# THE INSPIRATION OF THOMAS GRAHAM, CHEMIST

## An appreciation and history of his influence on the development of the Department of Pure & Applied Chemistry at the University of Strathclyde, Glasgow.

**Colin Suckling**
**Freeland Professor of Chemistry**

**2006**

# THE INSPIRATION OF THOMAS GRAHAM, CHEMIST

**At the 'Andersonian'.** The tag 'A place of useful learning' is well-known as the founding characteristic of the new University in Glasgow set up in the Will of John Anderson in 1796. It's something that the University of Strathclyde, grown from Anderson's vision, still strongly holds. But it takes more than a paper, even one with a strong visionary catch phrase, to make something happen. It takes people, usually many people. The story of Anderson's University as an institution has often been told but less has been said about the development and impact of the various fields of science, engineering, and medicine. Our story is about chemistry and the remarkable influence and inspiration of one professor of chemistry at Anderson's University, Thomas Graham. Much more could be said in this story but in a sleeve booklet, we must be content with exemplification and illustration.

Chemistry was one of the first subjects to be taught at Anderson's University. The first professor of chemistry was Andrew Ure who had a high reputation in analytical chemistry but also had responsibilities for natural philosophy in Anderson's University. When the University managers decided to separate responsibilities for natural philosophy and chemistry, Andrew Ure resigned. This created to opportunity for Thomas Graham who, through his own research and through his influence on his students, coupled the rapidly growing science of chemistry with the vision of 'useful learning'. Thomas Graham's bicentenary fell in 2005 and today's building that bears his name is nearing completion in its refurbishment so it is timely that we should recognise and reflect on his contribution.

**Thomas Graham.**

Thomas Graham was born in Glasgow in 1805, the son of a textile manufacturer, whose father intended him for the ministry (Humboldt-Sexton, 1894). However chemistry interested Thomas more and in 1826, he graduated with an MA from the University of Glasgow. It could be that Graham senior's occupation with textiles had an unwitting influence upon Thomas because in textiles, the application of chemical science was becoming important. Indeed at least two of

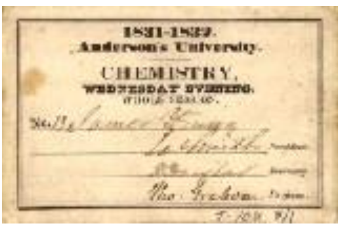
Thomas Graham's students had formative experiences in the textile industry. Having graduated, Thomas Graham quickly made a reputation for himself both in published science (Graham, 1826) and as a part time lecturer in Edinburgh, at the University of Glasgow, and at the Glasgow Mechanics Institution, so much so that in 1830, he was appointed Professor of Chemistry at Anderson's University, a post he held until 1837. Whilst his lecturing style may have lacked fluency according to his students (Frame, 1970), Thomas Graham was hugely influential and inspirational to his students, especially in encouraging research. The two principal outcomes in research of his tenure of the Andersonian chair were the foundations of the law of diffusion of gases and the polybasic character of phosphoric acid (Graham, 1837). In 1834, his work on diffusion earned Thomas Graham the Keith Prize of the Royal Society of Edinburgh and he was elected a Fellow of the Royal Society of London in 1836. Significantly, whilst the basis of his discoveries was experimental, the importance of applications was never far from Thomas Graham's scientific efforts.

Graham's contribution to the physical chemistry of gases has been divided into six important segments (Mason, 1970). He carried out the first quantitative experiments on gaseous diffusion; no-one knew anything about this process until Graham carried out his experiments. This led to his experiments on diffusion that became embodied in what we now refer to as Graham's Law, first presented to the Royal Society of Edinburgh in 1831. Later his work extended to effusion, the motion of gas molecules out of tiny holes in thin plates (Graham, 1846), and transpiration, the motion of gas molecules along a narrow tube, what is now called laminar flow. In addition to these four seminal experimental contributions, he provided a theoretical descriptive framework for the motion of gases. Lastly, he demonstrated the separation of gases by mechanical means, a process that was developed nearly 100 years later technologically for the separation of U-235 from non-fissile isotopes (Graham, 1866). Those who have studied Graham's experimentation in detail recognise especially the simplicity and clarity of his experimental design.

In his subsequent posts as professor of chemistry at University College London (1837 – 1855) and as Master of the Mint (1855-1879), applied science, both as a challenge to understanding and as a field for making use of discoveries, was characteristic. Like many scientists of his day and of today, he undertook both basic research and research in support of the government. Government works included a report on heating the Palace of Westminster, analysis of public water supply in London, and, reminiscent of John Anderson's activities two generations earlier, enquiries into methods of casting guns. Unlike some of his successors, Graham undertook little private analytical work and when he did, it occasionally got him into trouble. Some excise work on a cargo ostensibly of ‘napththa’ but thought to be liable for excise duty held at the Customs House in Liverpool led him into a sharp disagreement with his predecessor, Andrew Ure, who wrote an aggressive and insulting pamphlet! For chemists, a most important contribution made by Graham was to instigate and lead the foundation of the learned society for chemists, now an international body known as the Royal Society of Chemistry.

