had to encounter the task of systematizing the knowledge existing on the subject; and not content with this, he applied himself to adding by his own investigations precise knowledge on much that was doubtful . . .[37]

Taylor recognized the significance of Christison's work; personal experience had taught him how easily Counsel could undermine the value of scientific and medical evidence, rendering it incapable of establishing legal proof. The weakness of scientific evidence lay too often in a lack of attention to detail and in a failure to consider the legal objections which might be raised in court. Taylor insisted that specimens taken for chemical analysis should be placed in clean closed vessels, analysed as soon as possible and the results recorded at the time. They should not be left unattended or where they were accessible to anyone who might have a reason for tampering with them. If these basic precautions were not taken, Counsel could successfully challenge the validity of the analytical results, represent the medical witness as unreliable or incompetent, and so damage his reputation. Taylor argued that all medical students should be taught how to prepare for appearances in court, but he found little support among his colleagues, most of whom either ignored the problem altogether or argued that a good professional training in medicine itself was enough.

While insisting that it was essential for medical men to understand legal processes, Taylor thought it equally important for members of the judiciary to understand the fundamentals of scientific reasoning and how it differed from legal argument. They should know enough about medicine and chemistry to understand the status and limitations of any scientific evidence presented in court by medical witnesses so as to assess the underlying reasons for uncertainty or apparent confusion. Significantly, his first course of lectures at Guy's was attended by leading jurists, including barristers and judges, as well as prominent medical men and it was said that he,

> laid down limits within which scientific data are available for the guidance and application of legal principles and . . . combined the whole mass of anatomical and chemical data into a code of instruction . . . which stands unsurpassed in the literature of any country.[38]

In his first book, published in 1836, Taylor began with a discussion of wounds and planned to include poisons in a proposed second volume which never appeared. In his later *Manual of medical jurisprudence* the order was reversed, with poisons treated

[35] F. C. Accum, *A treatise on adulterations of food and culinary poisons*, London, Longman, 1820, 2nd ed., 1820, 3rd ed., 1822, concerned with the dangers arising from the widespread adulteration of food.
[36] R. Christison, *A treatise on poisons in relation to medical jurisprudence, physiology and the practice of physic*, Edinburgh and London, A. Black, 1829, 2nd ed., 1832, 3rd ed., 1836, 4th ed., 1845.
[37] Obituary of Christison, *Lancet*, 1882, i: 208.
[38] Obituary of Taylor, *Br. med. J.*, 1880, i: 905.

first, followed by wounds, suicide, and other causes of death.[39] It seems likely that his first-hand observations of gunshot wounds and their treatment during the Paris riots of 1830 gave him confidence to deal with this topic in his first book, but increasing familiarity with the effects of poisons and their growing importance in criminal trials, led him to change the order. After only two years a second edition was required and this gave Taylor the opportunity to introduce new material on toxicology for the improvement of the reliability of the chemical tests. He extended the discussion of arsenic, lead, copper, and opium, and added new facts about minimum fatal doses, the time taken by poisons to act, and the strengths of various medicinal preparations containing poisons. He also included some poisons not treated in the first edition. This amplification of the section on toxicology reflected the fact that during the preceding fifteen years poisoning had accounted for about 45 per cent of all cases in which the law required medical evidence.[40] Taylor also remarked on the importance given to toxicology by foreign authors including Orfila,[41] Devergie,[42] and the Italian medical jurist Barzellotti.[43]

The commonest poisons encountered in murder trials in the mid-nineteenth century were arsenic, opium, oxalic acid, and corrosive sublimate (mercuric chloride); strychnine was also found occasionally. In a simplified version of Orfila's classification, Taylor distinguished just three groups of poisons, the irritants, narcotics, and narcotico-irritants.[44] Corrosive and irritant substances were identified by their effects on the tissues of the mouth, throat, and stomach. The signs of poisoning in such cases were immediately obvious, but when there were no such effects it was harder to detect the poison and clinical experience was often the only way to distinguish symptoms of poisoning from those of disease in living subjects.[45]

A satisfactory legal definition of the term "poison" has never been easy to achieve, but Taylor aimed to define chemical and biological poisons in simple terms which could be accepted by jurists. For medical purposes anything which is swallowed and causes death must be considered a poison and this would include mechanical irritants and foods contaminated with bacteria. For the purposes of forensic toxicology, however, Taylor restricted his definition to chemical substances which produced abnormal symptoms and possibly, though not necessarily, death. Poisons were commonly thought to act in very small quantities, a point often made in legal arguments, but Taylor remarked that salts of lead, tin, copper, zinc and antimony are only poisonous in quite substantial doses, while substances regarded as non-toxic like

[39] Taylor, *Manual*, 1846, note 30 above, pp. 1–280, more than one-third of the book, are devoted to poisons.

