The Institute of Science & Technology

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Reverse of cover page.

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Editorial

Welcome ▶

I hope that you enjoy this summer edition of the IST's Journal. There are some really interesting and informative articles inside. My thanks extend to each and all of the contributors, with special thanks to Alan Gall.

In his President's Address, our outgoing president, Bob Hardwick mentions our chairman, John Robinson and his fight against cancer. I'm sure that I speak for all my colleagues in IST in wishing him well – our thoughts are with you John.

This year the new advances in science seem to be finding their way into the news and media quite a lot, and I wondered what might have found its way into the news a hundred years ago. So I looked up just a few anniversaries for 1911.

Thomas Hunt Morgan began to map the positions of genes on chromosomes of the fruit fly

Alfred Henry Sturtevant produced the first chromosome map showing five sex-linked genes

William Burton introduced thermal cracking of refining petroleum

Chaim Weizmann discovered how to obtain acetone from bacteria involved in fermenting grain

Niels Henrik Bohr made his first attempt to link atomic structure to Planck's constant

Heike Kamerlingh Onnes discovered superconductivity in mercury cooled close to absolute zero

Ernest Rutherford presented his theory of the atom, consisting of a positively charged nucleus surrounded by negative electrons

Federick Soddy observed that whenever an atom emits an alpha particle, it changes to an element two places down in the list of atomic masses

Marie Curie won the Nobel Prize for Chemistry for her discovery of radium and polonium

Wilhelm Wien won the Nobel Prize for Physics for determining the laws of radiation of black bodies

Roald Amundsen reached the South Pole

Rev Wilbert Awdry, inventor of Thomas the Tank Engine, was born 1911 (died 1997)

So what about today, 100 years on? Well some great advances are already consigned to 2011. For example:

A group of scientists from Columbia University have successfully created extremely small 'spider' robots measuring about 4nm across -about 100,000 times smaller than the diameter of a human hair. These robots are made up of DNA developed at the molecular level. They can turn right and left and 'walk' autonomously, though at the moment only very slowly – about 100nm/hour. Importantly, they can be programmed to sense the environment and react accordingly. For example, they can detect disease markers on a cell surface, identify whether it is a cancerous one and then bring a compound to kill it, if necessary.

But even more scarily:

Vivian Blick, MD at and the owner of Tango Group has developed a self powered shower radio, so you can now enjoy singing while having your shower with the reassuring knowledge that it is powered by 'sustainable green energy'. The FM Radio is called H2O, and is fixed in the hose of the shower and uses the water flow as its clean hydroelectric energy source.

Ian Moulson
Editor

President Address and Acting Chairman's Report

Bob Hardwick ▶

During my 12 years as President the Institute has made a number of important and indeed significant changes. Not least amongst these have been the major changes to the Institute's administrative structures including the move away from Stowe House, Lichfield. The emphasis has been on streamlining the organisation and the services provided to the Membership, whilst also ensuring that spending is kept within strict financial parameters. However, if there has been a disappointment, it's that we haven't increased the Institute's Membership and perhaps we need to prioritise this issue and devote more effort and resources to this area over the coming months.

Increasing the membership not only assists the financial resources available but transmits the message that the organisation is steadily growing and that its credibility and professionalism is being recognised. I've said it before but if our current members could recruit just one new member each, this would have a very positive effect on the Institute's financial stability. Further, I really do believe that it is achievable, not necessarily as I have just suggested but by developing a number of initiatives or campaigns backed up by a strong marketing strategy. Whilst there is obviously a cost to any marketing campaign, if successful this particular project could pay for itself several times over, particularly with the prospect of HEaTED becoming a special interest group within the IST.

To continue on the theme of HEaTED, our very successful relationship with them continues, although over recent months the future funding of HEaTED has been at the forefront of our efforts and particularly those of our Chairman, John Robinson. Whilst a number of HEI's continue to provide funding, the HEFCE project money has almost run out and whilst discussions and negotiations have taken place with HEFCE and the Gatsby Foundation, to date, progress is very slow and the outcome, particularly in terms of the role of the Institute, is unpredictable. On a positive note, whilst the position on sustainable funding is resolved, the IST continues to organise and support the very successful UK wide skills programme and I am pleased to record our sincere thanks to Michele Jackson, Wendy Mason and many others for their superb work in maintaining and expanding this vital activity.

I commenced my address by talking about changes made by the Institute and another change that has been introduced during my Presidency is the Chairman doing the main written IST report, which then appears in the Journal, whilst I simply deliver a brief address and extend a thank you to colleagues at the AGM. This practice would have continued on this occasion and you would then not have had to put up with me rambling on but we currently find ourselves with a slightly different situation to deal with and one that we certainly wish had not occurred. Indeed, having announced at last year's AGM that I would stand down as President from today, I should have been making my resignation speech but, as some of you will know, our Chairman, John Robinson was recently diagnosed with cancer and is currently undertaking extensive treatment, hence him not being here today. However, Joan Ward, a personal friend of John's, has kindly been keeping the exec informed of progress and I'm sure that you would all want me to convey your best wishes to John for a full and speedy recovery. I will of course continue as President until John is well enough to resume his Chairmanship and in the meantime I will do anything I can, along with my colleagues on the Executive, to cover John's duties and responsibilities.

Finally, I wish to record my personal thanks to our professional and hardworking administration, Joan who deals with all the IST financial and membership records and Wendy and the admin team at our Head Office here in Sheffield. Earlier in this address I mentioned the importance of marketing and I would particularly pay tribute to Ian Moulson and his team who have transformed the Institute's Journal into a full colour professional publication. Thanks are also extended to my friends and colleagues on the Executive who freely give hours of their time working on behalf of the Institute and particularly to John, our Chairman, who has for many years worked tirelessly on behalf of the IST and its membership and our thoughts and prayers will be with him over the coming weeks.

Many thanks

Bob Hardwick
(President)

A brief history of British Summer Time

Les Miller ►

Origins

William Willett was born on 10 August 1856, at Farnham in Surrey. The son of a builder of quality houses, he was educated at the Philological School, Marylebone Road, London, and after leaving school and obtaining some commercial experience, entered his father's business. He also became a member of the Royal Astronomical Society and a keen horseman and, it is claimed, it was while he was taking an early morning ride during the summer of 1905 in Petts Wood near Chislehurst in Kent where he lived, that the idea of 'saving' daylight occurred to him.

Reflecting on what appeared to him to be an unnecessary waste of daylight; Willett had the revolutionary idea of moving the clocks forward during the summer months to transfer, in effect, some of the early morning's wasted sunlight to the evenings. This scheme would, he considered, offer many advantages whilst not altering anyone's waking hour, and thus was born the idea of 'British Summer Time' (BST).

This was not, however, the first time that adapting the hours of daylight had been proposed.

Photo by Luc Viatour (www.lucnix.be)

Apparently, it was common practice in Ancient Rome,[1] and Benjamin Franklin[2] had resurrected the idea in a light-hearted satire whilst in France in 1784. Although Franklin's facetious proposals were probably intended to encourage people to arise earlier in the morning he is, nevertheless, sometimes erroneously credited with the invention of modern 'Daylight Saving Time' (DST). A more serious contender, however, was George Vernon Hudson (1867 – 1946), a London-born, New Zealand entomologist and astronomer who, in 1895, presented a paper[3] to the Wellington Philosophical Society in which he proposed a two-hour daylight saving adjustment. He followed this up with another paper in 1898[4] after considerable interest was expressed in Christchurch, New Zealand, but ultimately his proposals were not accepted.

There has never been any suggestion that Willett was influenced by, or even aware of, any of these previous ideas and he is credited, correctly, with conceiving the notion totally independently. As will be shown, his determination and perseverance in introducing 'Summer Time' not only to Britain but, eventually, to the rest of the world, cannot be underestimated.

Formulation and Development of the Scheme

Having conceived the idea, Willett spent the next two years formulating details of his daylight saving plan, giving careful consideration to many possible benefits and paying particular attention to the many potential objections he considered would inevitably arise. Eventually he arrived at a comprehensive proposal which, in 1907, he detailed in a pamphlet entitled *'The Waste of Daylight'*.[5] This he published and distributed widely entirely at his own expense, and thereby set in motion a determined campaign for the adoption of daylight saving time during the summer months in the United Kingdom.

In his pamphlet, Willett proposed a 'simple expedient' to secure the advantages to be obtained from withdrawing from the beginning and adding to the end of the day some of the wasted hours of sunshine during the spring, summer and autumn months. His plan required setting the clocks forward by twenty minutes at 2am on each of four Sundays in April for a total advance of one hour and twenty minutes, and setting them back by twenty minutes at 2 am on each of four Sundays in September.

He went on to state, "If we will reduce the lengths of four Sundays in April by twenty minutes, a loss of which practically no one would be conscious, we shall have eighty minutes more daylight after 6 pm every day during May, June, July and August, and an average of forty-five minutes every day in April and September."

To silence potential objectors, Willett pointed out that travellers by sea easily accommodated themselves to frequent alterations of time on board ship by simply adjusting their clocks and watches, whilst travellers crossing to or from Ireland, which followed Dublin Mean Time - twenty-five minutes behind Greenwich Mean Time (GMT) - reset their watches as required and, Willett contended, thought nothing of it.

Willett further claimed that, "Everyone, rich and poor alike, will find their ordinary expenditure on electric light, oil, gas and candles considerably reduced for nearly six months in every year" and then proceeded to demonstrate the overall financial benefit of his scheme to the nation as a whole, which he assessed at £2 million annually – probably equivalent to in excess of £120 million today.

He then went on to claim that the use of natural light would provide many more benefits. Less coal would be used for the production of gas and electric lighting, thereby increasing the longevity of coal supplies and, as a consequence, much less smoke would 'defile the air'; eye strain would be reduced and, furthermore, the additional hours spent outdoors would create an overall improvement in the health of the nation.

Willett also addressed himself to the effect of his proposal on train schedules, stating that with one exception, all trains would run in accordance with existing time tables. He accepted that a few trains running at 2 am on the four Sundays in April would arrive twenty minutes late but argued that since both the passengers and the operators would know this before the journey commenced, this should not cause difficulties. The only significant effect would be on trains connecting via steamer to trains on the continent which would require three special timetables – one for April, one for May to August (inclusive), and one for September.

Since, by international agreement, both astronomy and navigation used GMT, these two areas were specifically exempted from his proposal.

After discussing several other aspects of his proposal and having pointed out the advantages and disadvantages of each, Willett concluded by extolling the overall cumulative benefits of the scheme before finally encouraging readers of the pamphlet to appeal to their friends and colleagues to urge their Members of Parliament to support his proposals.

Summer Solstice Sunrise over Stonehenge - Photograph Andrew Dunn

The Debate Commences

Willett's proposals found immediate favour with Robert Pearce, the Member of Parliament for Leek in Staffordshire, who quickly drafted a bill embodying his proposals.

Although Willett had never specifically used the term 'daylight saving' in his pamphlet, the phrase now became the name of 'Pearce's Daylight Saving Bill', which he introduced in the House of Commons on 4 February 1908. "The purpose of the bill", Pearce wrote, "was to bring the hours of work and pleasure nearer to sunlight."

Matters moved quickly forward and by March Willett had obtained the support of nearly two hundred members, and a Select Committee, chaired by Sir Edward Sassoon, had scheduled hearings to discuss the merits of his proposal.

Willett appeared before the committee on 7 April 1908 and presented the ideas described in his 'Waste of Daylight' pamphlet, supplemented by several sets of documents and diagrams to illustrate the value of his proposals. Several others who testified, however, pointed to the practical problems of having several time changes in a year and a number of alternative schemes were proposed, including three steps of thirty minutes, three steps of twenty minutes and two steps of thirty minutes. In further testimony, it was pointed out that four small changes in time would cause undue public inconvenience and result in too much interference with the ordinary measurement of time by clocks and watches.

Accepting this observation, the committee decided, "for the sake of simplicity and convenience", to modify the bill to a system having a single advance of the clocks in the spring and reversal in the autumn. Under this revised plan, the clocks would be set forward one hour at 2 am on the third Sunday in April and set back on hour at 2 am on the third Sunday in September.

Willett accepted this modification and fully supported the revised bill, reworking subsequent editions of his 'Waste of Daylight' pamphlet accordingly.

From its initial publication, strong opinions were expressed both in writing and verbally by prominent people and organizations concerning the proposed alterations to the hours of the day contained within the 'Waste of Daylight' pamphlet. Many senior Members of Parliament voiced their support for the proposal(s) and Edward VII indicated that he, too, was favourably disposed to the bill. The King himself had for some considerable time recognised the waste of morning daylight and, in 1901, had introduced a form of daylight saving time at Sandringham to allow more evening daylight for hunting during the winter, which he facilitated by having the clocks advanced by thirty minutes. This measure was later extended to Windsor and Balmoral Castles also, the practice being known as 'Sandringham Time' and lasting until 1936 before being abolished by King Edward VIII.

Cover of the 19th (and last) edition of the pamphlet "The Waste of Daylight", written by William Willett, who independently conceived DST in 1905. The pamphlet advocated DST for Britain and reported progress toward that goal.

Despite strong support, however, Willett's proposal was not without its critics and opposition raged not only in parliament but also in the press. Most scientists and astronomers were opposed to any tampering with the time and Sir William Christie, the Astronomer Royal, declared that the scheme was simply legislation for the benefit of late risers. Sir William Napier Shaw, Director of the Meteorological Office, worried about the difficulties the practical effects of adding or skipping an hour would have, for example, in the compilation of data from continuously recording meteorological instruments, while scientists, transportation executives, businessmen and others who had achieved a worldwide standard time zone system objected to the introduction of any irregularity.

Some of the fiercest opposition, however, came from the agricultural industry when farmers complained they could not change their daily schedules and start work an hour earlier just because the numbering of the hours was changed. They stated that several farm operations could not possibly be performed earlier, whilst merchants who conducted trade with continental Europe feared that daylight saving would hinder their business. Additionally, those who dealt telegraphically with the United States of America objected to possible complications and inconveniences due to a shortening of the overlap of business hours.

As the debate intensified, some objectors resorted to ridicule with Willett himself becoming the object of a great deal of derision and personal insult, being called everything from a faddist to a dangerous crank.

The triviality of some of the objections perhaps reached a peak when *'The Outlook'* (a London weekly magazine published between 1898 and 1928) drew attention to two practical difficulties which, as they saw it, "had, with vulgar persistence, protruded themselves. The person who now dines at 7.30 pm, for instance – which is, perhaps, the average dining hour of the Londoner – will then be dining at 6.10, which is preposterously early and will be altogether unfashionable. Moreover, there is one aspect which would fill London with horror. If, for instance, a man were going to a 7 o'clock dinner, under the new arrangement of daylight he would appear on the streets of London in evening dress at 5.40, which would shake the British Empire to its foundations!"