**Thomas Graham’s students.**

Much more could be said about the celebrated Thomas Graham himself but to follow his trail to today, we must introduce his students at the Andersonian. One characteristic they all inherited from him was the great importance of practical experimental work, and indeed several of them acted as his assistants. Graham himself apparently regarded one of the most important parts of the teaching of chemistry as that required for the Andersonian Medical School. This is perhaps a contrast from today’s training of medics! However, he did have to gain accreditation from the Faculty of Physicians and Surgeons of Glasgow, the predecessor of the present Royal College of Physicians and Surgeons of Glasgow. It is interesting, therefore, that two of Thomas Graham’s most significant students were in the Medical School, namely *David Livingstone* and *Lyon Playfair*. Each in their own ways, David Livingstone and Lyon Playfair can be seen to have changed the world: David Livingstone, of course, as the explorer, and Lyon Playfair in his later political career as a powerful advocate of public health measures. David Livingstone’s career lies largely outwith this discussion but there is more to tell about Lyon Playfair.


1831-1832.
Anderson's University.
CHEMISTRY.
WEDNESDAY EVENING.

Graham also trained many students who combined leading scientific and industrial or entrepreneurial careers. *James Young* (whose chemistry class ticket is reproduced left) established the shale oil industry in Scotland and was a major benefactor of Anderson’s University and its President. He also was a strong financial supported of David Livingstone’s expeditions and provided a security of £5,000 for his former professor, Thomas Graham, the time of his appointment of Master of the Mint. *Walter Crum*, who grew up in Thornliebank, promoted both his family dyeing and calico printing firm and scientific research also serving for two terms as President of Anderson’s University. *Frederick Penny* was Graham’s substantive successor in the Chair of Chemistry and Anderson’s University; Penny was chiefly an analytical chemist who, following Graham's inspiration, trained the next generation of students with a great emphasis on practical chemistry.

**Successors to Graham's chair.**

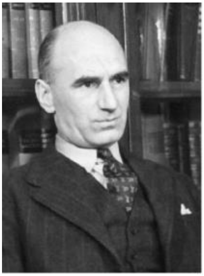
The principal chair of chemistry at the Andersonian and today at the University of Strathclyde became known in the mid 19th century as the Freeland Chair in recognition of a several benefactions by the eponymous Glasgow businessmen, John and Robert Freeland (Butt, 1996). Frederick Penny gave the first lectures under the Freeland Trust and his important contribution is discussed further later. Notably during Penny's tenure of the chair of Chemistry (1839-1870), student numbers increased steadily.

On Penny's sudden death, *Sir Thomas Thorpe FRS* (left) was appointed in 1870. His scientific standing led to his appointment as Principal of Government Laboratories. Amongst other things, Thorpe published on the production of olefins from paraffins by distillation under pressure (Thorpe & Young, 1870).

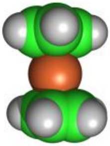
*William Dittmar FRS* (right) was a native of Darmstadt, Germany, who held the chair for 18 years (1874-1892). His laboratory was evidently very popular no doubt due to the immense enthusiasm he had for his subject. Dittmar published a standard work on analytical chemistry and research papers on 'spectrum photography' in quantitative analysis (Hartley & Dittmar, 1882) and physical properties of the elements (Dewar & Dittmar, 1872).

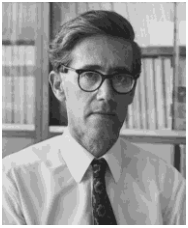
*George Henderson FRS* (left) was Freeland Professor from 1892-1919. He developed the study of natural products, especially terpenes, during the early years of the twentieth century (for example Henderson & Gray, 1903). This was a time when the structural relationships between natural products were beginning to become well established and their study prompted the discovery of new, selective degradation reactions. He also was one of the pioneers of industrial-academic collaboration establishing links with many local industries including Nobel Explosives, where like-minded industrial scientists were to be found, as we shall see later.

*Forsyth Wilson* (right, Freeland Professor 1934-1944) was an organic chemist who published on the synthesis and pharmacological properties of heterocyclic compounds, showing the beginnings of the systematic study of medicinal chemistry (Glen *et. al.* 1936).



*Frank Spring FRS* (left) was noted for his studies of many classes of plant natural products including alkaloids and phenolics, but especially complex triterpenes. During his tenure of the chair (1946-1959), the strength organic chemical research greatly grew (for example Beaton *et. al.* 1955).





*Peter Pauson* (right, Freeland Professor 1959-1990) initiated a new field of chemistry, organometallic chemistry, with the discovery of ferrocene (left, Kealy & Pauson, 1951) and proceeded to exploit the field in the synthesis of complex organic compounds with the discovery of what is now known as the Khand-Pauson reaction (Khand *et. al.* 1973). He was also one of the prime movers in transforming the chemistry activities into the modern Department of Pure & Applied Chemistry with its exceptionally broad coverage of basic and applied research and teaching, a feature that remains distinctive to the present day.

*Colin Suckling OBE* (right), the current holder of the Freeland Chair, promoted chemistry research at the interface with biology before it became fashionable, and has contributed substantially to the University of Strathclyde's wellbeing through the commercial exploitation of synthetic chemistry. Coincidentally, he has a strong family connection with Anderson's University that goes back to Penny's time.