[40] Ibid., p. 68. According to Taylor, in 1837/38 for example, there were 541 deaths by poison in England (282 male and 259 female). Of these, opium in all its forms accounted for 196 cases, including suicides and accidents. Arsenic was found in 185 cases, mainly criminal poisoning, sulphuric acid in 32 cases, prussic acid in 27, oxalic acid in 19, and corrosive sublimate (mercuric chloride) in 15 cases.

[41] Orfila, op. cit., note 13 above.

[42] A. Devergie, *Médecine légale, théorétique et pratique*, 2 vols, Paris, Germer-Baillière, 1836, 3rd ed., 1852.

[43] G. Barzellotti, *Questioni di medicina legale, secondo lo spirito delle leggi civili et penali veglianti nei governi d'Italia*, Pisa, Niccolo Capurro, 2nd ed., 1819. Later editions were published both in Pisa and in Milan.

[44] Taylor, *Manual*, 1846, note 30 above, pp. 12–15.

[45] Ibid., pp. 21–38.

common salt or magnesium sulphate (Epsom salt) can cause death if taken in very large amounts. Clearly quantity was not a reliable criterion for the definition of a poison. In framing legal indictments the evocative phrase "deadly poison" was often used even in cases where it was not strictly correct. The word *deadly* was usually superfluous[46] and Taylor thought that it should be dropped, as it was meaningless and had led to irrelevant legal wrangles about the nature of particular poisons. He aimed to frame a definition which would serve the forensic toxicologist by including poisons swallowed, inhaled and absorbed through the skin, but excluding mechanical irritants. To cover these demands he proposed to define a poison as:

> a substance which when taken internally is capable of destroying life without acting mechanically on the system.[47]

This definition was retained in his later work *On poisons*, published in 1848.[48]

MINERAL ACIDS, ALKALIS, AND SALTS AS POISONS

Taylor identified the mineral acids and alkalis by their familiar properties and cited the usual tests, including barium chloride for sulphuric acid and silver nitrate for hydrochloric acid, but for legal purposes he realized that more positive evidence than the formation of a precipitate would be needed.[49] In the case of sulphuric acid, for example, he reduced the dried precipitate of barium sulphate to the sulphide by heating it with powdered charcoal in a platinum crucible. A dilute acid would then yield hydrogen sulphide from the residue. Taylor claimed that by carrying out this test on a card glazed with a lead salt he could detect 1/40,000th part of sulphate by weight. The tests were equally successful when the acid was mixed with porter, tea or coffee, though in vomit or the contents of the stomach the observations were complicated by carbonates, phosphates, borates, oxalates or tartrates which might also be present. Yet even if a copious precipitate of barium sulphate were obtained, it could not be assumed that sulphuric acid had necessarily been administered *as a poison*, since sulphates were widely used in medicine. It was even more difficult to prove poisoning by nitric acid. Taylor suggested a delicate chemical test, by boiling a few drops of the liquid thought to contain nitric acid with small pieces of copper. If nitric acid were present, red fumes of nitrogen dioxide would be evolved leaving a blue solution. However, since strong nitric acid reacts vigorously with organic matter, it might not be found in the stomach by chemical tests even though it had been swallowed. In that case the yellowing of skin and tissues (the xantho-proteic reaction) would provide evidence of strong nitric acid, and the lack of positive chemical identification would be overcome by the clinical observations described by A. E. Tartra in 1805.[50]

The crystals of oxalic acid, a most powerful poison, resemble those of Epsom salt (magnesium sulphate) or white vitriol (zinc sulphate). All three compounds were

[46] Ibid., p. 4.
[47] Ibid., p. 5.
[48] *Idem, On poisons*, note 30 above, p. 7.
[49] Ibid., pp. 15–20; *idem, Guy's Hosp. Rep.*, 1839, **4**: 297.
[50] A. E. Tartra, *Essai sur l'empoisonnement par l'acide nitrique, présenté et soutenu à l'école de médecine de Paris, le 19 pluvoise an X*, Mequignon, Paris, 1802.

readily available from pharmacists and errors or deliberate substitution were easily made. Chemical tests would identify the acid—for example silver nitrate gives a white precipitate of silver oxalate which dissolves in cold nitric acid and detonates on heating—but tests such as this were unreliable when the acid was mixed with organic matter. The acid must then be isolated by precipitating lead oxalate and separating the free acid from its lead salt.[51]