Stunted Progress

Irrespective of the various objections, however, and after meeting thirteen times and hearing testimony from forty-two witnesses, the Select Committee reported favourably to parliament on the 'Daylight Saving Bill'.

In its Special Report issued on 30 June 1908, it defined the bill's objective as 'promoting the extended use and enjoyment of daylight between the months of April and September.' In its report, the Select Committee answered many of the criticisms levelled at the bill stating, for example, that the effect on business with Europe would be small compared to the overall benefit, and that the interference with American business could be minimized without serious loss as the various parties could adapt themselves to the changes.

Furthermore, GMT would still be used for scientific purposes, so that was not an issue.

But despite this positive report from the Select Committee, the opponents of daylight saving time stalled the bill. The real problem was that it did not have the support of the Prime Minister, Herbert Asquith, who, on 8 July 1908, told parliament that his government had no intention of giving facilities for the passing of the 'Daylight Saving Bill'.

Without Asquith's backing, the bill was unable to make further progress through the House of Commons but, refusing to accept this reversal, Willett and his supporters

Photograph of William Willett, builder, outdoorsman, and inventor of daylight saving time. Handwritten below the original print is "Mr. Wm. Willett. Author of the Daylight Bills of 1908 and 1909. 1909. J. Benjamin Stone"

tried again the following year when Thomas W. Dobson introduced the '1909 Daylight Saving Bill'. The motion was seconded by Sir Henry Norman and approved for committee hearings on 5 March 1909, when a second Select Committee heard testimony from twenty-four witnesses.

But at the close of the hearing the committee again rejected the bill, this time by the margin of a single vote.

Undaunted by this second defeat, Willett continued to exert pressure and worked tirelessly to win new supporters while continuing to spend large amounts of money for the cause. He sent out hundreds of letters each year to influential people in all walks of life and published several new editions of *'The Waste of Daylight'* pamphlet, with each edition naming more people who endorsed the proposal.

Then, in 1911, Robert Pearce introduced yet another bill in parliament, again proposing daylight saving time, which was by now being called 'Summer Time' or 'Summer Season Time.' When put before parliament, however, the results of the meetings of the previous committees were given considerable weight and it did not pass.

Subsequent attempts in 1912 and 1913, again led by the indefatigable Willett, met with a similar fate and when his supporters in parliament introduced yet another 'Summer Time' bill in 1914, his 'Waste of Daylight' pamphlet was in its nineteenth edition. It included endorsements from many influential persons and institutions, including 285 members of the House of Commons, 59 members of the House of Lords, 685 City, Town and District Councils, 82 Chambers of Commerce, 59 trade unions and 438 business, political and other institutions, societies and associations.

But all of this support was unable to generate a parliamentary majority and the bill was again rejected.

While the United Kingdom continued to debate the issue, the daylight saving proposal was attracting interest around the world and at the 1914 International Congress of Chambers of Commerce in Paris, Willett gave a talk on daylight saving time to delegates from thirty-seven countries. As a result, daylight saving time bills were introduced for Australia, Canada and New Zealand and although they received some support, ultimately none was accepted.

USA retailers hailed a 1918 DST bill.

Posthumous Recognition

On 4 March 1915, William Willett died at Chislehurst at the age of fifty-eight. Since having his initial idea, he had put ten years of undiminished enthusiasm and a large portion of his personal wealth into a courageous struggle to obtain the passage through parliament of a bill to conserve daylight during a large part of the year but was never to see his revolutionary proposal come to fruition. In the face of stubborn opposition by one parliament after another, it seemed that Willett's case had been lost.

Photo by P Ingerson - The William Willett Memorial Sundial is always on DST. This monolith was designed by G.W. Miller, unveiled 1927-05-21, and is in a glade in Willett Memorial Wood in Petts Wood, London, on the edge of St Paul's Cray Common to the east of the main north-south bridle path.

But this was about to change.

On 16 February 1916, Sir Basil Petro, the MP for Devises, Wiltshire, questioned the Prime Minister, Herbert Asquith, in parliament regarding the need to conserve electricity, gas and oil for the war effort and asked "Would the Prime Minister propose legislation on the lines of the late Mr Willett's 'Daylight Saving' bill?" "No sir!" Asquith replied dismissively, "I cannot introduce legislation on this contentious subject."

Nevertheless, a mere three weeks later, on 7 March, the Prime Minister was compelled to answer more questions about daylight saving time, including a suggestion that a committee of experts be appointed to study the subject.

While the UK debated and prevaricated, Kaiser Wilhelm II's Germany took action and on 6 April 1916, the German Federal Council, operating under its emergency powers, decreed that summer daylight saving time would be instituted in Germany as a wartime measure, starting at 11 pm on Sunday 30 April 1916, when the clocks would be advanced by one hour from Germany's Central European Time and remain in effect until 1 am on Sunday 1 October, at which point the clocks would be set back by one hour.

Thus Germany, not Britain, was the first to adopt a plan for saving daylight.

Meanwhile in Britain, with the Great War intensifying, the mounting debate continued to exert pressure in parliament. This culminated in the House of Commons on 8 May 1916 when Sir Henry Norman, a daylight saving time supporter since the original bill of 1908, made a motion asking the government to introduce a 'Daylight Saving Bill.'

This was carried by 170 votes to 2, only two months after the Prime Minister had refused even to consider a daylight saving time measure, and the following day the Home Secretary, Herbert Samuel, introduced yet another 'Daylight Saving Time' bill in parliament.

On this occasion it took members less than a week to complete their deliberations and on 15 May it approved the bill which received Royal Assent two days later - on 17 May 1916 – eight years after Robert Pearce had introduced the first bill embodying Willett's ideas.

The 'Summer Time Act of 1916' established British Summer Time – called 'Willett Time' by some – for the year 1916 and authorized extensions for the duration of the war. Under the Summer Time Act, British clocks were first advanced by one hour at 2 am on Sunday 21 May 1916, only four days after final approval of the Act and just three weeks after Germany's daylight saving time period had begun, and lasted until 3am on Sunday 1 October, when the clocks were set back to 2 am GMT.

Following the end of the Great War in November 1918, although some opposition persisted, the annual use of daylight saving time became firmly established and, based on the on-going support for the measure, parliament passed the 'Summer Time Act of 1922', continuing summer time for a five month period from mid-April to mid-September.

Under the Act, however, summer time had to be re-authorized each year, but in 1925 parliament finally passed the 'Summer Time Act of 1925', making daylight saving time permanent in the United Kingdom from the night following the third Saturday in April to the night following the first Saturday in October, annually.

William Willett Remembered

In 1927, with daylight saving time now established in many parts of the world, public money was raised to purchase and preserve the forty-five acres of Petts Wood which William Willett traversed many times during his early morning horseback rides as a living memorial to Chislehurst's posthumous hero.

It was named the Willett Memorial Wood and in a clearing near to his home and the churchyard where he is buried a sundial – keeping British Summer Time – was also erected in his memory.

As is often the case, in death he had become revered – his portrait was painted; a bronze bust sculpted; in 1931 a wax figure was unveiled at Madame Tussaud's in London and a public house, 'The Daylight Inn', was named in his honour.

World War 2 and Double Summer Time

Following the end of World War 1 Britain remained on summer time but elsewhere each country that had adopted daylight saving time as a wartime measure reached its own decision as to whether or not to preserve it.

Upon the outbreak of the Second World War in 1939, however, Britain did not wait for Germany to act. Just one month after the declaration of war, Britain extended its then current summer time period by about six weeks to mid-November and, in addition, went one step further when, in October 1940, the new Home Secretary, Herbert Morrison, extended summer time throughout the following winter and continuously thereafter, thereby giving year-round daylight saving time in Britain for the duration of the war.

But it did not end there.

Beginning in the spring of 1941, in an effort to improve war production, the clocks were moved forward a *further* hour during the summer. This 'double' summer time was utilized for about three months in 1941, starting in early May, and for increasingly longer periods during each year of the war with the result that, by 1944, the double summer time period had extended to five-and-a-half months, from April through to mid-September.

Although each of the country's three extensions of summer time – first to extended summer time, then to year-round summer time and then to periods of double summer time – was generally well received by the populace, the government acknowledged the particular difficulties encountered by farmers, and during periods of double summer time farms were permitted to remain on single summer time if the farmers and their farm workers wished.

The Post-War Years

When World War 2 ended, some countries immediately abandoned daylight saving time while others retained it. Britain revoked many of its wartime laws, including year-round daylight saving time in the summer, and returned to the pre-war summer time.

But in 1947, a fuel crisis led the government to extend daylight saving time again and Britain employed extended summer time *plus* double summer time for one year. Then, in 1948, with the fuel crisis over, the country reverted to regular summer time, a policy which continued for the next twenty years.

By the late 1960s, however, Britain and Italy were the only countries in Western Europe that continued to use daylight saving time. Consequently, when 'Summer Time' was in effect, the United Kingdom's time agreed with most of Europe's, but it fell one hour behind in winter, a situation which many business leaders felt put them at a competitive disadvantage and others felt went against the spirit of pan-Europeanism at a time when Britain was contemplating entry into the European Common Market.

As a result, in 1968, and despite significant opposition, the Labour government led by Prime Minister Harold Wilson, agreed a three-year experiment called 'British Standard Time', which extended summer time for the entire year and brought the time in Britain in line with most of Europe which used Central European Time. As the experiment proceeded, however, opposition continued to mount and in 1970, prior to parliament's end-of-year vote on whether to retain it, the Home Office and Scottish Office issued a 'Review of British Standard Time'.

The report found that in mid-winter 50% of the population favoured British Standard Time against 41% who preferred GMT, with the remaining 9% undecided. But these results did not sway the mood in parliament which had become strongly opposed to extending British Standard Time and in December 1970 the House of Commons voted overwhelmingly, by 336 votes to 81, to discontinue British Standard Time, amid loud cheers when the result was announced.

To re-establish daylight saving time for the following summer, parliament passed the 'Summer Time Act of 1972'. It contained a complex new definition of the summer time interval as, "The period beginning at 2 o'clock, GMT, in the morning of the day after the third Saturday in March or, if that day is Easter Day, the day after the second Saturday in March, and ending at 2 o'clock, GMT, in the morning of the day after the fourth Saturday in October.'

Shepherd gate clock at the Royal Observatory, Greenwich

The great forethought that was put into this definition may begin to be appreciated when one realises that the third Sunday in March will not be the day before Easter Day until the year 2285!

The 1972 Act made provision for the duration of British Summer Time to be varied, if required, by Order of Council, and since 1980 various alterations have taken place to bring the periods of summer time in line with those which were, by then, being used throughout Europe.

Europe Intervenes

In 1980, the 1st 'European Council Directive on Summer Time' stipulated common 'start' dates only for the duration of the summer time periods, no agreement having been reached on common 'end' dates. It specified an advance of sixty minutes during summer time and a common start time of 1 am GMT on the last Sunday in March. In the United Kingdom, the 'Summer Time Order of 1980', implemented under the 'Summer Time Act of 1972', applied both these variations to the previous rules, thereby complying with the European Directive whilst retaining the basis for determining the end dates.

The alteration of the times at which the clocks were now to change in the United Kingdom, namely, to 1 am from 2 am used prior to 1981, was inconsequential since the changes in March and October are, of course, *from* GMT to BST and *from* BST to GMT, respectively. Hence, the changes are from 1 am GMT to 2 am BST in March and from 2 am BST to 1 am GMT in October, rather than from 2 to 3 and 3 back to 2 , as was previously the case.

The 'Summer Time Order of 1994' subsequently implemented revised 'end' dates of the last Sunday in October to comply with the 7th 'European Council Directive of 1994', and it is of interest that in 1997 the summer period of daylight saving time commenced on Easter Day – an occurrence coming only 25 years into the 313 year period which the drafting of the 1972 Act was so careful to avoid!

The 9th 'European Council Directive on Summer Time of 2001' placed the common dates for the duration of 'Summer Time' on a permanent footing. It ratified the common start time, from 2002 onwards, of 1 am GMT on the last Sunday in March, and specified a common end time, also from 2002 onwards, of 1 am GMT on the last Sunday in October.

The 'Summer Time Order of 2002', under the 'European Communities Act, 1972', implemented the 9th 'European Council Directive of 2001' by amending the 'Summer Time Act of 1972'. It removed the power to vary the period of 'Summer Time' or to provide for 'Double Summer Time' by Order of Council and changed the rules to agree with European Directives on a permanent basis.

The Future

Yet the possibility of changing the United Kingdom's summer time policy remains a live issue and is the subject of continuing debate. Rightly or wrongly, many adherents of 'global warming' as well as those in favour of longer periods of daylight generally, continue to question why the entire country should suffer dark evenings just to keep some farmers happy, particularly those in Scotland, whilst others view 'British Summer Time' from a purely patriotic perspective.

As Sir Patrick Herbert said in the House of Commons in 1947, "Surely, this country should be the last to abandon Greenwich Mean Time . . . . it is one of the great glories of this country that all nations have agreed that Greenwich and Greenwich Mean Time shall be the centre of all astronomy and navigation – that is a thing we *must not* throw away. Let the Empire go – if you must – but cling fast to the Prime Meridian!"

But that was in 1947.

In the intervening period GMT has been superseded by Co-ordinated Universal Time (UTC), introduced on 1 January 1972. Derived from International Atomic Time (TAI), UTC necessitates the occasional insertion of a 'Leap Second' to keep the scale close to GMT with time being reckoned from midnight (0000 hours) rather than from noon (1200 hours). Legislation following our membership of the European Union has, as we have seen, changed not only the dates we change our clocks but the times at which the changes are effected, with BST now being identical to Western European Time.

Even our sacred line of longitude was moved eastwards a total distance of 336.53 (102.6) metres in 1984 from the official Greenwich Meridian set by international agreement in 1884 due to the meridians used by Global Positioning Satellites. The 1984 WGS84 grid used by the world GPS

system and another European grid, known as ETRF89, which were defined as being identical in 1989, became the global standard for air navigation on 1 January 1998.

Consequently, logic dictates that the traditional brass marker established by the Astronomer Royal Sir George Biddell Airy in 1881 and adopted internationally in 1884 should now be replaced by another 336.53 feet to the east and running along the GPS meridian. The Royal Observatory is unrelenting, however, and maintains Airy's line to be 'the most internationally recognised' meridian - even if it is (now) in the wrong place!

And, furthermore, English nationalists and those sceptics who are, and will always remain, suspicious of English/French entente cordiale, will point to the 1884 International Conference in which the French refused outright to accept the Greenwich meridian, agreed by the rest of the world by a majority vote of 22 to 1 with two abstentions, and object to the line being moved one nanometre towards Paris – whilst at the same time choosing to ignore the fact that this is the city which now hosts the International Earth Rotation Service responsible for controlling the time used by the Global Positioning System and, indirectly, GMT!