**Thomas Graham's Distinguished Students**


**Lyon Playfair**. The first of Graham's students for us to follow is Lyon Playfair (right, Butler 2006). His father was a medical man who worked in India where Lyon was born, but Lyon grew up in the care of his uncle in St Andrews. He enrolled in the University there at the age of 14 but apparently he found the lectures uninspiring. So he tried a commercial career with another uncle in Glasgow which he found tedious! Only when he enrolled at the Andersonian Medical School did life take off for him. Apparently Lyon Playfair spent more time on chemistry than on any other part of the medical curriculum. When Graham translated to London, Playfair tried to continue formal medical studies at the University of Edinburgh but had to stop because of eczma caused by the vapours of the dissecting room. His father persuaded him to take a commercial career in India but he found that also tedious! After all that, he returned to the man who had inspired him, Thomas Graham, to work as his assistant and to seek his advice. That advice was to go to Germany and get a doctorate which he duly did at the University of Giessen in von Liebig's laboratory. Duly doctored in 1840, Playfair's first chemical job was as a chemist at the then famous Clitheroe calico works, a town and industry in which Walter Crum also spent formative years. But the business did not last and the redundant Playfair kept his academic intellect going with unpaid lecturing at the Royal Institution in Manchester, there being a shortage of universities in England at the time! Eventually in 1858 Playfair was appointed to a chair in chemistry at the University of Edinburgh, where his work was more managerial than research.

What marked Playfair for success, however, were the political and governmental contacts that he obtained; the acquaintance with the prime minister, Robert Peel, was instrumental in persuading him to remain in Britain when offered a post in Canada. Peel also persuaded Playfair to contribute to a Royal Commission on the Health of Towns which reported on the appalling slum conditions of the Lancashire cotton towns (above left) and began Playfair's interest in public health for which he became renowned. In 1868, he felt that politics was where he should be and became Liberal MP for the Universities of Edinburgh and St Andrews and later for Leeds South. During this time, he was remarkable for bringing sound science into political debate, a feat that we could no doubt benefit from today! The power of his intervention was such that the amendment to back compulsory vaccination was carried by 286 votes to 16 (Hansard, 1883). Playfair is regarded today as one of the founders of the medical specialty of Public Health.

**James Young** (right) was born in Glasgow in 1811, the son of a cabinet maker, and studied at Anderson's University whilst apprenticed to his father's trade. He studied with Thomas Graham moving with him to London in 1837. With his experience with Graham as good as a degree, Young became a chemist and James Muspratt's works at St Helen's, Lancashire. Then, as is still common, moved into management at Messrs Tennants, Clow & Co in Manchester. By 1848 we find Young beginning to manufacture oil products from a petroleum spring in Alfreton in Derbyshire and in 1850 to transfer that interest to the a type of coal called 'torbanite' found in the Bathgate area. What made Young's fortune, from which many including Anderson's University benefited, was his patented process for the extraction of oil from shale, a plentiful rock in central Scotland, although low in oil content. The paraffin oil and paraffin wax produced were in demand and Young, consistent with modern business practise, also moved up the value chain and involved his company in the production of lamps and other hydrocarbon-burning devices. Young also vigorously prosecuted his patent throughout the world through the courts where necessary. After his patent expired in 1864, Young bought out his partners and then sold the company on to Young's Paraffin Light and Mineral Oil Company, which was a commercial success.

The commercial strength behind Young made it possible for him to play a major role in the development of Anderson's University through ensuring its legal and academic status, the most obvious result today is the founding of the Young Chair in Technical Chemistry, originally with its own laboratory on the south east corner of the current Royal College site (left). These things Young acted both as a Trustee and as President (between 1868 and 1877) of Anderson's University. In his role as President, we see him supervising the appointment of Dr William Dittmar as Freeland Professor of Chemistry (The Scotsman, 1874). Young was elected a

Fellow of the Royal Society of London in 1873. Interestingly, bills and prospectuses for shale oil exploitation continued long for some decades after Young had sold up. We find a further player in our story, Robert Rattray Tatlock providing the scientific basis for a company subscription (The Scotsman, 1884). Tatlock, who knew Young well, reports him to be clever and shrewd, and with "a real dry humour". Tatlock is significant to us as a witness, he recorded an account of his experiences and acquaintances in Anderson's University (Tatlock, 1920). In his own laboratory continued Graham's methods of bringing along young talent.

Personal contacts were clearly of great importance in the mid-19th century world of science and education, for example in the personal influence of Thomas Graham. James Young was notably helpful to David Livingstone whom he had met Graham's chemistry class. Apart from supporting his second and third expeditions financially, Young acted as a guardian for the Livingstone family after the death of Livingstone's wife. Young was also responsible for commemorating his former teacher and his explorer friend with statues in George Square and at Glasgow Cathedral.

**Walter Crum**, (right) born in the year that Anderson's University was founded, 1796, came from a commercial background and grew up in comfortable circumstances in Thornliebank, just to the south of Glasgow (Glasgow Digital Library 24). The family owned textile factories in Lancashire and Scotland. With opportunity from his family background and enthusiasm for learning and science from Thomas Graham, Crum was a major force in the intellectual and social life of Glasgow in the mid-19th century. He studied at the University of Glasgow and at Anderson's University with Graham. Crum added to his institutional education by spending two years travelling in Turkey and Asia Minor and becoming familiar with many European languages and engaging in scientific contacts with the leaders of knowledge in France and Germany. On his return from travel, Crum took over the family textile firm concentrating on dyeing and calico printing spending some significant time as Playfair did in the Lancashire town of Clitheroe. Interestingly, his industrial and commercial background was the basis for Crum's scientific reputation which centred initially on papers such as connected with dyeing (Crum, 1823, 1843). In the spirit of the times, however, he was wide in his view of the world publishing also upon such things as the stalactites of Derbyshire (Crum, 1861) and *The Supposed Influence of the Moon upon the Weather* (Crum, 1844). Like many chemists, he also investigate the nature of explosives; in fact in 1847 Crum undertook a thorough chemical investigation and standardised the nitrometer for the Royal Gunpowder Factory at Waltham Abbey in Essex.