Preparations containing salts of lead, mercury, copper, arsenic, and antimony were often encountered in criminal cases of poisoning. The toxicologist sought to identify these and other mineral compounds and also suggest how they entered the victim's body. Lead poisoning could result from long-term exposure to lead compounds in industry or from the prolonged effects of domestic lead pipes on drinking water.[52] Common among painters and decorators, or the makers of lead-glazed pottery and lead-glass, industrial lead poisoning was caused by lead carbonate (white lead) or lead oxides, but when a lead salt was deliberately used as a poison, lead acetate (sugar of lead) which looks like loaf sugar, has a sweet taste, and is very soluble in water, was more often chosen.[53] Taylor's preferred chemical tests for lead acetate included heating the salt in a small tube. The crystals melted, solidified, and melted again giving off acetic acid vapour and turning into a black mass of carbon and metallic lead. The fine yellow precipitate with potassium iodide, soluble in excess, and the black precipitate with ammonium sulphide were also proposed as tests for lead. These and similar tests would confirm the presence of lead acetate for the chemist, but courts of law demanded positive identification of metallic lead itself, and for this Taylor recommended the galvanic effect between strips of platinum and zinc in an acidified solution of lead acetate.

Among mercury compounds, corrosive sublimate (mercuric chloride), a heavy white crystalline powder, soluble in water and alcohol, was most commonly used as a poison. It could be identified by the fact that it sublimes on heating and forms coloured precipitates in aqueous solution—bright red with potassium iodide, yellow with caustic potash, black with ammonium hydrosulphide. The last might be mistaken for similar precipitates formed by lead, copper, bismuth, silver, nickel, and some compounds of tin. In any case, to confirm mercury to the satisfaction of the courts it was necessary to reveal the metal itself. To do this Taylor recommended heating the precipitate with anhydrous sodium carbonate to obtain globules of metallic mercury. Another method of revealing the presence of mercury was to heat a piece of copper which had become silvered by contact with the mercury compound. Still other methods included the reducing action of stannous chloride, which gave a

[51] There are then two options; the solid can either be diffused in water and treated with hydrogen sulphide to remove lead sulphide and organic matter, filtering and crystallizing the oxalic acid from the filtrate, or the lead oxalate may be boiled with dilute sulphuric acid to precipitate lead sulphate, leaving the oxalic acid in solution to be neutralized with ammonia. Taylor used both methods successfully. *Manual*, 1846, note 30 above, p. 100–1.

[52] Taylor, 'On the action of water on lead in relation to medical police', *Guy's Hosp. Rep.*, 1838, **3**: 60–91; Christison, 'On the action of water upon lead', *Edinb. Roy. Soc. Trans.*, 1844, **15**: 265–76.

[53] Taylor, *Manual*, 1846, note 30 above, p. 169.

grey precipitate of metallic mercury, and the galvanic effects of strips of gold and zinc foil in acid solution.[54]

Some of the problems faced by the forensic toxicologist were shown to a marked degree in relation to mercury poisoning. In vomit and stomach contents, corrosive sublimate may be precipitated or occluded in solid masses with albumen, fibrin or mucous membrane. The liquid portion must then be filtered off and tested for mercury with stannous chloride, or strips of copper (or gold) and zinc. The presence of mercury would be confirmed if globules of the metal condensed on the upper parts of a tube in which the copper or gold foil was heated. It had been objected that though this showed mercury to be present, it did not identify whether mercury chloride or mercury nitrate had been the poison used. Taylor thought this unimportant as both salts owed their poisonous properties to the metal and the symptoms were the same in both cases. From a legal point of view, however, it could be crucial to determine the precise poison used so as to confirm or refute other evidence. A further complication sometimes arose from the use of preparations containing calomel (mercurous chloride) in medicine, though the fact that such a mercury compound had been prescribed could usually be readily determined.

Copper salts were easily recognized by their blue colour, especially the deep blue cuprammonium solution formed when ammonia is added to a solution of a copper salt. Potassium ferrocyanide was known to give a claret-coloured precipitate and ammonium sulphide a chocolate-brown with acid solutions of copper salts. The only metal with which there could be any confusion due to the colour of its salts and their reactions with the sulphides was nickel, but the presence of copper would be confirmed if a steel needle suspended in the solution became coated with copper. Strips of platinum and zinc in contact would give an even more delicate test. If the red deposit gave a blue solution with nitric acid, followed by the above reactions, copper was confirmed. Copper poisoning was most often due to the sulphate (blue vitriol) or sub-acetate (verdigris). The poisonous nature of Scheele's green (copper arsenite), a toxic pigment used in the nineteenth century for colouring wallpaper and cheap confectionery, was due to arsenic rather than copper. Particles of copper arsenite in dust floating in the atmosphere of rooms decorated with wallpaper coloured by Scheele's green were a constant danger to the occupants.[55] Blue vitriol was also used in preserving fruits and making pickles, and such widespread health hazards led Taylor to call for the establishment of medical police in England, following the practice in France and Germany.