(Additional images courtesy Wiki Commons)

Author

Les Miller is a chartered mathematician and engineer, formerly specialising in the design of building services installations.

During a career spanning almost 50 years, he has won a number of regional and national awards for energy efficient design and energy conservation and contributed numerous engineering and research papers, principally in the fields of heat transfer and fluid mechanics, to various scientific, technical and professional bodies over a period of in excess of 40 years. He is also the author of 'The Students Textbook of Heating, Ventilating and Air Conditioning' and his design for the ventilation system for a swimming pool was the subject of the Department of Energy 'Good Practice Case Study 219' in 1994. He is a Freeman of the City of London and lives in Ipswich.

Time zones of Europe:

blue	Western European Time (UTC+0) Western European Summer Time (UTC+01:00)
light blue	Western European Time (UTC+0)
red	Central European Time (UTC+01:00) Central European Summer Time (UTC+02:00)
yellow	Eastern European Time (UTC+02:00) Eastern European Summer Time (UTC+03:00)
orange	Kaliningrad Time (UTC+03:00)
green	Moscow Time (UTC+04:00)

References.

(1) 'Daylight Saving in Ancient Rome' by B. L. Ullman.
The Classical Journal, 13 (6): 450 – 451.

(2) Benjamin Franklin, writing anonymously, 26 April, 1784.
Aux auteurs du Journal – Journal de Paris (117).

(3) 'On Seasonal Time-Adjustment in countries South of Latitude 30' by G. V. Hudson.
Transactions and Proceedings of the New Zealand Institute, 1895; (28); 734.

(4) 'On Seasonal Time' by G. V. Hudson.
Transactions and Proceedings of the New Zealand Institute, 1898; (31); 577 -588.

(5) 'The Waste of Daylight' by William Willett, F.R.A.S.
Published privately by the author, 1907, with further editions thereafter.

Further Reading.

'Saving the Daylight' by David Prerau.
Published by Granta Books, London, 2005.

'Time Lord - Sir Sandford Fleming and the Creation of Standard Time'
by Clark Blaise.
Published by Pantheon Books, New York, 2000.

'Longitude' by Dava Sobel.
Published by Fourth Estate, London, 1995.

Clinical laboratory haematology applied to Tilapia farming

David Conroy, Gina Conroy & Carlos Conroy

Introduction

The farming of tilapias (which are sometimes known popularly – though rather incorrectly – as "St. Peter's Fish") currently occupies third place among all types of productive freshwater fish farming worldwide as a source of food for human consumption. Tilapias are often referred to as 'aquatic chicken', because of the relative ease with which they can be farmed in a wide variety of suitable tropical, sub-tropical and temperate aquatic environments (Coward & Little, 2001). Fitzsimmons (2006), and Fitzsimmons & González (2006), reported a global production of slightly more than 2 million metric tonnes of tilapias in the year 2005, and estimated that this figure could rise to 3 million metric tonnes by the year 2010. Of that total, 11.5% is produced in the Western Hemisphere, where the fastest growing tilapia farming operations are located in Brazil - which accounts for 44% of the production in that Hemisphere (Alston, 2006). Various species of tilapias and their hybrids lend themselves to farming on a monoculture or a polyculture basis in extensive, semi-intensive or intensive systems of production, which include earth ponds, more traditional raceways, pens and floating cages in fresh, brackish and coastal sea water sites. The activity presently incorporates the use of commercially available pelleted feeds, aeration, water filtration and recirculation systems, bioflocs, pre- and probiotics, vaccines, and other sophisticated procedures to enhance production (Watanabe *et al.*, 2002).

Pond reared tilapia

The present article is intended to make a very general overview as to how routine haematological techniques can be of practical utility in tilapìa farming operations, as an aid to monitoring the nutritional, physiological and pathological status of the fish, thereby enabling the implementation of suitable corrective or preventive measures on the tilapia farm or production site.

Haematology can be briefly defined as the study of blood and its composition, functions and nature, as well as its performance when subjected to diseases and/or to other abnormal conditions. Blood is basically a liquid in which the various cellular elements are suspended in an isotonic plasma. Its principal functions include the transport of oxygen from the gills to the various organs and tissues of the body, as well as the transport of carbon dioxide from those sites to the gills. Furthermore, blood is the vehicle for the transport of hormones, nutrients and waste products, in addition to serving in the protection of the body against infectious diseases. One of its practical advantages is the relative facility with which samples can be obtained for analysis in the laboratory. By definition, therefore, clinical haematology refers to those laboratory procedures which help in the establishment of the diagnosis of any changes or dyscrasias which may manifest themselves in the blood picture. Campbell (1988), and Campbell & Murra (1990), have published practical guidelines to the use of fish haematology in clinical practice.

From the historical point of view, interest in the blood cells of fish, reptiles and other lower vertebrates developed in the 19th century (Gulliver, 1840, 1842, 1872, 1875; Mandl, 1839: Milne-Edwards, 1856). Since then, further research has been undertaken on the haematology of vertebrate species under culture and from the wild. Sources of reference are available, for example, on the haematology of amphibians, birds and reptiles (Campbell, 1988a; Duguy, 1970; Frye, 1993; Lucas & Jamroz, 1961; Pienaar, 1962; Saint Girons, 1970, 1970a; Thrall, 2004). Hawkey & Donnett (1989) published a very useful comparative atlas on veterinary haematology, which includes valuable information on the blood of various species of amphibians, birds, fish and reptiles.

Now that tilapia farming has become such an important economic and productive activity, an increasing number of papers dealing with basic and applied aspects of the haematology of those fish is available. These include the publications by Azevedo et al. (2006), Badawi & Said (1971), Benli & Yildiz (2004), Bittencourt et al. (2003), Conroy (2000), Conroy & Conroy (2007, 2007a), Doggett et al. (1987), Ezzat et al. (1974), Gabriel et al. (2007), Hattingh (1972), Hrubec et al. (2000), López (1984), McNulty et al. (2003), Martins et al. (2004), Nulsey et al.(1995), Oladimeji et al. (1988), Omeregie & Oyebanji (2002), Ranzani-Paiva et al. (2004), Sahan & Duman (2010), Silva et al. (2009), Silveira et al. (1996), Silveira-Coffigny et al. (2004, 2005), Tavares-Dias & Faustino (1998), Tavares-Dias & Moraes (2002, 2003), Tavares-Dias et al. (2000, 2002), Ueda et al. (1997, 2001), Verdegem et al. (1997), and Witten *et al*. (1998). These publications are recommended for consultation by all of those with a particular interest in the topic.

The haematological examination of tilapias

A complete haematological study of tilapias, as is also the case with other farmed fish species, is usually based on a small sample of blood taken from the caudal vein, from the heart, or by severing the caudal peduncle in small fish. Extractions of blood from the heart, and by severing the caudal peduncle, are lethal sampling procedures. When taken from the caudal vein, however, the sample can be obtained by an experienced operator in a non-lethal manner during routine weighing and measuring operations effected with the fish. Because fish blood tends to coagulate very rapidly, an anticoagulant (e.g. heparin sodium salt) must be used to obtain the sample.

The basic haematological tests which are undertaken include the determination of the haematocrit level, the haemoglobin content, the red and white blood cell counts, and the microscopical examination of thin blood smears stained by the Giemsa (or Leishman or Wright) techniques. The corresponding parameters, and the haematological indices calculated from those data, are generally expressed in the following manner:

(a) Haematocrit = Ht%

(b) Haemoglobin = Hb gm/100 ml

(c) Red blood cell count = rbc X $10^6/mm^3$

(d) White blood cell count = wbc X $10^3/mm^3$

(e) Mean corpuscular volume = MCV μm^3

(f) Mean corpuscular haemoglobin = MCH $\mu\mu g$

(g) Mean corpuscular haemoglobin concentration = MCHC %

The microscopical examination of a stained blood smear is of particular importance, and is often referred to as the haemogram. The haemogram *sensu stricto* consists of two fundamental and complementary aspects, the erythrogram and the leucogram, which are defined as:

(a) Erythrogram: a differential count of the normal and abnormal erythrocytes, to detect any qualitative or quantitative changes in the shape and size of those cells, and any obvious slight, moderate or marked hypochromia in the cytoplasm.

(b) Leucogram: also known as a differential white blood cell count, the leucogram includes the qualitative and quantitative distribution of the leucocytes in the blood smear, and their morphological identification.

For reference purposes, it must be remembered that in teleost fish the process of blood formation takes place primarily in the haematopoietic tissues of the anterior and mid-kidney, and in the spleen, **NOT** in the bone marrow. For that reason, the blood of fish is correctly defined as being of lymphoid, rather than of myeloid, origin. This fact has given rise to much confusion in the nomenclature of fish leucocytes, certain of which are described on a basis of an apparent morphological similarity to truly myeloid leucocytes as found in mammals. The "lymphoid" and the "myeloid" leucocytes in fish blood can be differentiated by means of the Sato & Sekiya (1926) staining technique, which enables them to be identified as peroxidase-positive granulocytes and peroxidase-negative agranulocytes. In turn, the peroxidase-positive granulocytes can be conveniently sub-classified into "fine granular granulocytes" (neutrophils) and "coarse granular granulocytes" (basophils, eosinophils), in accordance with their appearance in Giemsa-stained blood smears. The fine granules of the neutrophils stain a neutral colour, whereas the coarse granules of the basophils and eosinophils stain purplish-blue and reddish-pink, respectively. The nucleus of the neutrophils is usually central, and may have the appearance of a ribbon, a band, or be segmented into lobules (usually not more than 2 nuclear lobules in tilapias). The nuclei of the basophils and the eosinophils are generally excentric in their location within the cell. Conroy & Conroy (2007) have prepared a comprehensive atlas which describes and illustrates the various types of normal and abnormal blood cells which might be detected in smears of the peripheral blood of tilapias.

Interpretation and significance of haematological findings in tilapias

To better understand the significance of the haematological findings from tilapias, and to be in a position to interpret the situation as "normal" or "abnormal", the concept of anaemia needs to

be defined. This term basically signifies any loss of a normal balance between the production and the destruction of erythrocytes in the blood. An anaemia may be due to a reduction in the normal volume of the blood (oligaemia) - as might occur after a severe haemorrhage - a reduction in the numbers of circulating erythrocytes (oligocytaemia) and/or a reduction in the haemoglobin content (oligochromaemia).

Fish anaemias can be classified on a basis of the numbers, shape and haemoglobin content of the erythrocytes, as "responsive" (= "regenerative") and "non-responsive" (Ferguson, 1989). On examination of a stained blood smear, the anaemias can be reported as "normocytic" (when the erythrocytes have the normal size for the species), "macrocytic" (when the erythrocytes are larger than the normal for the species) or "microcytic" (when the erythrocytes are smaller than the normal for the species). With respect to the haemoglobin content, a greater pallor in the erythrocytic cytoplasm is interpreted as "hypochromia", to differentiate it from the normal colour ("normochromia"). It is therefore possible to report a "macrocytic normochromic anaemia", a "microcytic hypochromic anaemia", etc.

A "hypoplastic" (= defective development) anaemia" may be due to a failure in the synthesis of haemoglobin, or one in which the production of erythrocytes is defective. In turn, a "haemolytic anaemia" can be caused by the presence of certain toxic substances in the aquatic environment, or to the action of haemolysins produced by some common bacterial fish pathogens (e.g. *Aeromonas* and *Vibrio* spp.). Haemolysis leads to the destruction of the erythrocytes and the resulting release of haemoglobin into the plasma (something which can be detected on reading the haematocrit and by examination of a stained blood smear). Except when the haematopoietic tissues themselves are destroyed, most anaemias are "responsive". Evidence of increased numbers of polychromatocytes (which correspond to the reticulocytes of mammals) and other immature erythrocytes in the blood is a condition known as "polycythaemia", and may also be characterised by an increase in the haematocrit and haemoglobin levels, as well as by a slight decline in the haematological indices (MCV, MCH, MCHC). Where there is a haemoconcentration, due to the loss of water, other body fluids or plasma, the condition is termed a "secondary polycythaemia" (due to contraction of the spleen, and the liberation of erythrocytes into the peripheral blood).

On attempting to interpret the "blood picture" of tilapias, it is of the utmost importance that the findings be analysed with reference to the phase of growth, degree of maturity, sex, population density, type of food etc., as well as the physico-chemical parameters (e.g. pH, temperature, dissolved oxygen and carbon dioxide, water hardness, salinity, ammonia, nitrates/ nitrites) of the aquatic environment in which the fish are being farmed. It is not feasible to speak of "absolute values" for the blood parameters of fish species, but rather to consider the "range of values" which might be accepted as normal for the corresponding species under culture at a particular population density and in a specific type of aquatic environment. As examples, López (1984) undertook haematological studies of Mozambique tilapias *(Oreochromis mossambicus)* and Nile tilapias (O. *niloticus*) farmed in ponds and in pens in the Philippines, and Hrubec et al. (2000) established reference intervals for tilapia hybrids (O. *niloticus* X O. *mossambicus* X O. *aureus*) raised under highly intensive conditions in the USA. The data reported by these workers are summarised here in **TABLE 1**.

TABLE 1. Haematological reference intervals for species/hybrids of farmed tilapias (Hrubec *et al.*, 2000; López, 1984).

haematological parameter	Mozambique tilapia (*O. mossambicus*) (1)	Nile tilapia (*O. niloticus*) (2)	Tilapia hybrid (*O. niloticus* X *O. mossambicus* X *O. aureus*) (3)
haematocrit (%)	37.1 (28.3 - 36.6)	32.7 (21.9 - 43.3)	33 (27 - 37)
haemoglobin (gm/100 ml)	-	-	8.2 (7.0 - 9.8)
erythrocyte count (X 106/mm3)	3.07 (1.96 – 3.97)	2.51 (1.89 – 3.09)	2.31 (1.91 – 2.85)
leucocyte count (X 103/mm3)	21.0 (4.4 – 54.3)	18.0 (4.1 – 49.4)	7.56 (2.15 – 15.41)
MCV (u3)	-	-	135.7 (115 – 183)
MCH (%)	-	-	34.4 (28.3 – 42.3)
MCHC (uug)	-	-	25.7 (22 – 29)

(1) López (1984): farmed in ponds. Water temperature = 28 – 31°C; dissolved oxygen = 1.9 – 6.2 ppm; CaCO3 hardness = 17.5 – 25.1 ppm; S = 0.4 – 3.6‰

(2) López (1984): farmed in pens. Water temperature = 28 – 33°C; dissolved oxygen = 2.1 – 8.5 ppm; CaCO3 hardness = 26.8 – 43.1 ppm; S = 5.8 – 36.5‰.