There was an excitement about science not only amongst the professionals but also amongst the public at that time. With none of the modern, instant media to hand, for most people, access to science meant attending a course of a meeting. The newspapers have many contemporary advertisements for courses at Anderson's University (The Scotsman, 1843) and many did indeed attend. In 1876 Lectures under the Freeland Trust in natural philosophy and chemistry together with those on anatomy, physiology, and music numbered 2230. Anderson's University and the Glasgow Mechanics Institution both played key roles making science accessible and Crum devoted 40 years of his life contributing to these. It has been written of Anderson's University that during Crum's Presidency between 1848 and 1865 it was 'a college of science which … did more in its day to bring physics and chemistry within the range of the ordinary artisan and the general public than perhaps any other teaching institution in the country.' (Glasgow Digital Library, 24).

Crum's commitment to propagating science and its serious discussion extended to opening his home at the Rouken in Thornliebank (left) to large numbers of guests for regular scientific *Conversazioni*. This informal combination of scientific and social event is not familiar to us today but it played a major role the spread of scientific knowledge and culture to us today. Sometimes more than a hundred people would attend. We have no direct records of the sorts of discussions that took place but one participant, the above mentioned Robert Tatlock, expressed his considerable debt to Walter Crum for being invited to attend and take part at a relatively young age (Tatlock, 1924).

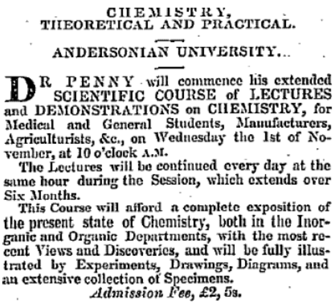
**Frederick Penny.** After the very short tenure of W Gregory, Frederick Penny (right). succeeded to Graham's chair. Penny was clearly a most determined man because at his own expense, he went to Liebig's laboratory in Giessen and in 1843, obtained a PhD. On returning to continue his work at Anderson's University, he was faced with a major problem. Lacking private means and there being no salary attached to his chair, he was forced as many others of his day were to undertake commercial work based upon his science. Then as now, student fees were scarcely sufficient to cover the costs of running courses. But Penny added immense business energy to his great knowledge of chemistry. He sensed exactly what a commercial public and dilletantist scientific public wanted and they responded with contracts and numbers at courses.

Scientifically, what was especially ripe for Penny and his public was the beginning of routine and reliable analytical chemistry. Penny advertised his services in the press in an engaging style, but without quoting prices. Much of his most celebrated work was of a forensic nature. He was a skilled expert witness, often congratulated by the judge. At the trial of Madeleine Smith in 1857 the Lord Justice-Clerk observed 'Certainly, Dr Penny, more satisfactory, lucid, or distinct evidence I never heard'. But it was the case of Dr Edward Pritchard that enjoyed the greatest notoriety. In 1865, Pritchard was tried, convicted, and hanged for the murder of his wife and mother-in-law and probably at least one servant. He was the last man to be hanged in public in Glasgow. Key evidence as to the nature of the poison was provided by Dr Penny from his laboratory and it seems certain that Tatlock did much of the analysis. The nature of the chemical analysis is primitive by modern standards. Penny reported identifying 'aconite' by taste and by observing the effect of some of the case productions on rabbits. However the most significant poison was antimony which had been administered as 'tartarised antimony', a water soluble form.

Penny was closely cross-examined about his analysis. With respect to taste, an exchange ran thus:
"Counsel: has aconite a bitter taste? – Witness (Penny): No.
Has antimony a burning taste? – It has and after a time a metallic taste.
When it enters the mouth, has it a burning taste? – Not so far as I have tasted it. What it may be when it goes down the throat in sufficient quantity to poison, I do not know [Laughter from the Court]." (The Scotsman, 1865).

Despite this, there was a scientific basis for identifying antimony-containing compounds that is still cited in analytical works today namely the Reinsch test. This involves treating the sample with dilute hydrochloric acid and then immersing a clean piece of copper; a purple-grey colour is indicative of antimony and this is what Penny reported in Court. The Pritchard trial was as high profile as it came for a professional scientist in the 1860s. At Strathclyde today, the Forensic Science Centre, which is part of the Department of Pure & Applied Chemistry is arguably the leading academic and professional centre for forensic science training and practice in the country.

Penny's professional work earned him both a living and a reputation. However what first made him well known to the Glasgow public was his teaching. In 1843 (left), we find his classes advertised in the Scotsman with emphasis on regular classes, topicality, and the use of experiments. If you wanted a more thorough and professional grounding, you could attend a more substantial course in the Andersonian's 'Private Laboratory'. The implication of the advertisement is that having attended and qualified from this course, students would have the skills to engage in original experimental research (The Scotsman, 1843).



CHEMISTRY,
THEORETICAL AND PRACTICAL.

ANDERSONIAN UNIVERSITY...

DR PENNY will commence his extended SCIENTIFIC COURSE of LECTURES and DEMONSTRATIONS on CHEMISTRY, for Medical and General Students, Manufacturers, Agriculturists, &c., on Wednesday the 1st of November, at 10 o'clock A.M.

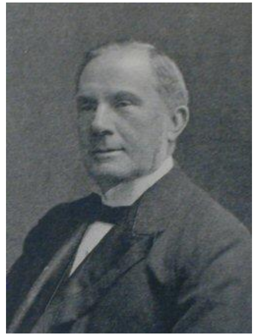
The Lectures will be continued every day at the same hour during the Session, which extends over Six Months.