THE ARSENIC PROBLEM

In the first half of the nineteenth century the commonest mineral poison was arsenic in the form of arsenious oxide, "white arsenic".[56] There were many chemical

[54] Ibid., pp. 147–62; Danger et Flandin, 'De l'empoisonnement par le mercure', *C. r. hebd. Ac. Sci. Paris*, 1845, **20**: 951–4.

[55] Taylor, 'On arsenic in paper-hangings', *Pharm. J.*, 1858, no. 17, pp. 6; *idem*, 'On arsenical paper-hangings and the mode in which they produce noxious effects on health', *Lancet*, 1859, i: 4.

[56] *Idem, Manual*, 1846, note 30 above, p. 68.

tests for arsenic,[57] though none was wholly satisfactory for toxicological purposes and chemists disagreed about the relative merits of the different tests. Most thought that a deposit of metallic arsenic on a cold glass or porcelain surface (the so-called "arsenic mirror") was the most convincing evidence of its presence. An evaluation of analytical methods for arsenic was made in Germany by Fresenius in a work on qualitative analysis published in 1841.[58] Fresenius, who had worked with Liebig at Giessen, established a teaching laboratory for analytical chemistry at Wiesbaden in 1848, where he sought to improve the accuracy and reliability of qualitative and quantitative analysis. He organized qualitative tests for metal ions into a system which was later developed into the group analysis familiar to later generations of chemists. In relation to forensic chemistry Fresenius argued that standard analytical procedures ought to be laid down to protect chemists engaged in forensic work from criticisms of their methods in the courts. In the absence of such official procedures Fresenius proposed rigorous analytical methods to cover every conceivable situation. In the case of arsenic, for example, his methods covered every context in which arsenic might be found and he aimed to detect minute quantities of it in the presence of many other metals. He compared four common tests for arsenic in organic matter, including the Marsh and Reinsch tests, both of which he criticized.[59]

Marsh's test, introduced in 1836[60] was really an industrial technique intended mainly for detecting the presence of arsenic as an impurity in zinc. In applying the test for the purposes of forensic toxicology it was necessary to ensure that the zinc used was pure so that there could be no doubt that if arsenic were detected it came from the material under test and not from the reagents. The procedure was to prepare hydrogen from pure zinc and sulphuric acid in a solution containing the material to be tested and to burn the gas at a jet playing on cold porcelain. If arsenic were present a metallic deposit would be formed. The Marsh test replaced earlier methods which depended on the sublimation of arsenious oxide or the deposition of metallic arsenic,[61] but although it was sensitive, Fresenius thought it inappropriate for toxicological work because the presence of arsenic in organic matter could easily be missed. Also, both zinc and sulphuric acid were often contaminated with arsenic, a weakness of the test when cited in evidence in court.

Fresenius also considered Reinsch's test unsuitable for toxicological purposes because it was not applicable to *every* form in which arsenic may be combined with organic matter. In this test the suspect material was boiled with hydrochloric acid and a small strip of bright copper foil. In the presence of arsenic the surface of the copper became coated with a dark, iron-grey deposit.[62] The test was further rejected by

[57] W. A. Campbell, 'Some landmarks in the history of arsenic testing', *Chem. in Britain*, 1965, **1**: 198–202.

[58] C. R. Fresenius, *Anleitung zur qualitativen chemischen Analyse*, Bonn, 1841, transl. J. Lloyd Bullock, *Elementary instruction in qualitative chemical analysis*, with a short introduction by Liebig, London, 1841, (there were numerous later editions).

[59] Ibid., pp. 156–7.

[60] J. Marsh, *Edinb. new phil. J.*, 1836, no. 21, pp. 229–36.

[61] See for example Christison, op. cit., note 36 above, pp. 180–1.

[62] H. Reinsch, 'De l'essai de l'arsenic par le cuivre' (transl. from *Repertorium für die Pharmacie*), *J. Pharm.*, 1842, **2**: 36–43. Reinsch claimed that his test was more convenient than the Marsh test and sensitive to a millionth part of arsenic.

Fresenius because, like the Marsh test; it could not be made to yield a quantitative result, it contaminated the materials under test with copper and nitrates, and mercury and some other substances interfered with the results.