(3) Hrubec *et al.* (2000): farmed in intensive recirculation conditions. Water temperature = 29.8°C; pH = 7.4; dissolved oxygen = 9.4 ppm; total hardness = 281.0 ppm; nitrites = 0.36 ppm

Correctly interpreted, the results of the haematological laboratory tests can be of great practical importance in tilapia farming operations. They enable the nutritional, physiological and pathological conditions of the fish to be monitored on a permanent and routine basis, thus making it possible to "correct errors" or to implement suitable control and prevention measures, as may be necessary. Graff & Zinkl (1999) prepared a very useful table which indicates the qualitative and quantitative effects of a number of extrinsic and intrinsic factors on the blood picture of the carp *(Cyprinus carpio)* and the goldfish *(Carassius auratus)*. Because that information applies just as easily to tilapias, the data are reproduced here in **TABLE 2.**

TABLE 2. Qualitative effects of certain extrinsic and intrinsic factors on the haematological parameters of carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*), which are also applicable to farmed tilapias (Groff & Zinkl, 1999; PRESENT AUTHORS)

parameter	raised value	reduced value
haematocrit, haemoglobin, erythrocyte count	haemoconcentration; males; mature fish; severe hypoxia; stress; water T°C increase	haemodilution; females; young fish; haemolysis; nutritional deficiency anaemia; starvation; infectious disease; toxicity
metahaemoglobin	low water T°C; nitrite toxicity	
MCV	immature erythrocytes; prolonged or undue retention in the body; stress	mature erythrocytes
mature erythrocytes	constant water T°C increase	
immature, dividing or degenerative erythrocytes	cyclical T°C changes; hypoxia; "responsive" anaemia	"non-responsive" anaemia
leucocytes	water T°C increase; infectious diseases	infection with *Aeromonas* and *Vibrio* spp.; stress
granulocytes	water T°C increase; infectious diseases	infection with *Aeromonas* and *Vibrio* spp.
lymphocytes	water T°C increase	water T°C decrease; infectious diseases
monocytes	infectious diseases; stress	
thrombocytes	water T°C increase; stress	stress

As much in tilapias as in many other farmed fish species, clinical haematology has proved to be of exceptional utility in the detection of certain problems associated with nutritional deficiencies and toxic conditions, something to which the present authors can bear witness. Tacon (1992) reviewed the haematological findings with reference to such problems in farmed fish in general, and Lim & Webster (2006) have mentioned the principal haematological manifestations of these problems in blue tilapia (*Oreochromis aureus*), Mozambique tilapia (O. *mossambicus*), Nile tilapia (O. *niloticus*), O. *spilurus*, and in certain tilapia hybrids (e.g. O. *mossambicus* X O. *niloticus*; O. *niloticus* X O. *aureus*). The information is given here in **TABLE 3.**

In tilapias, it has been possible to appreciate the importance of folic acid and vitamin B12 in the diet. As occurs with salmon and trout (Kawatsu, 1975; Smith, 1968), a deficiency of dietary folic acid becomes manifest in tilapias by the presence of numerous erythroplastids (which are anucleate) and erythrocytes whose nuclei are in division ("fragmentation" or "segmentation"). It is known that folic acid and vitamin B12 play a complementary rôle between each other, and are related to the maturation of erythrocytes and the synthesis of haemoglobin. A deficiency of folic acid produces a macrocytic normochromic anaemia, whereas a deficiency of vitamin B12 produces a macrocytic or a microcytic normochromic anaemia.

On considering the possible causes of vitamin deficiency anaemias in tilapias, it is important to remember that the uncontrolled (and unwarranted) administration of antimicrobial substances together with the feed can often be counterproductive in practice. Such antimicrobial compounds may exercise a negative effect on the microflora present in the intestinal tract of herbivorous/omnivorous fish which contributes to the synthesis of folic acid and vitamin B12 (and possibly of biotin and thiamine as well) under natural conditions (Lowell & Limsuwan, 1982: Sugita et al., 1990, 1991).

The effects of aflatoxins present in commercial feeds administered to tetrahybrid red tilapias (O. *mossambicus* X O. *urolepis hornorum* X O. *niloticus* X O. *aureus*) farmed in Venezuela have been reported by Conroy (2000). Two such feeds were evaluated, of which the first had total aflatoxin levels of 3.78 – 6.6 ppb, and the second had total aflatoxin levels of 7.1 – 14.25 ppb. Both were used over a 135-day period on an operating tilapia farm. The haematocrit levels were low for both feeds, and increased numbers of microcytes and poikilocytes were present after 95 and 135 days of the trials. In the case of "Feed A", hypochromia became evident at an earlier stage (55 days) than in the case of "Feed B".

Another type of problem is the toxaemia induced by nitrites in the water. Nitrites oxidise haemoglobin and transform it into metahaemoglobin (MetHb), which latter cannot transport oxygen in an effective manner. The result is hypoxia in the tissues which are deprived on oxygen. Although nitrite toxicity appears to be less in salt water (S = 32.5°/oo) than in freshwater, Palacheck & Tomasso (1984: cited by Vinatea Arana, 2004) reported that in fresh waters with a temperature of 23°C, a pH of 7.9 and a CaCO3 hardness of 190 ppm, the LC50 at 96 hours was 16.00 ppm of nitrites in the case of the Nile tilapia (*Oreochromis niloticus*). When metahaemoglobinaemia occurs, the blood acquires a brownish colour where the MetHb concentration is greater than 25%. When the MetHb concentration increases to 40% or more, the blood becomes chocolate brown in colour (a condition described as "chocolate blood"). The present authors have observed this phenomenon in tilapias farmed in waters with high nitrite concentrations, for which reason it is essential to include measurements of the nitrite levels in all routine physico-chemical tests which are undertaken with the water.

TABLE 3. Haematological manifestations of dietary deficiencies and toxic substances in farmed tilapias and other fish species (Lim & Webster, 2006; Tacon, 1992)

deficiency/condition	haematological effects
essential fatty acid	reduction in haemoglobin level and MCV
iron	impaired erythropoiesis (*); microcytic hypochromic anaemia (*)
vitamin B1 (thiamine)	reduction in haematocrit and erythrocyte count (*)
vitamin B2 (riboflavine)	"anaemia" (not further defined)
vitamin B6 (pyridoxine)	microcytic hypochromic anaemia
vitamin B12 (cyanocobalamin)	macrocytic or microcytic hypochromic anaemia; reduction in haematocrit; presence of erythrocytes with nuclear fragmentation or segmentation (*)
vitamin C (ascorbic acid)	macrocytic or normocytic hypochromic anaemia (*)
vitamin D2 (cholecalciferol)	reduction in haemoglobin level (*)
vitamin E (alpha-tocopherol)	"anaemia" (not further defined); increased erythrocyte fragility (*); impaired erythropoiesis (*)
vitamin K3 (menadione)	"anaemia" (not further defined) (*); increased blood coagulation time (*)
folic acid	macrocytic normochromic anaemia (*); reduction in haematocrit and erythrocyte count (*)
pantothenic acid	"anaemia" (not further defined) (*)
presence of aflatoxins	"anaemia" (not further defined); reduction in haematocrit, haemoglobin level and erythrocyte count; impairment of blood coagulation

(*): confirmed in farmed species/hybrids of tilapias

Quite obviously, a careful microscopical examination of stained blood smears would reveal the presence of any patent bacteraemia (either bacteria free in the blood, or ingested by phagocytes) and/or parasitaemia (e.g. extracellular haemoflagellates or intracellular haemogregarines). In the case of a bacteraemia, samples should always be taken for microbiological studies, so as to isolate and identify the bacterium detected. The careful interpretation of a haemogram (and more specifically of a leucogram) is of great importance in the study of microbial diseases in tilapias which produce clinical signs of granulomatosis (e.g. francisellosis, mycobacteriosis, streptococcosis). A good example of that is provided by Ranzani-Paiva et al. (2004), who monitored the progress of *Mycobacterium marinum* following its experimental injection into Nile tilapias (*Oreochromis niloticus*). The infection produced an important effect on the kidney and the spleen, as shown by an initial discrete microcytic hypochromic anaemia and a moderate lymphocytosis. On the third day post-infection, an increase in the numbers of monocytes in the blood was detected, many of which had vacuoles in the cytoplasm (= macrophages). Ranzani-Paiva et al. concluded that the blood picture had exhibited changes characteristic of an initial inflammatory reaction, which later became transformed into a typically chronic infection manifested by granulomatosis. The principal disease problems detected and reported to date in farmed tilapias have been extensively reviewed and illustrated by Conroy & Conroy (2008).

Tilapias are truly delicious and wholesome to eat, and their retail prices place them well within the range of most pockets. As was so nicely phrased by Coward & Little (2001): "The tilapiine's ability to resist disease and grow fast under high density conditions adds to its reputation as an 'aquatic chicken', as does the quality of its boneless fillets which are firm, white and without a strong flavour". Tilapia farming is a yet another good example of how the application of science and technology can contribute to alleviating the increasingly more pressing demands for food in the modern world, and serves to illustrate how close cooperation between people working at the laboratory bench and people working in the field can be of great benefit to all concerned. Those who may still be unaware of, or unfamiliar with, the many gastronomic delights associated with farmed tilapias, are recommended to try them to confirm that "the proof of the pudding is in the eating thereof". The culinary photos may provide some encouraging and enlightening 'food for thought' in that direction…..

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References

Alston, D. E. 2006. Global outlook for tilapia culture with emphasis on Latin America. Proc. 7th. International Symposium on Tilapia in Aquaculture (Editors: W. M. Contreras-Sánchez & K. Fitzsimmons). Boca del Río, Veracruz, Mexico: 3 – 11.

Azevedo, T. M. P., M. L. Martins, F. R. Bozzo & F. R. Moraes. 2006. Haematological and gill responses in parasitized tilapias from Valley of Tijacas, S.C., Brazil. Sci. Agric., Piracicaba, Brazil 63: 115 – 120.

Balawi, H. K. & M. M. Said. 1971. A comparative study of the blood of four tilapia species (Pisces). Mar. Biol. (Berlin) 8: 202 – 204.

Benli, A. C.K. & H. Y. Yildiz. 2004. Blood parameters in Nile tilapia (*Oreochromis niloticus* L.) spontaneously infected with *Edwardsiella tarda*. Aquacult. Res. 35: 1388 – 1390.

Bittencourt, N. L. R., M. Molinari, D. O. Scoaris, R. B. Pedroso, C. V. Nakamura, T. Ueda-Nakamura, B. A. de Abreu Filho & B. P. Dias Filho. 2003. Haematological and biochemical values for Nile tilapia, *Oreochromis niloticus*, cultured in semi-intensive system. Acta Scientiarum: Biol. Sci. (Maringá, Brazil) 25: 385 – 389.

Campbell, T. W. 1988. Fish cytology and hematology. Vet. Clin. North America: Small Animal Practice (Tropical Fish Medicine) 18: 349 – 364.

Campbell, T. W. 1988a. Avian Hematology and Cytology. Iowa State University Press, Ames, Iowa, USA.

Campbell, T. W. 2004. Hematology of Lower Vertebrates. 55th. Ann. Meet. Am. Coll. Vet. Pathol/39th. An. Meet. Am. Soc. Clin. Pathol., Middleton, Wisconsin, USA (available on www.ivis.com).

Campbell, T. & F. Murra. 1990. An introduction to fish hematology. Compendium on Continuing Education for the Practising Veterinarian, Small Animal Practice 12: 525 – 533.

Conroy, G. 2000. Manual Aflatoxicosis de la Tilapia: Alteraciones asociadas con dos alimentos comerciales en tetrahíbridos de tilapia roja cultivados en Venezuela. Asociación Americana de Soya (ASA)/United Soybean Board (USB), Caracas, Venezuela: 36 pp.

Conroy, D. A. & G. Conroy. 2007. Basic Atlas of Normal and Abnormal Blood Cells in Farmed Tilapias/Atlas Básico de las Células Sanguíneas Normales y Anormales en Tilapias Cultivadas. Paterson Peddie Consulting Ltd., Carrickfergus, UK: CD-ROM.

Conroy, G. & D. A. Conroy. 2007a. Haematology as a tool to assess farmed tilapia health. Aquaculture Health International (8): 29 – 31.

Conroy, G. & D. A. Conroy. 2008. Important Infectious and Parasitic Diseases of Farmed Tilapias/Importantes Enfermedades Infecciosas y Parasitarias de Tilapias Cultivadas. Schering-Plough Ltd., Saffron Walden, UK: CD-ROM.

Coward, K. & D. C.Little. 2001. Culture of the 'aquatic chicken'. Present concerns and future prospects. Biologist 48: 12 – 16.

Doggett, T. A., A. B. Wrathnell & J. E. Harris. A cytochemical and light microscopical study of the peripheral blood leucocytes of *Oreochromis mossambicus*, Cichlidae. J. Fish Biol. 31: 147 – 153.

Duguy, R. 1970. Le sang des Reptiles. **IN**: "Traité de Zoologie" (Editor: P-P. Grassé), Masson et Cie., Paris, France. Tome XIV: Reptiles. Caractères généraux et anatomie. (Fascicule II): 474 – 498.

Ezzatt, A. A., M. B. Shabana & A. M. Farghaly. 1974. Studies on the blood characteristics of *Tilapia zillii* (Gervais). J. Fish Biol. **6**: 1 – 12.

Ferguson, H. W. 1989. Systemic Pathology of Fish. A Text and Atlas of Comparative Tissue Responses in Diseases of Teleosts. Iowa State University Press, Ames, Iowa, USA. 1st. edition: 263 pp.

Fitzsimmons, K. 2006. Prospect and potential for global production. **IN**: "Tilapia. Biology, Culture and Nutrition" (Editors: C. E. Lim & C. D. Webster). Food Products Press, The Haworth Press Inc., Binghamton, NY, USA: 51 – 72.

Fitzsimmons, K. & P. González. 2006. Future expansion of global supplies and markets for tilapia products – 2006. Proc. 7th. International Symposium on Tilapia in Aquaculture (Editors: W. M. Contreras-Sánchez & K. Fitzsimmons). Boca del Río, Veracruz, Mexico: 312 – 319.

Frye, F. L. 1993. Hematology of captive reptiles. **IN**: "Zoo and Wildlife Medicine" (Editor: M. E. Fowler). W. B. Saunders Company, Philadelphia, USA. 2nd. Edition: 181 – 184.

Gabriel, U. U., P. E. Anyanwu & A. O. Akinrotimi. 2007. Blood characteristics associated with confinement in black chin tilapia *Sarotherodon melanotheron*. J. Fish. Int. **2**: 186 – 189.