This Course will afford a complete exposition of the present state of Chemistry, both in the Inorganic and Organic Departments, with the most recent Views and Discoveries, and will be fully illustrated by Experiments, Drawings, Diagrams, and an extensive collection of Specimens.

*Admission Fee, £2, 5s.*

**Penny follows Graham's example.** We now move a generation following Graham's own students along a line of tradition that he established working with skilled, motivated assistants. Just as Penny learned at Graham's side, so *Robert Tatlock* learned at Penny's side. Tatlock was Penny's assistant for over ten years at Anderson's University and at the Glasgow Mechanics Institution. Penny clearly ran a school of analytical chemistry of some distinction because another student of his, *William Wallace*, was appointed a lecturer in Chemistry at the Andersonian and in due course became Tatlock's business partner. The entrepreneurial spirit, important at Strathclyde today, was strong in Penny's students too. Wallace also obtained a PhD from Liebig's laboratory at Giessen. Tatlock, who also taught chemistry at Glasgow Mechanics Institution, and Wallace were clearly both expert formidable scientists as their company, *Wallace, Tatlock, & Clark* duly became, virtually monopolising analytical work in and around Glasgow. At a meeting of the British Association in Glasgow in 1876, it was declared that the best method for the analysis of potassium salts was that of

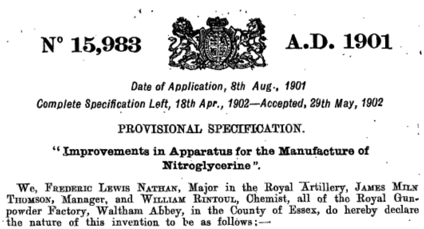
Wallace, Tatlock, & Clark (The Scotsman, 1876). A local Glasgow satirical rag called the firm 'The Chemical Trinity'.



Early in his career, Tatlock (right) also needed to earn a living from analytical chemistry and, apart from lecturing, advertised his services as an analyst from a laboratory in Leith, evidently in competition with his senior, Penny. Amongst Tatlock's students was the very young *William Ramsay*, later knighted for his services to chemistry and Nobel Prize winner for the discovery of argon and the other noble gases, of whom more anon. Tatlock's expertise soon led to important appointments along with his partners, including City Analyst for Glasgow. It seems from press reports that many of the tasks undertaken related to foodstuffs, either to determine their origin for excise purposes, or to detect adulteration, commonly in milk and butter. For example, Robert Kerr of the unfortunately named farm 'Shitterflat' was charged at Glasgow Sherriff Court in August 1876 with selling skimmed milk 'which was not what it was represented to be' (The Scotsman, 1876). In his evidence, Tatlock stated that there was 7% added water and Mr Kerr was found guilty and fined £10. The analytical and consulting work was not only local but also national. Tatlock contributed to debates before Royal Commissions on explosives and on the serious question 'What is Whisky' (Final Report, 1909). This is notable because the firm of Wallace, Tatlock, & Clark, through several transformations is still in existence as *RR Tatlock & Thomson*, a firm specialising in food and drink analysis based in Inverkeithing, Fife.

The Thomson of Tatlock & Thomson was Tatlock's nephew who again is both a player and a witness in the trail from Thomas Graham. As a boy of 13, *Robert Tatlock Thomson* entered the laboratory of Robert Tatlock and began to learn chemistry. His younger brother, *James Thomson*, the great grandfather of the current holder of the Freeland Chair, Colin Suckling, did the same. Robert Thomson gave an extended interview in 1938 to the Glasgow Herald in which he recalled the high jinks in the Andersonian laboratory of some seventy years earlier and in which Ramsay was a prime figure (Glasgow Herald, 1938). Much of what he reported would cause a safety officer apoplexy today. For example, noticing that opposite the laboratory in George Street, a woman regularly indulged in a hingie or sat sewing or knitting at the open window, Ramsay took the box used for the generation of smoke rings, filled it with hydrogen sulphide, and allowed invisible sulphurous rings to float across the street. Sure enough after a short time the woman detected the foul smell and set about trying to locate its cause but to no avail!

**An explosive connection.** Whilst Robert Thomson became part of the family firm and remained with it until after Tatlock's death in 1934, James Thomson moved to the Ayrshire coast to Nobel's Explosives Factory at Ardeer. From Ardeer, James Thomson migrated to the Royal Gunpowder Factory at Waltham Abbey in Essex where he became manager and, in contrast to his brother's recollections of the academic laboratory, took great care with health, safety, and environmental matters as far as the technology of the time allowed. Another associate of Tatlock, *William Rintoul*, who assisted with Tatlock's teaching also found his way to Waltham Abbey, which was the leading explosives factory in Britain at the time. The chemistry was led by staff who had trained at the precursor institutions to the University of Strathclyde. Thomson, Rintoul, and their boss, Sir Frederick Nathan, appear as joint inventors in a patent of 1901 on *Improvements in Apparatus for the Manufacture of Nitroglycerine* (left) (Nathan *et. al.* 1901).


N° 15,983 A.D. 1901

*Date of Application, 8th Aug., 1901*

*Complete Specification Left, 18th Apr., 1902—Accepted, 29th May, 1902*

PROVISIONAL SPECIFICATION.