In Taylor's view the identification of arsenic in forensic medicine did not require analytical sophistication of the kind advocated by Fresenius. He thought the German chemist's methods were too complex for the purpose and, having examined Fresenius' method,[63] he remarked that even in the hands of an experienced analyst it could easily lead to errors. He argued that it was unnecessary to test for lead, bismuth, copper and mercury in every suspected case of arsenic poisoning as these metals were so rarely found together with arsenic and, anyway, he said,

> a court of law requires to know whether arsenic was present and was the cause of death, rather than whether it was mixed with traces of bismuth or lead, a fact which however interesting in a chemical, is wholly unimportant in a medico-legal way.[64]

Considering the practical difficulties involved, Taylor concluded that Fresenius' method was not the safest way to detect arsenic for medico-legal purposes. Instead he favoured the Reinsch test and relied heavily on it,[65] though he remained unconvinced of the need to obtain metallic arsenic in order to confirm the presence of this poison. He also thought that some other reactions gave equally conclusive evidence of arsenic and should be accepted as such in law.

Taylor also adopted Marsh's test,[66] considering it capable of detecting as little as one part per million of arsenic. Nevertheless, its reliability could be challenged unless absolutely pure reagents were used and it was essential to run "blank" tests on them first. Another objection was that, while the solution tested might contain a very small proportion of arsenic, by using a large volume of solution the total quantity of the poison detected would be increased. Thus it was important to state the total quantity of solution tested. For medico-legal purposes the presence of arsenic as a poison could only safely be assumed when the concentration reached at least 1/100th part of a grain in 1 fluid oz. of water (1 part in 48,000). Both the Marsh and Reinsch tests were capable of detecting such a low concentration, but were open to the objection that antimony, tin, lead, bismuth, and mercury all gave similar results. Taylor remarked that arsenic could be distinguished from the rest in Reinsch's test by heating the arsenic-coated copper foil gently in a tube when the arsenic would sublime as white octahedral crystals of arsenious oxide, while the other metals, including antimony, would not do this. Although Taylor so strongly advocated the Reinsch test for its delicacy, Christison was less convinced.[67] He suggested that the quantity of

[63] Taylor, *On poisons*, note 30 above, pp. 158–9.

[64] Ibid., p. 159.

[65] Taylor was quick to use the Marsh test in his analyses, *Guy's Hosp. Rep.*, 1837, **2**: 68–103; he was also the first to use the new Reinsch test in forensic toxicology, *idem*, 'Report on the new test for arsenic [Reinsch's process], and its value compared with the other methods of detecting that poison', *Br. for. med. Rev.*, 1843, **16**: 275–82. See also J. B. A. Chevalier and J. Barse, *Manuel pratique de l'appareil de Marsh ou guide de l'expert toxicologiste dans la recherche de l'antimonie et de l'arsenic; contenant un exposé de la nouvelle méthode Reinsch applicable à la recherche médico-légale de ces poisons*, Paris, 1843.

[66] Taylor, *On poisons*, note 30 above, p. 345.

[67] Christison, 'On the detection of arsenic in medico-legal researches by Reinsch's test', *Edinb. mon. J. med. Sci.*, 1843, **3**: 774–7.

arsenic revealed by both the Marsh and the Reinsch tests could be estimated roughly, and for legal purposes this was generally sufficient.

Nevertheless, mistakes were easily made and Taylor's reliance on the Reinsch method gave rise to an error which seriously damaged his reputation. At the trial of Thomas Smethurst in 1859, Taylor's evidence of arsenic was shown to be incorrect and had to be withdrawn.[68] Clinical observations suggested that an irritant poison was being administered to the deceased and Taylor, assisted by Odling, identified arsenic in a sample examined by the Reinsch test. Smethurst was arrested on the basis of this result, but when about thirty other samples, including medicines and parts of the body of the deceased, were later examined, no trace of arsenic could be found, although there was some antimony. The first sample was also found to contain a chlorate which had been given to the patient and was known to expel arsenic rapidly from the body. When heated with hydrochloric acid in the Reinsch test some of the copper foil, later found to be contaminated with arsenic, was dissolved. Now Smethurst, a medical man, could have known that Taylor relied on the Reinsch test and he would certainly have known that potassium chlorate removes arsenic from the body. It therefore seemed possible that this might well be a case of arsenic poisoning, cleverly disguised and confused by Taylor's known preference for the Reinsch process. In the light of other medical evidence given at the trial Smethurst was convicted, but on appeal his case was reviewed by Sir Benjamin Brodie, who concluded that the conviction was unsafe and Smethurst was therefore pardoned.