Groff, J. M. & J. G. Zinkl. 1999. Hematology and clinical chemistry of cyprinid fish. Common carp and goldfish. Vet. Clin. North America: Exotic Animal Practice (Clinical Pathology and Sample Collection) 2: 741 – 776.

Gulliver, G. 1840. On the blood corpuscles of the Crocodilia. Proc. Zool. Soc. Lond. 8: 131 – 133.

Gulliver, G. 1842. On the blood corpuscles of the British ophidians, reptiles and other viviparous vertebrates. Proc. Zool. Soc. Lond. 10: 108 – 111.

Gulliver, G. 1872. On the size of the red corpuscles of the blood of Samonidae and some other vertebrates. Proc. Zool. Soc. Lond. 1872: 833 – 836.

Gulliver, G. 1875. Observations on the sizes and shapes of the red corpuscles of the blood of Vertebrates, with drawings of them to a uniform scale, and extended and revised tables of measurements. Proc. Zool. Soc. Lond. 1875: 474 – 495.

Hattingh, J. 1972. Observations on the blood physiology of five South African freshwater fish. J. Fish Biol. 4: 555 – 563.

Hawkey, C. M. & T. B. Dennet. 1989. Colour Atlas of Comparative Veterinary Haematology. Wolfe Medical Publications, London, UK.

Hrubec, T. C., J. L. Cardinale & S. A. Smith. 2000. Hematology and plasma chemistry reference intervals for cultured tilapia (*Oreochromis* hybrid). Vet. Clin. Pathol. 29: 7 – 12.

Kawatsu, H. 1975. Folic acid anemia in brook trout. Bull. Freshwater Fish. Res. Lab. 25: 21 – 30.

Lim, C. E. & C. D. Webster. 2006. Nutritional requirements. **IN**: "Tilapia. Biology, Culture and Nutrition" (Editors: C. E. Lim & C. D. Webster). Food Products Press, The Haworth Press Inc., Binhamton, NY, USA: 409 – 501.

López, N. C. 1984. Blood values of some aquacultured fish in the Philippines. Typewritten manuscript report prepared as part of a Dissertation for the degree of PhD, University of the Philippines, Quezon City, Philippines. 19 pp. + Tables and photographs.

Lowell, R. T. & T. Limsuwan. 1982. Intestinal synthesis and dietary nonessentiality of vitamin B12 for *Tilapia nilotica*. Trans. Am. Fish. Soc. 111: 485 – 490.

Lucas, A. M. & C. Jamroz. 1961. Atlas of Avian Hematology. US Department of Agriculture, Washington DC, USA. Monograph (3): 116 pp.

Mandl, I. 1839. Note sur les globules sanguins du protée et des crocodiliens. Ann. Sci. nat. (2) 12: 289 – 291.

Martins, M. L., F. Pilarsky, E. M. Onaka, D. T. Nomura, J. Fenerick, K. Ribeiro, D. M. Y. Miyazaki, M. P. Castro & E. B. Malheiros. 2004. Hematologia e resposta inflamatoria aguda em *Oreochromis niloticus* (Osteichthyes: Cichlidae) submetida aos estimulos único e consecutivo de estresse de captura. Bol. Inst. Pesca 30: 71 – 80.

McNulty, S. T., P. H. Klesius, C. A. Shoemaker & J. J. Evans. 2003. Hematological changes in Nile tilapia (*Oreochromis niloticus*) infected with *Streptococcus iniae* by nare inoculation. J. World Aquacult. Soc. 34: 418 – 422.

Milne-Edwards, A. 1856. Notes sur les dimensions des globules du sang de quelques vertébrés. Ann. Sci. nat. 5: 165 – 167.

Nulsey, C., J. H. J. Vanvuren & H. H. Duprees. 1995. Effect of copper on the differential white blood cell count of the Mozambique tilapia (*Oreochromis mossambicus*). Comp. Biochem. Physiol. C, 111: 381 – 388.

Oladimeji, A. A., A. A. Ayantoye & K. A. N. Esievo. 1988. Hematological differences between two tropical freshwater fishes, *Oreochromis niloticus* and *Clarias lavera*. L. J. Afr. Zool. 102: 487 – 492.

Omeregie, E. E. & S. M. Oyebanji. 2002. Oxytetracycline-induced blood disorder in juvenile Nile tilapia (*Oreochromis niloticus*) (Trewavas). J. World Aquacult. Soc. 33: 389 – 394.

Pienaar, U. de V. 1962. Haematology of some South African Reptiles. Witwatersrand University Press, Johannesburg, South Africa: 298 pp.

Ranzani-Paiva, M. J. T., C. M. Ishikawa, A. Cocuzza das Eiras & V. Rosaffi da Silveira. 2004. Effects of an experimental challenge with *Mycobacterium marinum* on the blood parameters of Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758). Braz. Arch. Biol. Technol. 47: 1 – 11.

Sahan, A. & S. Duman. 2010. Influence of beta-1,3/1,6 glucan application on some non-specific cellular immune response and haematologic parameters of healthy Nile tilapia (*Oreochromis niloticus* L., 1758). Turk. J. Vet. Anim. Sci. 34: 75 – 81.

Saint Girons, M-C. 1970. Morphology of the circulating blood cells. **IN**: "Biology of the Reptilia" (Editors: G. Gans & T. S. Parsons). Academic Press, London and New York 3: 73 – 91.

Saint Girons, M-C. 1970a. Numbers of blood cells and their variation. **IN**: "Biology of the Reptilia" (Editors: G. Gans & T. S. Parsons). Academic Press, London and New York 3: 93 – 109.

Sato, A. & S, Sekiya. 1926. A peroxidase staining method for differentiating myeloid from lymphoid leucocytes. J. Exp. Med. 7: 111 – 115.

Silva, B. C., M. L. Martins, A. Jacobá, C. B. Neto, F. N. Vieira, G. V. Pereira, G. T. Jerônimo, W. G. Seiffert & J. L. Mouriño. 2009. Hematological and immunological responses of Nile tilapia after polyvalent vaccine administration by different routes. Pesq. Vet. Bras. 29:

Silveira, R., Y. Vinjoy & A. Prieto. 1996. Los análisis hematológicos como sistemas de diagnóstico en *Oreochromis aureus* de cultivo en Cuba. Rev. Latinoam. Acuicult. 36: 4 – 6.

Silveira-Coffigny, R., A. Prieto-Trujillo & F. Ascencio-Valle. 2004. Effects of different stressors in haematological variables in cultured *Oreochromis aureus* S. Comp. Biochem. Physiol. C, 139: 245 – 250.

Silveira-Coffigny, R., Y. Cruz-Quintana, M. Martínez-Pérez & F. Ascencio-Valle. 2005. Características morfológicas y citoquímicas de las células de la sangre periférica de *Oreochromis aureus* S., Cichlidae. Rev. Electrón. Vet. REDEVET 6 (10): 8 pp.

Smith, C. F. 1968. Hematological changes in coho salmon fed a folic acid deficient diet. J. Fish. Res. Bd. Canada 25: 151 – 156.

Sugita, H., C. Miyajima & Y. Deguchi. 1990. The vitamin B12 producing ability of intestinal bacteria isolated from tilapia and channel catfish. Nippon Suisan Gakkaishi 56: 701.

Sugita, H., C. Miyajima & Y. Deguchi. 1991. The vitamin B12-producing ability of the intestinal microflora of freshwater fishes. Aquaculture 92: 267 – 276.

Tacon, A. G. J. 1992. Nutritional Fish Pathology. Morphological Signs of Nutrient Deficiency and Toxicity in Farmed Fish. FAO Fish. Tech. Paper (330): 75 pp.

Tavares-Dias, M. & C. D. Faustino. 1998. Parámetros hematológicas da tilapia-do-Nilo (Cichlidae) em cultivo extensivo. Ars. Vet. 14: 254 – 263.

Tavares-Dias, M. & F. R. Moraes. 2002. Características hematológicas de tres teleósteos dulceaqüícolas brasileiros de interesse zootécnico. Resúmenes do VII Encontro Brasileiro de Patologistas de Organismos Aquáticos/III Encontro Latino-americano de Patologistas de Organismos Aquáticos. Foz de Iguaçu, Brazil: 37.

Tavares-Dias, M. & F. R. Moraes. 2003. Características hematológicas da *Tilapia rendalli* Boulanger, 1896 (Osteichthyes: Cichlidae) capturada em pesque-pague de Franca, Sao Paulo, Brasil. Biocien. J. 19: 103 – 110.

Tavares-Dias, M., C. M. D. Frasca-Scorvo, P. F. C. Novato & F. R. Moraes. 2000. Hematological characteristics of hybrid red tilapia, *Oreochromis hornorum* X O. *mossambicus*, under intensive rearing. Proc. 5th. International Symposium on Tilapia in Aquaculture (Editors: K. Fitzsimmons & J. C. Filho). Rio de Janeiro, Brazil: 533 – 541.

Tavares-Dias, M., F. R. Moraes, M. L. Martins & A. E. Santana. 2002. Haematological changes in *Oreochromis niloticus* (Osteichthyes: Cichlidae) with gill ichthyophthiriasis and saprolegniasis. Bol. Inst. Pesca 28: 1 – 9.

Thrall, M. A. 2004. Hematology of Amphibians. Veterinary Hematology and Clinical Chemistry: Text and Clinical Care Presentations. Lippincott Williams & Wilkins, Philadelphia, USA.

Ueda, I. K., M. I. Egami, W. S. Sasso & E. R. Matushima. 1997. Estudos hematológicos em *Oreochromis niloticus* (Linnaeus, 1758) (Cichlidae: Teleostei) – Parte I. Braz. J. Vet. Res. Anim. Sci. 34: 270 – 275.

Ueda, I. K., M. K. Egami, W. S. Sasso & E. R. Matushima. 2001. Cytochemical aspects of the peripheral blood cells of *Oreochromis (Tilapia) niloticus* (Linnaeus, 1758) (Cichlidae: Teleostei) – Part II. Braz. J. Vet. Res. Anim. Sci. 38: 273 – 277.

Verdegem, M. C. J., A. D. Hilbrands & J. M. Boon. 1997. Influence of salinity and dietary composition on blood parameter values of hybrid red tilapia, *Oreochromis niloticus* (Linnaeus) X O. *mossambicus* (Peters). Aquacult. Res. 28: 453 – 479.

Vinatea Arana, L. 2004. Princípios Químicos da Qualidade da Água em Aqüicultura. Editora da UFSC, Florianópolis, Brazil. 2nd. edition: 231 pp.

Watanabe, W. O., T. M. Losordo, K. Fitzsimmons & F. Hanley. 2002. Tilapia Production Systems in the Americas: Technological Advances, Trends and Challenges. Rev. Fish. Sci. 10: 465 – 498.

Witten, P. E., W. Villwack & L. Renwrantz. 1998. Haematogram of the tilapia *Oreochromis niloticus* (Cichlidae: Teleostei) and application of a putative phenoloxidase for differentiating between neutrophil granulocytes and monocytes. Can. J. Zool. 76: 310 – 319.

Sunshine at Sheffield
An overview

Terry Croft ▶

The world is entering a period of crisis: there is not enough energy or food and their costs are rising; there is environmental destruction and loss of biodiversity at an accelerating rate; and increasing evidence of potentially catastrophic climate change. A common feature is the unsustainable nature of most human activity. The University of Sheffield has realigned its science research, creating Project Sunshine, to discover sustainable routes to food and energy security through collaborative research and innovation, uniting scientists across the traditional boundaries in both the pure and applied sciences.

The vision of a positive and sustainable future

The University of Sheffield offers an optimistic vision of a future in which a stable global population lives prosperously and sustainably, supported by the ample energy resources of the sun. Given global will and a lot of effort to develop the truly sustainable technologies we need, we have the opportunity to emerge from some difficult years to a much more positive future.

The brainchild of Professor Tony Ryan OBE Project Sunshine encompasses "All the Science Under the Sun" which underpins food and energy sustainability.*

The challenge – fossil fuel dependent growth is unsustainable

Since the industrial revolution, we have become dependent on energy in a highly concentrated form, from burning fossil fuels - it's this that has led, not just to our prosperity in the developed world, but also to our very ability to feed the world at its current population levels. Before the industrial revolution, the limits on the population were set by the sun and by the productivity of the land; fossil fuels broke that connection by enabling energy-intensive agriculture and industrialisation.

Now, we see that the last 300 years have been a historical anomaly, powered by fossil fuels in a way that can't continue and we are now witnessing the stark reality that fossil fuel dependent growth is unsustainable. Limits to the production of food and energy are rapidly being approached, pushing up prices and threatening economic, political and social upheavals throughout the world. Climate change threatens to massively disrupt food supplies and cause severe environmental damage - all levels of human activity are affected.

Meeting the challenge – re-establishing the link between sunshine and human activity

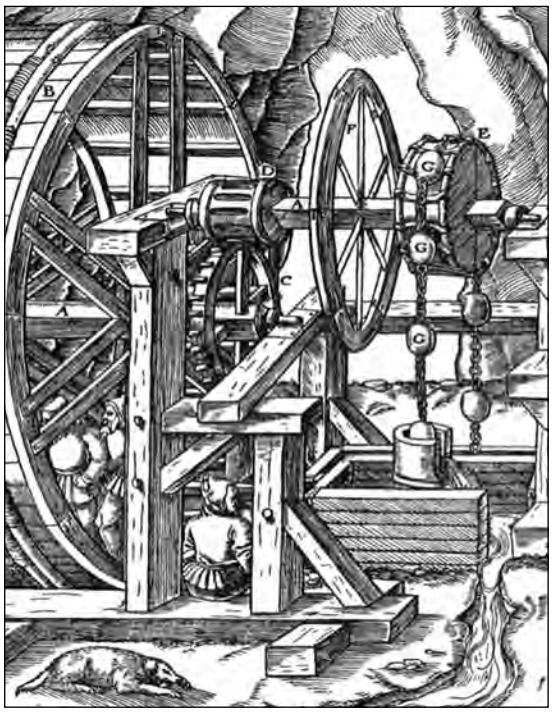
There is no alternative but to dramatically change the way we use and produce energy and food, to adapt to the already changed climate and to ameliorate the extent of future change. In effect, we should re-establish the link between sunshine and human activity. We know this is possible in principle, because the total energy arriving on the planet every day from the sun far exceeds any projection of what energy we might need, even if the earth's whole population enjoys the standard of living that we in the developed world take for granted.

The transition to a sustainable solar economy – Project Sunshine

The inextricable links between climate change, energy supply and food production dictate an integrated solution to these problems, from different perspectives, using different approaches. Therefore, the University of Sheffield has created Project Sunshine, to revolutionise the way science is planned, executed, perceived and exploited, catalysing a change in outlook, motivation and philosophy of scientists - a new era of scientific investigation and a new generation of young scientists that have global issues as their focus.