**"Improvements in Apparatus for the Manufacture of Nitroglycerine".**

We, FREDERIC LEWIS NATHAN, Major in the Royal Artillery, JAMES MILN THOMSON, Manager, and WILLIAM RINTOUL, Chemist, all of the Royal Gunpowder Factory, Waltham Abbey, in the County of Essex, do hereby declare the nature of this invention to be as follows:—

An excursion to the south east of England might seem a departure from the line of Thomas Graham. But it serves to emphasise both the extent and the cohesiveness of the chemical community in and from Glasgow at the turn of the 20$^{th}$ century. A guest card from a dinner bringing together chemists from Ardeer included the name of *Sir Robert Robertson*, who eventually became Government Chief Chemist. There are also records of the Society of Chemical Industry meeting in Glasgow which met approximately monthly to hear original papers on topics that were clearly of current interest. *The fixation of nitrogen On the manufacture of blasting gelatine* were two examples (Society of Chemical Industry, 1890)

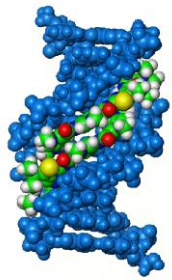
The Rintoul-Nathan partnership, however, had another twist. Both returned to the west of Scotland to manage Nobel's Explosives factory at Ardeer and this was to lead to further close involvement with the fore-runners of the University of Strathclyde (Miles, 1955). Rintoul was in charge of research and the laboratory staff. He found that it was crucial to employ the most able local boys and set about interacting with the local education establishment. He worked with the local schools to identify the most promising candidates, saw to it that they had the chance to attend Higher Grade classes, and expected them to pass. Bonuses were awarded for passing. Moving into higher education, Rintoul lobbied the Scottish Office and Board of Education sufficiently to raise strong interest in devising a new scheme of education. They were looking for a way to get the junior staff to attend the evening classes at the Glasgow and West of Scotland College of Technology (another embodiment of University of Strathclyde fore-runners), but were faced with the problem that the young students would not get back to Ardeer by train until after 11 p.m. The solution was that all classes, except those in the final year, would be held locally. The Company appointed the teaching staff with the approval of the College and the local education board met the cost. Eventually, these arrangements made it possible for junior staff at Ardeer to progress to courses leading to Associate of the Royal Technical College (left), the degree level qualification of the ultimate fore-runner of the University of Strathclyde. As mentioned earlier, an enthusiastic academic partner was found in Professor George Henderson. The higher education system today still grapples with issues of accessibility to relevant education!

Rintoul was also central to innovations in collaborative research. During the later years of the First World War, he recognised that there were many issues of scientific significance resulting from the Company's research but not of sufficient commercial importance to justify further investigation by the Company. Rintoul therefore had a list of such issues prepared and then discussed them with suitable university professors. For agreed topics, the Company paid for a post-graduate student through a grant and also a fee to the university and the professor. Rintoul insisted on regular reporting but left the conduct of the research to the academics. Much research in organic and physical chemistry was undertaken, including studies of aromatic sulphonation, the decomposition of anilides, and problems of gelatinisation. However any work related to blasting or detonating explosives was expressly excluded. In 1926, ICI was formed and the Nobel Explosives Company became Nobel Division. Rintoul became research director of ICI. His scheme continued in ICI and was recognisably still in place in the 1950s.

Rintoul's innovations in training and academic partnerships bring us remarkably close to modern times. They establish a direct connection for us between the inspiration of Thomas Graham that inspired his students and the academic and industrial environment in which we work today. It is perhaps a little bizarre that industrial-academic collaboration, begun so purposefully and successfully nearly 100 years ago still requires scheme after scheme of re-invention.

**Research themes today at Strathclyde**

In Graham's day, there was one professor of chemistry; today there are 10, which indicates the great breadth of chemical science today. The professorial team leads research with a balance of basic and applied science that hopefully would meet with Graham's approval.



The current Freeland Professor, *Colin Suckling*, has stimulated, led, and managed research collaborations not just between disciplines but also between institutions. In the context of chemistry, the fruit of this is the WestCHEM partnership with the University of Glasgow in a joint research school. Suckling was awarded the OBE for services to science and higher education in 2006. His own research is chiefly concerned with the development of some very promising heterocyclic compounds for the treatment of infectious and cardiovascular disease (for example Anthony *et. al.* 2004).

The tradition of organometallic chemistry established by Peter Pauson is continued in *William Kerr's* laboratory. His team develops new reagents and catalysts at the cutting-edge of synthetic organic chemistry and of direct relevance to the pharmaceutical, agrochemical, and fine chemicals industries (Henderson *et. al.*, 2002). These methods make it much easier and more economical than before to synthesise precursors for drugs in single-handed form, which is absolutely crucial to avoiding unacceptable toxicity such as found in the thalidomide case in the 1960s.

*John Murphy*, the Merck-Pauson Professor, specialises in the study of the reactivity of organic chemicals and chemical intermediates in chemistry and biology, leading to innovations in the development of new chemical reagents and processes. This work has created new reagents for DNA cleavage, new reagents for conducting radical reactions, and the first methods to produce unstable radicals and anions using exclusively organic reagents (Murphy *et. al.* 2005).

Polymer chemistry related to synthesis is led by *David Sherrington* who was one of the primary innovators in the field of polymer supported synthesis and polymer supported reagents, both of which have great significance in making preparative chemistry more environmentally friendly. Recently, the growing interest in nanostructures has presented further opportunities for the exploitation of the skills of the Sherrington group (MacIntyre and Sherrington, 2006).

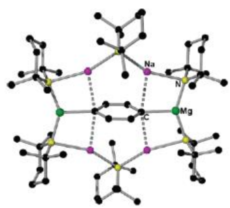
*Dick Pethrick* led physical chemistry research for many years. He continues Thomas Graham's pioneering research on gas diffusion through on the fundamental mechanisms of gas diffusion through polymer membranes. Using the technique of positron annihilation lifetime spectroscopy researchers are measuring at an atomic scale the pore sizes and are able to explain changes in chemical structure influence permeability of various polymer gas membranes.