Taylor's reputation as an analyst, which had already been tarnished by his failure to detect strychnine in the Palmer case three years before (see below), was further damaged by this latest blunder and his competence as an analyst was questioned. In a letter to *The Times* Taylor's rival, William Herapath, professor of chemistry and toxicology at the Bristol Medical School, wrote, "the whole set of operations were [*sic*] a bungle", and another medical correspondent in the same issue said, "No sound chemist, in an ordinary case of suspected impurity, would certify to the presence of arsenic by such an analysis".[69] The folly of relying on a single test was pointed out by Herapath, while others remarked that a competent analyst should have recognized at once from the blue colour of the solution that the copper had been dissolved and have taken steps to remove the dissolving substance before repeating the test. Henry Letheby, chemistry lecturer at the London Hospital, remarked that though the Reinsch test was unsuitable for detecting arsenic in the presence of chlorates, other tests worked perfectly well and should have been used.[70] The incident adversely affected Taylor's reputation as an analyst and his statement that he had habitually used the same type of copper in Reinsch tests raised doubts about the chemical evidence he had given in other trials involving arsenic. This was probably unjustified, but it was clear that there were still many analytical problems to be resolved before evidence based solely on chemical analysis could be relied upon in court.

[68] For the Smethurst trial see *The Times*, Oct.–Nov. 1859; L. A. Parry, (ed.), *The trial of Dr Smethurst*, Edinburgh and London, William Hodge, 1931; J. F. Fielding, '"Inflammatory" bowel disease' [Trial of Dr Thomas Smethurst], *Br. med. J.*, 1985, **290**: 47–8.

[69] *The Times*, 25 Aug. 1859.

[70] H. Letheby, *Lancet*, 1859, **i**: 546.

Another form of poisoning which was not uncommon in the nineteenth century was due to antimony. This was usually caused by tartar emetic (potassium antimony tartrate), another readily-available poison widely used in medicine.[71] When heated in a combustion tube tartar emetic was found to char without melting; it dissolved in water, but not in alcohol. With hydrogen sulphide or ammonium sulphide a deep orange precipitate soluble in caustic potash and hydrochloric acid was formed, reactions which distinguished antimony from cadium and arsenic. The Marsh test could also be used to distinguish between antimony and arsenic, as antimony yielded a grey-white sublimate but no definite metallic mirror. When dissolved in aqua regia and evaporated to dryness the sublimate was converted into white antimony oxide. In testing for antimony in stomach fluids, tartaric acid may be added to dissolve the poison, which could then be precipitated by hydrogen sulphide. The precipitate was filtered off, washed, dried, collected, and dissolved by boiling for several minutes with a small quantity of strong hydrochloric acid. On adding the acid solution to a large quantity of water a dense white precipitate of antimony oxychloride would be formed. Bismuth gave a similar reaction, but bismuth could be distinguished by its black sulphide compared with the orange sulphide of antimony. If no antimony were found in the fluids, the solid parts of the stomach were cut up, boiled with tartaric acid solution, filtered, and tested in the same way as the fluids.

Orfila had proposed a method of detecting antimony in organs and tissues by dissolving the dried tissues in boiling nitric acid, evaporating the solution, carbonizing the residue, and boiling it with hydrochloric acid. The resulting antimony chloride could then be detected by the Marsh test, or by evaporating the liquid on a slip of glass and adding a drop of ammonium sulphide. Using this method Orfila had detected antimony in the urine, liver, and other viscera.[72] Taylor, who particularly after 1859 became dissatisfied with the reliability of the available tests for arsenic and antimony, continued to investigate the problem.[73]

THE ALKALOIDS

Opium posed even more problems for the toxicologist. Natural opium extracted from the opium poppy is a complex mixture of substances, mainly morphine and meconic acid.[74] The white prismatic crystals of morphine melt on heating, become dark-coloured, and burn like a resin, evolving ammonia. Sparingly soluble in cold water, morphine dissolves in 100 parts of boiling water to give a faintly alkaline solution. It was also known to be soluble in ether, alcohol, oils, solutions of potash, and dilute acids. Meconic acid, the other component of opium, was known to form reddish crystals, sparingly soluble in cold water. In dilute acetic acid it gave a white precipitate with lead acetate and a deep red colour with ferric chloride which could be destroyed by sulphur dioxide or stannous chloride but not by corrosive sublimate or

[71] Taylor, *Guy's Hosp. Rep.*, 3rd ser., 1856, **2**: 249; ibid., 1857, **3**: 369.

[72] Orfila, op. cit., note 13 above, pp. 99–161 on arsenic.