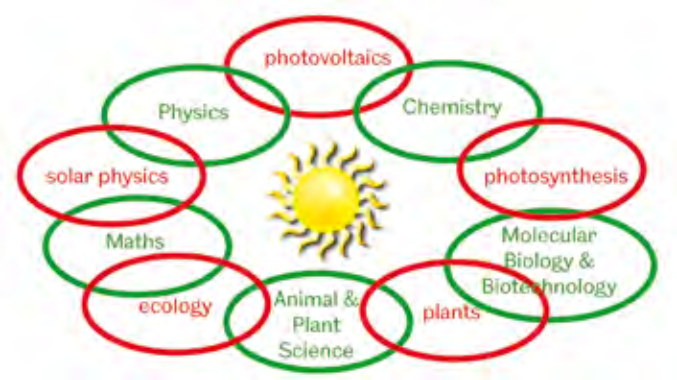
We will help embed such change throughout society – not only in universities, but also in government, in commerce and industry, in international organisations, and in the behaviour of the public.

Building upon extensive achievements in food, energy and environmental research, and world-class research facilities, Project Sunshine brings together over 40 scientists (biologists, chemists, physicists and mathematicians) and draws upon complimentary



Mankind's resources are being squeezed to the limit

Food production needs to increase by 50% in the next 20 years – Source Global Food and Farming Futures Report



A focus on integrated solutions

Sheffield University provides state-of-the-art facilities to meet these challenges including the Arthur Willis Environment Centre and the Sir David Read Controlled Environments Facility

skills of 15 groups of engineers, social scientists and economists to form a research centre committed to finding new ways of using solar energy more effectively, more extensively and more efficiently.

The aim is to develop integrated systems for food and energy security, examining complete systems – approaches derived from the expertise of scientists and engineers, in the context of the perspective offered by social scientists and economists.

Engagement and communication

Project Sunshine, along with activities of a similar nature in other institutions in the UK and world wide, provides a model for a new way of thinking about and doing science, which is focused on innovative pure science, but at the same time geared toward providing practical solutions. A vital part of this process is engagement and communication with individuals and organisations from across many areas of academia, business and the public sector, and with the general public. With this aim in mind, in September Sheffield University will be hosting a major event, the Shine 2011 international conference.

Further information on Project Sunshine and the Shine Conference is available at:
http://shine.sheffield.ac.uk/

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* Professor Tony Ryan OBE is Pro-Vice Chancellor for the Faculty of Science at the University of Sheffield and Chair of Project Sunshine.

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A pioneering history: dentistry and the Royal College of Surgeons of Edinburgh

Helen Dingwall ▶

The Surgeons' Hall, Royal College of Surgeons of Edinburgh, designed by W.H. Playfair

During the 500 years of its history the Royal College of Surgeons of Edinburgh (RCSEd) has been shaped by many internal and external influences, and this has been no less the case with its dental wing. Though a separate Dental Council was not set up until the early 1950s, a number of individual Fellows had promoted the cause of dentistry for some considerable time before then.

Before the Dentists Act of 1878, dentistry was not considered to be a profession, the general view being that it was unregulated, unethical and amateur, with all sorts of individuals offering to pull teeth or advise on cures for toothache or other oral problems. There had been no real attempts to professionalise dentistry, and there were no specific Scottish dental qualifications on offer. A few RCSEd Fellows had turned their attention to dental matters during the second half of the eighteenth century, but largely within the context of general surgery. It would take considerable efforts to persuade both doctors and the public that dentistry had its place alongside medicine, surgery and pharmacy within the spectrum of the increasingly organised and regulated medical profession (particularly so after the Medical Act of 1858), and the RCSEd had a key role to play in this process.

Robert Liston

The first evidence of attention to dental matters within the RCSEd comes from the 1770s, when James Rae offered a course of lectures on surgery, including "diseases of the body depending on those of the teeth, thro' all the stages of life … such particularly as affect the head, eye, glands, and neighbouring parts". During the early-nineteenth century some of the most famous RCSEd Fellows, such as James Syme and Robert Liston, carried out maxillo-facial procedures, and in 1825 Robert Naysmith worked with Liston in the "splinting of mobile mandibular fragments following resection of part of the jaw for neoplasm.[1] Brodie Imlach, one of only two dentists to become President of the RCSEd, devoted the major part of his practice to dentistry. He was acquainted with James Young Simpson, and maintained a keen interest in anaesthesia. Imlach performed the first extraction of a tooth under chloroform in 1847, only a few days after Simpson had tried it in an obstetric case.

The key stimulus to the more formal organisation of dentistry within the RCSEd came from John Smith. He was one of the founders of the Edinburgh Dental Dispensary in 1860, and was engaged to provide dental services to the Royal Infirmary in 1863. Smith was president of the RCSEd in 1883-4, and of the British Dental Association, founded in 1879.[2] Smith was strongly in favour of the licensing of dental practitioners and in 1856 had instituted the first lecture course entirely devoted to diseases of the teeth, stating:

'I am entering on an experiment as yet untried in this place; I therefore do so with less confidence since not having the advantage of a predecessor in the same province … I am left very much to my own resources in the arrangement and manner of conducting the course'.[3]

This teaching was, of course, extra-mural, which allowed individuals the freedom to shape their own courses, as there was no specific curriculum or university regulation to provide constraints. In most areas of professional development, a piece of key legislation tends to appear at some point, and in the case of dentistry this took the form of the first Dentists Act in 1878.

Patrick Heron Watson

Dorothy Geddes

Not wasting any time, the RCSEd established its first dental Licentiate examination (LDS RCSEd) in 1879 (in 1895 Lilian Lindsay became the first woman in the United Kingdom to graduate in dentistry, with the Edinburgh LDS).[4] The Edinburgh Dental Hospital and School was also founded in 1879, and the RCSEd president, Patrick Heron Watson, was ex officio one of its directors, while John Smith was listed as one of the 'consulting officers'.

In dentistry as elsewhere, publications and societies were important, and Smith made an unsuccessful attempt to establish a dental society in 1865, with the aim of promoting the practice of 'ethical dentistry'. This initiative failed but the Odonto-Chirurgical Society of Scotland was founded two years later. Members of the Society were banned from advertising, and in keeping with the general perception that learned societies benefited from political support, the first honorary member of the Society was Charles James Fox, elected in 1869.[5]

The Society held regular meetings, and the lecture programme covered a range of topics, including 'conservative dentistry of exposed pulp', 'case of sarcoma of the lower jaw', and in March 1890 one of the prominent RCSEd members, W. Bowman Macleod, spoke on a very Scottish topic - 'the effects of bagpipe playing on the teeth'. Scientific progress was closely followed, and members heard papers on 'nitrous oxide gas' (1868), 'inhalation of gas and ether' (1898) and 'micro-organisms of the mouth and their relationship with disease'(1883). Laboratory sciences were by now crucial to progress in all areas of medicine and this was no less true of dentistry.[6]


David S. Middleton

Of key importance also was the hospital setting. Dental staff had been appointed to the Edinburgh Infirmary since 1863, including John Smith, William Guy and David S. Middleton, and there was also, as mentioned, a close link between dentistry and anaesthetics. Several anaesthetists in the post-World War I period were dentally-qualified, and operated dental practices in addition to their duties as anaesthetists. These included John Gibbs, who served in the Infirmary from 1903-1929, and was considered to be the 'father of oral surgery in Edinburgh'[7] but who also served as an anaesthetist with the ENT department. D.S. Middleton also combined dental and anaesthetic practices before leading a field ambulance unit in France at the start of the Second World War. The role of the RCSEd in relation to dentistry at this time was thus determined by several interacting influences, including advances in knowledge, the requirements of legislation, the necessities of war, and the individual enthusiasm of key players, who wished to change the negative image in which their calling was portrayed. As with surgery in general, the RCSEd was both proactive and reactive according to the complexities of the medical spheres and general context in which it operated.


Frederick G. Gibbs

Recognition as a discrete element of the RCSEd structure did not come until the early 1950s, though there was by that time dental representation on the College Council. Consideration was given to the creation of a Dental Faculty, but this would have required expensive alteration to the College Laws, whereas a Dental Council would not, and the decision was taken to set up a Council rather than a Faculty. The first meeting of the Dental Council took place on 26 February 1954, chaired by the RCSEd President, Sir Walter Mercer. Mr F.G. Gibbs was elected as its first convener, and Mr W. Russell Logan was appointed secretary to the Dental Fellows. Representatives were also chosen to serve on the College Library and Museum Committees. The Convener of the Dental Council became an ex-officio member of the President's Council, and representatives were nominated to serve on various national boards and committees. The Royal College of Physicians and Surgeons of Glasgow established a Dental Council in 1967[8] and joint meetings between the Edinburgh and Glasgow dental wings began in 1968. The first female member of the RCSEd Dental Council was the late Professor Dorothy Geddes, who in 1992 became the Dean of the Dental Faculty, and was also the first female Dental Professor in Britain.

Relations between the RCSEd and its Dental Council were not always cordial, though. There were disputes about voting rights of dental Fellows; there was a lukewarm response to the request for a dental section in the RCSEd journal; and considerable disquiet was voiced when the RCSEd expressed the view that Oral Surgery should be the province of higher surgical training, and not higher dental training.[9] Relations did improve, though, and in 1982 it was resolved 'that the College shall have a Faculty of Dental Surgery which shall consist of Fellows and Associate Members in Dental Surgery; the Convener of the Dental Council shall be Dean of the Faculty of Dental Surgery *ex officio*'. The Dental Faculty has since that point been organised on very similar lines to the College itself, as well as being an integral part of its structure Just as the Dental Faculty was established, though, serious implications for the future of dental surgery in Edinburgh arose, with the threat of closure of the Edinburgh Dental School. Plans were drawn up for a new dental hospital and postgraduate institute, but the Dental School closed in June 1994 before these arrangements could be implemented. The Edinburgh Dental Institute eventually opened in late 1998, with responsibilities for postgraduate dental education and training, and involving RCSEd Fellows and Members.

Examinations

As noted above, the first dental examination run by the RCSEd was the Licentiate in Dental Surgery Diploma (LDS RCSEd), established in 1879. In time, and in the light of scientific progress, and, importantly, the development of maxillo-facial surgery and the technology of dentistry, the need for a higher qualification became clear. The Higher Dental Diploma (HDD RCSEd) was established in 1920, attracting considerable numbers of candidates, especially those who wished to follow a career in hospital dentistry. The HDD RCSEd was eventually replaced by a Fellowship qualification, the first diet of the FDS RCSEd taking place in 1949. From 1997 candidates for the FDS sat an intercollegiate first examination, followed by an examination for entrance to the RCSEd to which they wished to adhere. Shortly after the establishment of the FDS, the question of reciprocity of primary examinations arose, and after considerable difficulty this was achieved among the British and Irish colleges of surgeons in 1969.[10] The FDS RCSEd was discontinued in 2002 (the last diet being held in Bahrain), to be replaced by a more flexible examination, based, as are the surgical examinations, on a Membership qualification followed by a Specialty Fellowship. The Membership qualification for dental surgery and dentistry (MFDS/MFD RCSEd) is now partly intercollegiate, but the final part is collegiate, allowing specific college affiliation. At the end of higher dental training candidates will take a Specialty Fellowship by assessment, and as with surgery, Membership signifies completion of basic training, and the Specialty Fellowship the culmination of higher training and full competence to practise as a specialist.

The Dental Specialties

A number of factors combined to induce the Dental Council, and later Dental Faculty, to pursue the issue of specialty examinations. These included the advances in of Oral and Maxillofacial (OMS) surgery (from the early 1990s OMS surgeons were required to qualify in both medicine and dentistry), the technological advances in areas such as restorative dentistry, orthodontics and paediatric dentistry and, of course, the more general background factors such as the effects of fluoride and the increasing market for cosmetic dental procedures. The technology of dentistry was just as significant as the technology of surgery in acting as stimulus towards new methods of training and new kinds of examinations.

The growing significance of OMS – coupled with the setting up of a specialist unit in the Infirmary and the need for general surgical as well as dental expertise – prompted the Dental Council to approach the RCSEd with a proposal that a Part II FRCSEd examination in OMS be established. A Specialty Advisory Board was created and the first examination took place in January 1985.

There has been a recent proliferation of specialty dental examinations, including:

- Diploma in Restorative Dentistry (1978), superseded by MDS RCSEd in Restorative Dentistry (1993)
- Diploma in Orthodontics (1987), superseded by MDS RCSEd in Orthodontics (1989)
- MDS RCSEd in General Dental Surgery (1990)
- Conjoint MDS RCSEd in Restorative Dentistry with Hong Kong (1996)
- MDS RCSEd in Paediatric Dentistry (1998) MDS RCSEd in Surgical Dentistry (1999)
- MDS RCSEd in Oral Surgery (2000)
- MDS RCSEd in Oral Medicine (2000)
- Diploma in Dental Hygiene (2001)[11]

Most of these new qualifications have been introduced in the very recent past – perhaps a reflection of the rapid advances in the science and technology of these areas. They are designed to provide proof of competence in a world of much advanced and increasingly technological dental surgery. The general context is, of course, important here, not least the changing proportions in the workload of dental practitioners between treatment of dental caries and prophylactic and orthodontic treatments, particularly in the light of fluoridation, however controversial that might have been, and indeed may still be.[12] Better general dental heath has the natural consequence of reshaping the work of dental practitioners.

Just as the RCSEd's surgical examinations have reached many parts of the globe, so the Dental Faculty offers local examination facilities to candidates in Amsterdam, Bahrain, Hong Kong, Chicago, India, Singapore and Egypt. The first RCSEd dental examination in Europe took place in Amsterdam in 1993, and of the worldwide locations, the Chicago centre is perhaps the most interesting, given that it is in the most advanced nation in the world, with its own complex training structures.

The Dental Faculty is nowadays an integral part of the RCSEd, though operating independently through its examinations and training programmes, which include distance learning packages as well as 'hands on' courses and masterclasses. Despite the unfortunate loss of the Dental School, the Dental Faculty appears to be in a healthy state. The long history of the RCSEd has not been forgotten, and in anticipation of its quincentenary in 2005, the Dental Faculty established the King James IV Professorships in 1995. These professorships are offered in open competition to dental practitioners; the successful candidates give a prestigious lecture, and among the topics covered have been 'Intracellular signalling pathways in osteoblasts', 'dentistry and the medically compromised patient', and 'the evolution of extra-cranial carotid artery surgery'.