*Andrew Mills* currently is head of physical chemistry and achieved distinction recognised by a Royal Society of Chemistry medal for research into artificial photosynthesis solar energy conversion systems. In recent years his research has broadened to include optical sensors, semiconductor photochemistry and redox catalysis.

*Peter Halling* is a specialist on the behaviour of enzymes in non-aqueous media and their use in chemical synthesis (Halling *et. al.*, 2005). This is a field that has important industrial applications and is often referred to as 'biotransformations'.

*David Littlejohn* is an outstanding analytical chemist with a reputation for technical innovation and applications of new techniques in the industrial context. His work on ultra-trace elemental analysis and real-time methods for monitoring and control of chemicals manufacturing has resulted in three separate awards from the Royal Society of Chemistry. The Centre for Process Analytics and Control was founded largely as a result of David's efforts.

*Robert Mulvey's* research has been recognised by the award of two Royal Society of Chemistry medals. He has opened up a new field of inorganic chemistry, so-called synergic chemistry, which occurs when two different metals, for example, sodium and magnesium, are combined within the same molecule along with suitable ligands. The compounds that arise have not only aesthetically beautiful structures but also have stimulated the discovery and development of important new reactions such as alkali-metal-mediated magnesiation and -zincation in synthetic chemistry and inverse



crown ring compounds in host-guest, supramolecular chemistry (Mulvey, 2006).

*Jim Fraser* leads the Centre for Forensic Science and concentrates research on the interface between science and law and understanding the contribution of science to the criminal justice system (Fraser, 2005). This includes the nature and limitations of expert witness evidence, assimilation of new technologies such as Isotope Ratio Mass Spectrometry, effective use of forensic science in police investigations and development of evidence based standards, policy and practice for science in the criminal justice system.

*Duncan Graham's* prize-winning research has exploded to international prominence with the establishment of the Centre for Molecular Nanometrology. The Centre's research exploits molecular manipulation and control to produce novel biomolecular probes that can be used to measure biological species and events using optical spectroscopy with unprecedented sensitivity and precision. This has resulted in a number of world firsts places the University of Strathclyde well be leaders of the future on the global stage in this competitive and growing area of science.

**WestCHEM**

Despite the breadth of interests at Strathclyde, it has become almost impossible to remain internationally competitive without a critical mass greater than the Department of Pure & Applied Chemistry could support. Following through the culture change initiated by Suckling in the mid 1990s with the formation of a novel research partnership between the Universities of Glasgow and Strathclyde, a new school of chemical research, known as WestCHEM has been established between the partners. WestCHEM is also part of a strategic umbrella organisation for Scottish academic chemistry known, unsurprisingly, as ScotCHEM. The resources that these new arrangements have attracted have made it possible to appoint additional professors to lead research teams.

*Peter Skabara's* group makes and analyses new organic semiconductors for the electronics industry. The materials are key components in flexible plastic solar cells, transistors, displays, sensors and other types of devices (Kanibolotsky *et. al.* 2004).

*Jonathan Percy's* interests involve making new molecules which will help us to understand and intervene in important processes from Nature. One or more fluorine atoms are incorporated into their molecular designs to achieve specific effects both at the molecular level and above; novel synthetic methods are usually required to obtain the molecules of interest.

**The Thomas Graham Building.**

In his bicentenary year, the University of Strathclyde began the last major phase in the refurbishment of the Thomas Graham Building (right). New research and teaching accommodation has been created within the strong structure erected in the early 1960s and parallel work has been carried out in the Royal College Building which Tatlock, Rintoul, and others would have known well. Over the past 7 years, the University of Strathclyde has invested over £10M in infrastructure redevelopment for chemistry using its own resources and contributions from the Scottish Funding Councils, UK Research Councils, the Robertson Trust, private individuals and companies. The confidence of the University and its funders has been justified by a near doubling of the undergraduate intake over the past ten years, reaching a peak of just over 170 in 2005. Research activity has increased with the Department of Pure & Applied Chemistry hosting laboratories and units of major importance. Analytical chemistry, from which the Andersonian drew its strength, is still prominent for example in the Centre for Process Analytics and Control (CPACT), the Centre for Molecular Nanometrology, and the Centre for Forensic Science. The Department has also scored successes in the commercial exploitation of polymer science and medicinal chemistry, fields that were unknown in the Andersonian days.

Some cynics say that there is nothing more to be discovered in chemistry. Nothing could be further from the truth. At Strathclyde, and in WestCHEM, our synthetic chemists are creating remarkable new structures, discovering new ways of carrying out reactions selectively, inventing new materials, and probing biology more and more intimately. And this is being repeated right across the country in active research schools. We owe it to our predecessors to ensure that the enthusiasm and importance of what we do is passed on and continued. The engineers and shipbuilders of the Clyde have rightly been celebrated and, following Thomas Graham's inspiration, we should also celebrate the chemists and chemistry.

Colin Suckling, September 2006

## References

Anthony NG (2004), Fox KR, Johnston BF, Khalaf AI, Mackay SP, McGroarty IS, Parkinson JA, Skellern GG, Suckling CJ, Waigh RD. DNA binding of a short lexitropsin. *Bioorg. Med. Chem. Letters*, *14*, 1353-1356.

Beaton JM (1955), Spring FS, Stevenson R, Steward JL. The constitution of taraxerol *J. Chem. Soc.* 2131-2137. A further 5 papers were published that year alone.