[73] Taylor, 'Facts and fallacies connected with the research for arsenic and antimony; with suggestions for a method of separating these poisons from organic matter', *Guy's Hosp. Rep.*, 3rd ser., 1860, **6**: 201–71.

[74] Analysis for opium based on the identification of these compounds was described by Christison, op. cit., note 36 above, pp. 515–23; Taylor, *Manual*, 1846, note 30 above, pp. 217–37, (chemical analysis of opium, pp. 232–6).

gold chloride. Taylor thought this a reliable test for meconic acid, as it distinguished the red colour from that due to potassium thiocyanate, which was destroyed by gold or mercuric chlorides. The reducing action of a mixture of zinc and dilute sulphuric acid had no effect on meconic acid but the thiocyanate colour was discharged and hydrogen sulphide was released. Taylor's descriptions of the tests available for the constituents of opium give a clear idea of the experimental work which formed the basis of chemical evidence for the nineteenth-century medical witness.

Table: Taylor's qualitative tests for morphia (morphine) and meconic acid.

Reagent 1	Tests on morphine	Results	Reagent 2	Result
1. Conc. H_2SO_4	crystals	pink colour	pot. chrom. soln	green colour
2. Conc. HNO_3	strong soln in HCl	deep orange-red soln	boiling	colour lightens
3. Conc. HNO_3	crystals	same, and NO_2 evol.	boiling	colour lightens
4. Sat. $FeCl_3$ soln neut. with KOH	aq. soln	inky blue	acid (HCl)	colour destr.
5. Sat. $FeCl_3$ soln neut. with KOH	aq. soln	inky blue	nitric acid	blue colour destr., orange-red soln forms
6. Cold iodic acid soln	aq. soln	brown colour due to iodine	starch-KI soln	blue colour
	Tests on meconic acid			
7. Lead acetate soln	in dil. acetic acid soln	yellow-white precipitate		
8. Sat. $FeCl_3$ soln	in aq. soln	deep red soln	SO_2 or $SnCl_2$ soln	red colour destr.
9. Sat. $FeCl_3$ soln	in aq. soln	deep red soln	dil. HCl, mercuric or gold chloride	no effect
10. Sat. $FeCl_3$ soln	in aq. soln	deep red soln	zinc and dil. H_2SO_4	no effect

Source: A. S. Taylor, *On poisons*, 1848, note 30 above, pp. 622–4.

Taylor thought that none of the tests for opium was wholly unambiguous. Other alkaloids also gave a red colour with nitric acid, though in each case there were differences. Strychnine gave a scarlet colour sparingly soluble in the acid; brucine also gave a scarlet colour, but this was soluble. Narcotine gave bright yellow; delphinine, yellow turning rust-red, and so on. As these colour reactions provided the main

observations on which the identification was based, there was clearly plenty of scope for confusion. In the test for morphine using ferric chloride, the blue colour could be confused with that formed by solutions of tannic or gallic acid, and as the compound of morphine with meconic acid in opium gave no reaction at all with ferric chloride, morphine might be present yet remain undetected. None of the alkaloids except morphine would release iodine from iodic acid though even here care was needed, since iodic acid yields free iodine by spontaneous decomposition and it was therefore essential to test for iodine *before* adding the morphine solution.[75] In later researches Taylor pursued his interest in the alkaloids when he investigated nicotine poisoning.[76]

Taylor often cited analytical results supplied by colleagues who were not themselves required to appear in court, but when the chemical evidence seemed likely to be crucial several expert witnesses would be called by both sides. This sometimes resulted in controversy both in court and outside, as in the case of William Palmer, the Rugeley poisoner, convicted of murder in 1856.[77] The Palmer case demonstrates the problems which arose when the results of chemical analysis did not confirm the clinical evidence. The victim's symptoms strongly suggested strychnine poisoning, yet no strychnine was found by chemical tests on his body. Little was then known about the physiological properties of strychnine, though it was later shown to pass rapidly into the blood. Taylor and G. O. Rees had been asked to examine the stomach and intestines, which were sent to London by carrier from Rugeley. They failed to find strychnine, prussic acid or opium, but they did find antimony. Medical evidence was given at the trial to the effect that tartar emetic had been administered to the victim and the analysts were driven to the conclusion that it was,

> impossible to say whether any strychnine had or had not been given just before death, but it is quite possible for tartar emetic to destroy life, if given in repeated doses, and so far as we can at present form an opinion, in the absence of any natural cause of death the deceased may have died from the effects of antimony.[78]

Though undeniable, this was in conflict with the clinical observations and an admission that the search for strychnine had been unsuccessful. At least ten medical witnesses called by the defence, led by Herapath, emphasized the weakness of the chemical evidence of strychnine poisoning. They adopted the traditional view that, since the alleged poison had not been found in the body, there was no proof that strychnine had caused the death of the victim and its absence from the analytical results should be taken at face value.