Conclusion

The relationship between the College and dentistry has been difficult at times, but was influenced primarily by factors common to surgery and to medicine in general as well as to dentistry in particular. In the early days a few College Fellows included dentistry in their surgical work, and as time went on they began to offer some specific teaching in that area. The major stimulus to more formal provision came with the Dentists Act and the need to offer training and examinations which would validate professional dentists and begin the long and difficult process of separating the amateur tooth puller from the professional, well-trained practitioner. In more modern times the examination structure has evolved in the wake of both government requirement and advances in the science and technology of dentistry. In other words, the sphere of College dentistry was contained within, and interacted with, the wider spheres of science, medicine, regulation and legislation. The other British surgical colleges offer similar dental training and qualifications, and examinations are increasingly intercollegiate in nature, so the RCSEd must continue to be pioneering if it is to maintain a key role in the future of dentistry. Its past activities suggest that this can be achieved, though to suggest this would be a postmodernist's worst nightmare.

Author

Helen Dingwall BA, PhD, FRHistS is Honorary Lecturer (formerly Senior Lecturer) at the University of Stirling. She is the author of a number of books and papers on the history of Scottish medicine. Her book *A History of Scottish Medicine* was published by Edinburgh University Press in 2003.

Notes and references

1 I am grateful to Dr L.D. Finch and Dr J.F. Gould for providing me with detailed notes on this topic. (Naysmith's brother Alexander gave his name to the eponymous membrane which covers the enamel surface of newly erupted teeth).

2 Keeping things in the family, Smith's son-in-law, William Guy, served as Dean of the Edinburgh Dental Hospital and School in the early years of the twentieth century, and was prominent in the treatment of facial injuries sustained by casualties of the Great War who were treated at the Second Scottish General Hospital at Craigleith.

3 Quoted in *Centenary Brochure* of the Edinburgh Dental Schoool and Royal College of Surgeons Licence in Dental Surgery (Edinburgh, 1979), 1.

4 Lilian Lindsay faced the same sort of problems as did female medical students – being informed by Henry Littlejohn that she was 'taking the bread out of some poor fellow's mouth'. Cohen, R. A., 'Lilian Lindsay 1871-1960, *British Dental Journal* 131 (3) (1971), 122.

5 *Ibid.,* 128-44.

6 Geissler, P. R., *The Royal Odonto-Chirurgical Society of Scotland* (Edinburgh, 1997), 29.

7 Gould, J. F., manuscript notes on development of oral surgery in Edinburgh, 2.

8 Hull and Geyer-Kordesch, *The Shaping of the Medical Profession (Glasgow and Ohio, 1999),* 207. It acquired Faculty status in 1990.

9 RCSEd, College Minutes, 1 February, 1974.

10 RCSEd, Dental Council Minutes, 14 March 1969.

11 I am grateful to Mrs Violet Brown, RCSEd Dental Faculty administrator, for this information.

12 Craig, G. C., 'Fluorides and the prevention of dental decay: a statement from the Representative Board of the British Dental Association', *British Dental Journal* 188 (12) (2000), 654.

Note

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John Dalton's unofficial biographer, James Woolley

Alan Gall, IST Archivist

You will find poor Dalton, if you find him alive, quite a shadow of his former self …

I fear, if he survives, it can only be a melancholy second childhood.[1]

Mr James Woolley (from Woolleys of Manchester)

So wrote Charles Henry[2] to Justus von Liebig[3]. Had he read the letter, John Dalton might have repeated the sentiments of Mark Twain in saying "The reports of my death have been greatly exaggerated" because he rallied well enough to continue as President of the Manchester Literary and Philosophical Society (Manchester Lit & Phil) for several years. However, the first serious sign of a health problem, a partial paralysis in 1837, had hastened thoughts of mortality and he bequeathed his scientific manuscripts to Charles Henry, who vowed to act as biographer. Ten years were to elapse after Dalton's death before Henry's *Memoirs of the Life and Scientific Researches of John Dalton* went to press, and considered a rather poor effort by future historians. In the meantime, James Woolley had presented his own memoir on Dalton's life to the Manchester Lit & Phil in 1848. Subsequent biographers, including Henry, would make much use of Woolley's manuscript, and also his generosity in supplying extra source material.

Illustration by courtesy of Michael Pritchard

The literature on Dalton is large[4] and only a brief sketch is given here. He was born into a Quaker family in the village of Eaglesfield, near Cockermouth in Cumbria, on or about 6 September 1766, and by the age of 12 had matured enough to start his own school. He established a reputation as an accomplished mathematician by providing solutions to various problems in the publications *Gentleman's Diary and Ladies' Diary*[5]. This helped him secure an appointment teaching mathematics at the New College, Manchester. A number of publications centred on his love of meteorology, such as Meteorological Observations and Essays (1793 & reprinted 1834). In 1808, his *New System of Chemical Philosophy* appeared that promoted the atomic theory and gave a list of atomic weights, along with his newly devised (largely arbitrary) set of symbols representing elements. He conducted very many experiments – on gas partial pressure, solubility of gases, thermal coefficients of gas expansion and diffusion, to name a few. His results were not always correct but his influence on the development of chemistry far-reaching. Dalton died on 27 July 1844 in Manchester, after suffering a number of strokes. The turnout for his funeral was astounding. The *Manchester Guardian* of 14 August covered the event, listing 93 carriages carrying the (mainly) rich and famous. Salford Corporation accounted for ten coaches and many walked. About 100 members of the Manchester and Salford Temperance Society preceded the hearse, walking six abreast. Some sources say that about 40,000 people turned up to pay their last respects.

Advertisement in Nature 1923

Dalton had given lectures on colour blindness, an impairment that he shared with his brother. One theory of the day was that this condition resulted from a defect in the brain. But Dalton supposed the cause to be a blue tint in his vitreous humour and requested that his eyes should be taken out for study when he died.

His doctor performed the examination but found no physical defect and could only conclude that the problem had existed in the "phrenological organ of colour". Dalton's eyes continued in storage. DNA analysis in 1995 finally showed that the gene responsible for green cone-pigment was absent, a condition known as deuteronopia.[6]

The Market Street shop (from Woolleys of Manchester)

James Woolley came from the town of Dukinfield, born on 9 June 1811. His career choice of medicine was not to be, due to the harrowing experience of seeing operations performed without anaesthetics while studying at Edinburgh[7]. He had already trained under a pharmaceutical chemist in Manchester and so, after consulting with Dalton[8], decided to continue with pharmacy. In 1833 he opened a chemist's shop. This would be the start of a business empire that encompassed chemicals and drugs, scientific and surgical instruments, laboratory apparatus and photographic equipment.

The works on Knowsley Street in 1873 (from Saga of a Family)

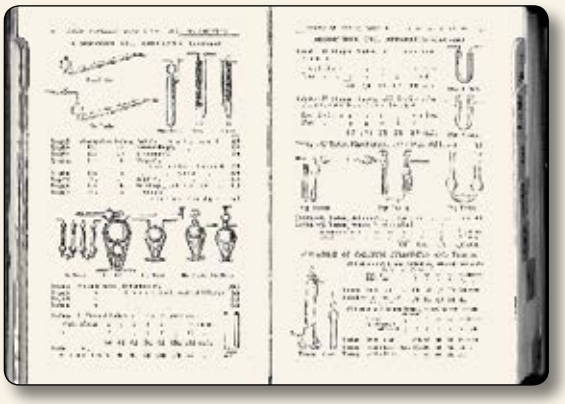
Dalton lodged with the Johns family of George Street, Manchester for some 26 years. The head of the house, William Johns, had trained as a Unitarian minister and, with Dalton, was one of the officers of the Manchester Lit & Phil. The Reverend's household also contained three children orphaned by the death of his brother Stephen. It was one of the trio, Ann Johns, who married James Woolley in 1836. Eight children followed.

The first chemist's shop stood at 58 King Street, Manchester but when an opportunity presented itself, the business moved to 69 Market Street with the acquisition of a pharmacy run under the name of Robert Halsted Hargreaves. A second shop opened at 64 Stretford New Road, Hulme in 1841, operated as a partnership with William Cartman, trading as Cartman & Woolley. When James moved house from Great Ducie Street to Summer Place, Broughton in 1844 he converted his former home into another chemist's. The interest in the Great Ducie Street shop was given up in 1849 and by 1857 James only held a nominal interest in 64 Stretford New Road. Another avenue of interest had opened up – the manufacture of chemical products.

Map published 1851. The Quay Street premises of Pochin & Woolley are marked "Chemical Works" and "Chemical Stores"

The Victoria Bridge premises (from Woolleys of Manchester)

On Quay Street in Salford stood a factory for the production of starch, gum and mordants. It ran under Andrew Paton & Son until the proprietors, Andrew Paton Halliday and Eliza Paton went bankrupt in 1849[9]. The premises at Salford, and facilities at Cornbrook, Manchester, were advertised for sale in that year. According to Milliken (1967) James Woolley joined with Halliday, presumably saving the business by buying the Quay Street works[10], and when Halliday fell ill asked one Henry Pochin[11] to manage the Quay Street works. It is not clear how this all worked except that it operated as A.P.Halliday & Son, then Halliday, Pochin & Co and became Pochin and Woolley. Young Pochin was certainly an asset on the technical side as he developed and patented a process in 1855 for the manufacture of aluminous cake[12], and later, with James Woolley, registered "Improvements in the manufacture of gum or dextrine from amylaceous substances" (1857).



1911 catalogue (courtesy of Michael Pritchard)

James Woolley moved up the ranks in the pharmaceutical world: Hon Secretary of the Pharmaceutical Society of Great Britain's Manchester branch shortly after the formation of the national body in 1841, member of council of the PSGB in 1843 and President of the Manchester Pharmaceutical Association 1855. His interests extended to the Manchester Mechanics Institute[13], of which he became a director.

The Quay Street works prospered under Pochin and Woolley, well enough to need extra manufacturing capacity. A chemical plant with "… large vitriol chambers and every requisite to carry on an extensive business …" came on the market in 1855 and was duly acquired. The plant stood next to the Rochdale canal at Newton Heath.[14]

As the end of 1857 approached, James Woolley developed a serious medical condition. Henry Pochin kept a diary and described the events leading up to the death of his friend. The arrival of the eminent surgeon Professor James Syme[15] is recorded and on the following day, Wednesday 20 January 1858, surgery began. There were three other doctors in attendance[16], equipped with the new surgical aid, chloroform. However, this did not guarantee a pain-free experience, as Pochin's diary makes clear.

He appeared not to be all the time perfectly under the influence of chloroform … they were nearly 1½ hours upstairs. In the afternoon examination they found they had not cut into the urethra but were cutting at the false passage. They again operated, i.e. Syme and Harrison but did not give the chloroform and could not get on. Mr. W. screamed very much and another operation will be necessary in the morning … poor fellow.

The day after, Pochin administered the chloroform himself and seems to have given sufficient to keep the patient unconscious throughout.

I was present during the operation …It is terrible butchery. The operation did not last more than 20 minutes … he was perfectly insensible all the time. All think it successful this time and it appears to be so. Mr. W. is better than might be expected.

Hopes for a recovery were short lived: "Mr W. going on very favourably (22 January), "Bleeding has commenced from the wound and Mr Woolley is not nearly so well" (23 January), "There is not so much bleeding this morning but it has weakened him very much" (24 January), "Mr Woolley sinking … cannot continue long in this state" (27 January).

James Woolley rallied briefly on 28 January, "and even spoke of going to Bath", but the next day saw him "sinking fast". Finally, on Saturday 30 January 1858, came the sad end.

It is now a question of how many hours Mr. Woolley can live … I left him in the morning for about 2 hours … he did but just know me when I returned. I continued with him all day and he died about one minute after 6 o'clock p.m. I closed his eyelids after death. There were present Mrs. Woolley, myself, Mr. Hyde[17], Mr. John Woolley and Miss Johns. Poor man … I lose a friend of no common character. His place will never be suppl'd.

Two days later, Henry Pochin reported the death on behalf of the family. James was only 46 years old and died from "stricture of the urethra" despite having the best medical attention that money could buy in those days. His remains now rest in plot A3 at Weaste cemetery, Salford.

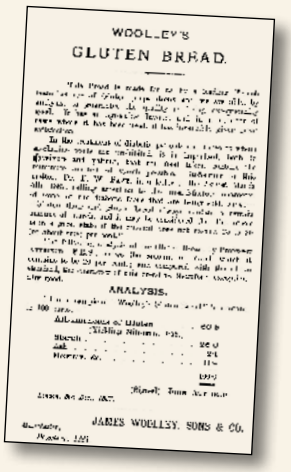
From top to bottom: Edward James Woolley, George Stephen Woolley, George Stephen Woolley, the younger (from Woolleys of Manchester)

After James's demise, Henry Pochin continued with the Quay Street venture alone and went on to establish himself as a leading industrialist, with directorships in twenty-two companies. H.D.Pochin & Co acquired several china clay mines in Cornwall, and so developed into one of the largest British producers of china clay. Pochin also served in various public offices: a J.P, a deputy lieutenant and the Sheriff of Denbighshire.

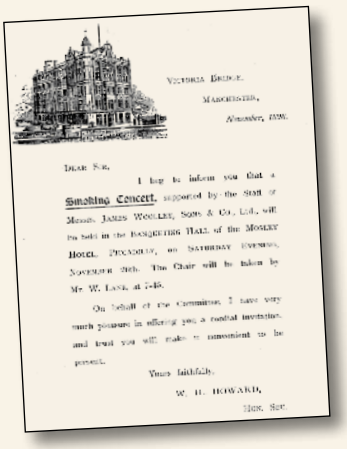
While Henry acquired fame with his many appointments, his son Percival Gerald Pochin achieved infamy in private life. In 1891 Percival faced charges, with his wife Matilda, of cruelty to a pageboy in their employ.

It was shown that the boy was thrashed by Mr. Pochin with a horsewhip, and beaten by Mrs. Pochin with a stick, and the lad declared that on one occasion he was tied naked to a bedpost and whipped.[18]

The fines of £5 for Percival and £10 for Matilda wouldn't have caused much hardship, but being disinherited from the family fortune generated by Henry Pochin probably did!


WOOLLEY'S
GLUTEN BREAD.
ANALYSIS.
JAMES WOOLLEY, SONS & CO.

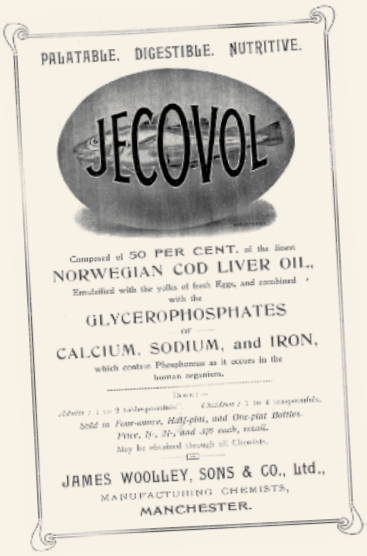
The main business at James Woolley moved at an early stage from the retail dispensing of remedies into the wholesale supply of pharmaceuticals, but laboratory supplies became an important section within the organisation. This expansion of interests probably came after James Woolley's death and before 1872 when James's son Harold[19] joined to take charge of the "scientific apparatus and surgical instruments department".