Butler A (2006) Lyon Playfair (1818-1898) and compulsory vaccination. *Scottish Medical J. 51*, 43-46.

Butt J (1996) John Anderson's Legacy. Tuckwell Press, East Linton.

Crum W (1823) Experiments and observations on Indigo and on certain substances which are produced by means of sulphuric acid. *Ann. Phil. 5*, 81-100.

Crum W (1844) On the manner in which cotton unites with colouring matter. *Phil. Mag. 24*, 241-246

Crum W (1844) On the supposed influence of the moon upon the weather. *Proc. Royal Phil. Soc. Glasgow 1*, 243.

Crum W (1861) On the stalactitic sulphate of barytes found in Derbyshire. *Proc. Royal Phil. Soc. Glasgow 5,* 39.

Dewar J and Dittmar W (1872) On the vapour density of potassium. *Proc. Roy. Soc. London*, *21*, 202-204.

Final Report of the Royal Commission on Whiskey and Other Potable Spirits(1909) Cd. 4796.

Frame E (1970) Thomas Graham: a centenary account. *The Philosophical Journal, 7,* 116-127.

Fraser JG (2005) Cold Case Investigations: Encyclopaedia of Forensic and Legal Medicine, J Payne-James *et. al.* (Eds) Elsevier.

Glasgow Digital Library http://gdl.cdlr.strath.ac.uk/mlemen/mlemen024.htm

Glasgow Herald (1938) 29th December. Practical Jokes of a great chemist.

Glen WL (1936), Sutherland MJJ, Wilson FJ. The preparation and therapeutic properties of certain acridine derivatives. *J. Chem. Soc.* 1484-1487.

Graham T (1826) On the absorption of gases by liquids. *Annals of Philosophy.12,* 69-74.

Graham T (1837) Inquiries respecting the constitution of salts. Of Oxalates, nitrates, phosphates, sulphates, and chlorides. *Phil. Trans. Roy. Soc. London*, *127*, 47-73.

Graham T (1846) On the motion of gases. *Phil. Trans. Roy. Soc. London*, *136*, 573-631.

Graham T (1854) On osmotic force. *Phil. Trans. Roy. Soc. London*, *144*, 177-228.

Graham T (1866) On the absorption and dialytic separation of gases by colloid septa. *Proc. Roy. Soc. London*, *15*, 223-224.

Halling PJ (2005), Ulijn RV, Flitsch SL. Understanding enzyme action on immobilised substrates. *Current Opinion in Biotechnology 16* 385-392.

Hansard (1883) *Parliamentary Debates*, *280*, 1014-1030.

Hartley WN and Dittmar W (1882) Researches on spectrum photography in relation to new methods of quantitative analysis. *Proc. Roy. Soc. London*, *34*, 81-84.

Henderson GG and Gray T (1903) Contributions to the chemistry of terpenes part 1. On the oxidation of pinene with chromyl chloride. *J. Chem. Soc.* 1209-1305.

Henderson KW (2002), Kerr WJ, Moir JH , Magnesium amide base mediated enantioselective deprotonation processes. *Tetrahedron*, *58*, 4573-4587.

Humboldt-Sexton A (1894) The first technical college. London, Chapman & Hall.

Kanibolotsky AL (2004), Berridge R, Skabara PJ, Perepichka IF, Bradley DDC, Koeberg M, Synthesis and Properties of Monodisperse Oligofluorene-Functionalized Truxenes: Highly Fluorescent Star-Shaped Architectures, *J. Am. Chem. Soc.*, *126*, 13695-13702.

Kealy TJ and Pauson PL (1951) *Nature, 168*, 1039.

Khand IU (1973), Knox GR, Pauson PL, Watts WE, Foreman I. Reaction of acetylenehexacarbonyldicobalt complexes, $(R^1C_2R^2)Co_2(CO)_6$, with norbornene and its derivatives *J. Chem. Soc., Perkin Trans. 1*, 977-981

Macintyre FS and Sherrington DC (2006) Ultra-high Surface Area Monodisperse Porous Polymer Nanoparticles, *Macromolecules, 39*, 5381-5384.

Mason EA (1970) Thomas Graham and the kinetic theory of gases. *The Philosophical Journal, 7,* 99-115.

Miles FD (1955) A history of research in the Nobel Division of ICI, ICI Kynoch Press.

Mulvey RE (2006) Modern ate chemistry: applications of synergic mixed alkali- metal-magnesium or -zinc reagents in synthesis and structure building *Organometallics 25*, 1060-1075.

Murphy JA (2005), Khan TA, Zhou S-Z, Thomson DW, Mahesh M, Highly efficient reduction of unactivated aryl and alkyl iodides by a ground-state neutral organic electron donor, *Angew. Chem. Int. Ed.*, *44*, 1356-1360.

Society of Chemical Industry (1890) *Glasgow and West of Scotland Section Minutes, 4th March.* University of Strathclyde Archives.

Tatlock RR (1924) Reminiscences of a college life. *Journal of the Royal Technical College, Glasgow.* 8.

The Scotsman (1843) 18th October.

The Scotsman (1865) 6th July.

The Scotsman (1874) 23rd September.

The Scotsman (1876) 24th August.

The Scotsman (1876) 9th September.

The Scotsman (1884) 3rd May.

Thorpe TE and Young J (1870) Preliminary notice on the production of olefins from paraffin by distillation under pressure. *Proc. Roy. Soc. London*, *19*, 370-371.

## Illustrations