Most of the defence witnesses claimed that the symptoms displayed by the victim, J. P. Cook, were similar to those of tetanus, but despite his inability to identify strychnine, Taylor was strongly opposed to this view on the strength of the clinical

[75] *Idem, On poisons*, note 30 above, p. 624.

[76] Taylor, 'On poisoning by nicotina, and detection of the poison', *Pharm. J.*, 1859, no. 18, pp. 620–6.

[77] For the trial of William Palmer see *The Times*, 14 May 1856 *et seq.*; 'The scientific evidence on the trial of William Palmer', *Lancet*, 1856, **i**: 563–86, 596–613; Leonard A. Parry, *Some famous medical trials*, London, 1927, pp. 235–58.

[78] *The Times*, 19 May 1856.

symptoms, which, he declared, were quite different from tetanus. After the trial, during which attempts had been made to discredit his analytical competence, Taylor published his own assessment of the evidence and arguments on both sides.[79] In part this was an exercise in self-justification, but it was also done in an effort to clear up the confusion left by the Palmer trial and several other recent cases of strychnine poisoning. Taylor showed that some of the expert witnesses for the defence were unable to distinguish between the symptoms of strychnine poisoning and those of tetanus and much of their evidence was very doubtful. He was concerned about press criticisms of the medical profession in general and thought that,

> One of the worst effects produced by the trials of the recent strychnine murderers was the impression left on the public mind, enforced by the Press, enforced by the prosecution and almost sanctioned by the Bench, that with a little search medical men might be got to prove *anything* . . .[80]

Taylor again remarked on the strength of the clinical evidence that indicated strychnine poisoning and he maintained the certainty of this in spite of the lack of chemical confirmation. But even when a poison was positively identified, he said, care was still needed, for,

> Chemistry may detect a poison; but it fails, without the aid of physiology and pathology, to show whether it was or was not the cause of death; and in some instances, it cannot enable us to determine whether the poison was introduced into the body during life or after death . . .[81]

Clearly Taylor was well aware that chemical analysis alone could not be relied on to supply the conclusive evidence of deliberate poisoning required to secure a criminal conviction.

Taylor's reputation as an expert witness and his contributions to forensic toxicology were largely based on his shrewdness in recognizing what was required by the courts, rather than his skill as a chemical analyst, which was not outstanding. In the witness-box he was thorough, discreet, and astute. He was as impartial as possible and insisted that the scientific evidence must be supportable in itself, irrespective of which side of a case it might favour. He had an intense dislike of "professional witnesses" who sold their services to one side or the other, and he consistently refused to adopt such a position. In preparing his account of chemical tests made to support scientific testimony, he always tried to recognize and forestall objections which might be raised in court. In his teaching too, Taylor promoted the same forethought among medical students by insisting on careful attention to every detail of each case.

His remarkable ability to bring scientific evidence into line with the demands of the law, coupled with his long experience, enabled him to perfect a comprehensive system

[79] Taylor, *On poisoning by strychnia, with comments on the medical evidence given at the trial of William Palmer for the murder of John Parsons Cook*, London, Longmans, 1856.

[80] *Idem*, 'On poisoning by strychnia, and the processes for the detection of that poison', *Guy's Hosp. Rep.*, 3rd ser., 1856, **2**: 269.

[81] *Idem*, op. cit., note 79 above, p. 50.

of medical jurisprudence. The problems of establishing the role of the expert witness and the value to be placed upon scientific and medical evidence were widely discussed in Taylor's time and his professional interest in these problems is revealed by the extensive collection of medico-legal tracts he built up as a means of supporting his teaching, by the preparation of new editions of his books, and by his appearances in court.[82] Taylor's important contributions to the rise of forensic toxicology stem from thoroughness, impartiality, a love of accuracy, and a scientific approach to the details of each case, qualities which were too often missing in the work of his medical colleagues. The extent and astuteness of his work and its continuing influence among medical jurists so long after his death bear testimony to his importance among nineteenth-century pioneers of forensic toxicology and to the dignity which he brought to the role and status of the expert witness.

[82] Alain Besson, 'The Medico-Legal Tracts Collection of Dr A. S. Taylor, FRCP', *J. Roy. Coll. Phys. Lond.*, 1983, **17**(2): 147–9.