Smoking Concert.

Smoking concerts were generally live-music events, popular in Victorian times

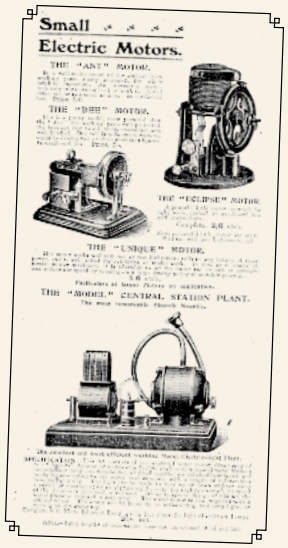

JAMES WOOLLEY SONS & CO LTD
"Premo" Film Camera.
"Excelsior" Folding Camera.
VICTORIA BRIDGE, MANCHESTER.

Catalogue page, c.1907



Pre-First World War, exact date unknown

Leaflet from 1911



Pre-First World War, exact date unknown

Advertisement in the University of Manchester's Calendar 1907-1907

Behind the shop on Market Street stood a warehouse, said to be of six storeys height, that housed a range of drugs and chemicals, all inflammable. In particular, the cellars contained large amounts of oil and turpentine so when a fire broke out on 17 March 1872, firemen arrive in force. The cellars did not ignite, thanks to the combined efforts of the local Manchester fire stations, the Broughton Volunteer Fire Brigade and the Salford Fire Brigade[20]. After this event, new premises for laboratories and drug mills were established on Knowsley Street in the Cheetham Hill district of Manchester. By the late 1880s further facilities were needed and a plot of land, at Victoria Bridge, on the banks of the River Irwell was acquired on which to erect an imposing building that could house offices, showrooms, dispatch facilities, and offer substantial storage space. Although this site fell on the Salford side of the river, it was invariably described as being in Manchester.

A further location, established in 1931 at Mary Street, not far from Victoria Bridge, accommodated the scientific apparatus. In a publication of 1946, James Woolley, Sons & Co Ltd reported:

The firm does a large business in chemical and physical apparatus and laboratory equipment, as well as in hospital furniture and all kinds of surgical instruments and X-ray requisites and these are stored and dealt with in the Mary Street premises.

With the take-over of J.C.Arnfield & Sons Ltd of Stockport in 1936 came additional manufacturing capacity for pharmaceuticals, and the damage caused by bombing after 1939 prompted the acquisition of property in Oldham. By the end of the war, Vice-Chairman George Stephen Woolley represented the only family member still on the board of directors. He was the great-grandson of James Woolley.

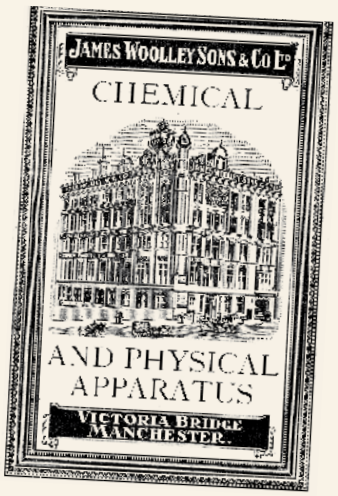
The Times newspaper reported on 16 May 1962 that British Drug Houses had offered £1 per share for the issued ordinary capital of James Woolley, Sons & Co Ltd. The directors supported the take-over bid. It was the beginning of the end for the 130-year-old business[21]. At the annual general meeting of BDH the following year, shareholders were told that James Woolley, and its subsidiary J.C.Arnfield & Sons Ltd, had been amalgamated under the name BDH (Woolley & Arnfield) Ltd.

Before ending it would be nice to put a human face to Woolley's great friend, John Dalton, and quote from one of the letters that Dalton wrote to the Rev. Johns (part of the Dalton memorabilia passed on to James Woolley's descendants).[22]

London, Dec. 27th 1809

Mr Davy[23] had invited me to Dine with the club of the Royal Society at the Crown & Anchor at 5'oclock, but I was detained till near six … all was over … I went therefore to the nearest eating house I could find to seek a dinner… I went in and asked for a beefsteak. No – What can I have – boiled beef. Bring some immediately. There was nothing eatable visible in the room; but in three minutes I had placed before me a large pewter plate, covered completely with a slice of excellent boiled beef, swimming in gravy, two or three potatoes, bread, mustard, and a pint of porter. Never got a better dinner. It cost me 11^{d} ½. I should have paid 7^{s}/- at the Crown and Anchor.

I should tell Mrs J. something about the Fashions here; but it is so much out of my province that I feel rather awkward. I see Belles of New Bond Street every day, but I am more taken up with their faces than their dresses. I think blue and red are the favourite colours. Some of the Ladies seem to have dresses as tight around them as a drum. Others throw them around them like a blanket. I do not know how it happens, but I fancy that pretty women look well either way.



Letter dated shortly before the firm became part of BDH

I sent for a basin of soup the other day before I went to lecture, thinking I should have a good three penny worth, but I found they charged me one shilling & nine pence for a pint, which was not better than some of our Mary's broth. Of course I could not digest much more of this soup.

Sources and References:

Boyns, T. (2004), "Pochin, Henry Davis (1824-1895)", *Oxford Dictionary of National Biography,* Oxford University Press, [http://www.oxforddnb.com/view/article/47964, accessed 29 May 2011].

Greenaway, F. (2004), "Dalton, John (1766-1844)", *Oxford Dictionary of National Biography,* Oxford University Press, [http://www.oxforddnb.com/view/article/7063, accessed 29 May 2011].

Jones, R.W. (2003), "Dalton's Unfortunate Choice", *Notes and Records of the Royal Society of London,* 57(1), pp.15-33.

Milliken, H.T. (1967), *Saga of a Family: The Story Behind the House of Woolley, British Drug Houses.*

Smyth, A.L. (1966), *John Dalton 1766-1844: A Bibliography of Works by and About Him,* Manchester University Press.

Tovée, M.J. (1995), "Dalton's Eyes and Monkey Genes", *Current Biology,* **5**(6), pp. 583-586, [http://www.cell.com/current-biology/abstract/S0960-9822%2895%2900115-1, accessed 29 May 2011].

James Woolley, Sons & Co. Ltd. (1946), *Woolleys of Manchester: A Record of 150 Years in Pharmacy,* James Woolley, Sons & Co. Ltd.

Other sources are indicated in the text and footnotes.

A shorter version of this article has appeared in the journal of the British Society of Scientific Glassblowers, July 2011 issue.

Thanks to Tim Ashworth and staff of the local history library at Salford for the following illustrations: the Smoking Concert, Gluten Bread, Jecovol, Sour Milk Treatment, and Small Electrical Motors.

Thanks also to Dr Michael Pritchard for supplying illustrations. http://britishphotohistory.ning.com

References:

1 Quoted by R.W.Jones (2003)

2 William Charles Henry (1804-1892) son of William Henry who formulated Henry's law. This states that the solubility of a gas in a liquid is proportional to the pressure of the gas above the surface.

3 Justus von Liebig (1803-1873), German organic chemist after whom the Liebig condenser is named.

4 See Smyth (1966) for a very comprehensive bibliography up to the mid-1960s.

5 "The Ladies' Diary: or Woman's Almanac … Containing New Improvements in Arts and Sciences, and many entertaining particulars designed for the use and diversion of the fair-sex."

6 For an account of the genetics involved see the paper by M.J.Tovée (1995).

7 Charles Darwin (1809–1882) had the same experience after enrolling at Edinburgh in 1825.

8 During Woolley's apprenticeship he had studied at the Medical School in Pine Street where Dalton lectured.

9 Reported in *The London Gazette,* 11 May 1849.

10 Andrew Paton & Son also operated from premises at Cornbrook, Hulme. It appears that this site was not taken on by James Woolley. Both works were advertised for sale in the *Manchester Guardian,* 4 August 1849.

11 Who was also said to be previously working from the Market Street base as a salesman.

12 Used in bleaching and papermaking.

13 Founded in 1824, it evolved into the University of Manchester Institute of Science & Technology (UMIST) and merged with the Victoria University of Manchester in 2004.

14 The plant was advertised for sale from July to September 1855 in the *Manchester Guardian.*

15 James Syme (1799-1870), Regius Professor of Clinical Surgery at Edinburgh, innovative surgeon and father–in-law of Joseph Lister (later Lord Lister).

16 Doctors J.Raynor of Stockport, J.Jordan of Manchester and J.B.Harrison of Broughton, Salford.

17 Likely to be Edward M.Hyde, a partner in the firm of Pochin & Woolley.

18 For the full newspaper report and further details see: http://www.chrishobbs.com/sheffield/pochinsheffield1891.htm

19 Harold died in an accident (1889) by inhaling fumes from nitric acid.

20 The incident was reported in *The Manchester Guardian,* 18 March 1872.

21 In 1946 the firm published a booklet to commemorate 150 years in pharmacy. To achieve this, they selected 1796, the date of foundation for R.H.Hargreaves. Taking, instead, the date of James Woolley's first shop in 1833 gives approximately 130 years.

22 Complete letter quoted in Jones (2003, pp.30-32).

23 Humphry Davy (1778-1829), chemist and inventor of the safety lamp in 1815.

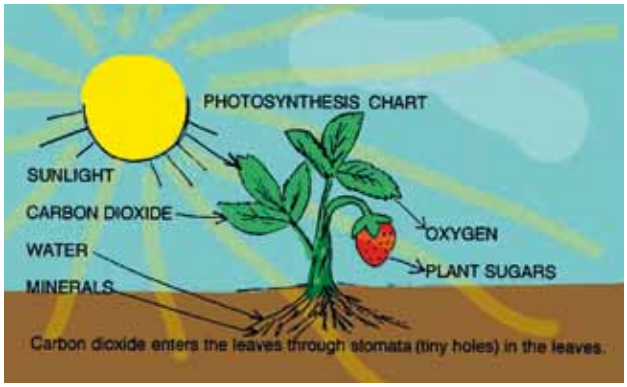
Science for citizenship?

Kevin Fletcher

With schools now teaching "Citizenship", it is all too easy to wonder what use science might be to our everyday lives as citizens. What use is the equation for photosynthesis for example? Apart from being worth a couple of marks in an examination (and this is all the majority of pupils believe it is worth, Fletcher, 1997), it may give a better appreciation in more general terms.

It can tell us that plants are necessary for our very existence because they take up carbon dioxide that we produce in breathing or when we make fires. They supply us with the very oxygen that sustains life and the crops that we depend upon. Such information may be useful for some citizens but more than this, it can inform us that our destruction of the rainforests is senseless when viewed in these terms.

Such issues may be of little immediate relevance and depend upon time and social context while being value-laden (Jenkins 1993, p235) but science can have more general influences and assist in the formation of informed citizen opinions and decisions generally (ibid.,p234-6, Black 1993). It has been argued in the past that college and school science, however, presents only a very limited amount of useful information (Chapman 1993) but it gives learners a taste of subject-matter and may form the foundation of more advanced work (Roberts 1988). Doubtless the majority feel that they are only going through the motions (Jenkins 1993, p234-6) but what perhaps they may not realize is that they have an experience that allows intellectual, social and general development (Roberts 1988, p9). If nothing else, they have sampled something that they discover is not for them. The experience may be negative but it makes it nonetheless valuable (Calderhead 1988, p78).



Science may be useful for citizenship like a novel food; one soons discovers what one likes and dislikes and this can save some future disastrous experience and potentially expensive mistakes whether in a restaurant, college or undergraduate course. But how do we justify the high priority that science has in the curriculum (Roberts 1988, p3)? Scientific knowledge appeals to and is eagerly sought by a wide range of individuals and groups (Jenkins 1993, p232) because it may be useful but it must be careful not to serve only as a filtering gateway for a minority of students into scientific professions (Fensham 1993, p109).

It influences many other lives at various contact points and it should be these points which are used as the basis of courses suitable for the majority in our colleges and schools (ibid.p116).

One function of our colleges and schools may be as guardians and transmitters of our society's culture (Fensham 1988, p2-15) and as science is primarily a human enterprise it should contribute to the general personal and intellectual development of our future

citizens, making them able to participate fully in social and political choices (Fensham 1993, p107). It also exerts influence over economics and culture but most of all it is important for an individual's development (ibid. p109).

Science may be able to say a lot about people's personal lives because it enhances the need to look after oneself and be protected from the flow of incomplete information. Such knowledge can prevent unrealistic expectations evolving into disenchantment and hostility (Jenkins 1993, p235) because science cannot operate without a knowledgeable supportive society (Harlen 1993,p126) and its applications cannot take root without an informed public (ibid. p126). It is related to a world of both work and leisure to allow better participation in a democratic society. It should be applicable to local circumstances (ibid.,p129) but also give meaning to global experience, improve living conditions, increase productivity and well-being within societies (ibid.,p129) while at a more individual level it allows an evaluation of scientific evidence used in adverts, diet, medication and energy useage (Jenkins 1993, p235).

Certain Learned Societies, according to Jenkins (1993, p234), seem to believe that science is important for citizenship because improving public understanding is an investment for the future and not a luxury to be indulged in when the resources allow because it can improve the national prosperity, raise the quality of decision making and enrich the lives of individuals (ibid.,p234) whether they are in school, college or university (Blin-Stoyle 1993), from ethnic minorities (Dennick 1993) or areas of social deprivation (Solomon 1993), or are girls (Harlen 1993) or pupils with special educational needs (Purnell 1993).

Science must cater for them all while bearing in mind that we are all citizens of Planet Earth and must not neglect the inequalities between advanced and third-world countries (Chapman 1993, p269-71) so it is important that we instil compassion and creativity as well as competence and curiosity (Baez 1993, p283 - 286) in our citizens. And this is something, perhaps, that science has the potential to do?

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References

Baez, A.V. (1993) Curiosity, creativity, competence and compassion-guidelines for science education in the year

2000 in Whitelegg, E., Thomas, J. and Tresman S. (eds), *CHALLENGES AND OPPORTUNITIES FOR SCIENCE EDUCATION,* London, PCP Ltd.

Blin-Stoyle, R. (1993) Science education through college and school, college and university in Whitelegg, E., Thomas, J. and Tresman S. (eds), *CHALLENGES AND OPPORTUNITIES FOR SCIENCE EDUCATION,* London, PCP Ltd.

Calderhead, J (1988)The Development of Knowledge Structures in The Open University (1994) ES821 Science Education Study Guide. Milton Keynes. The Open University. hapman, B. (1993) The overselling of science education in the eighties in Whitelegg, E., Thomas, J. and Tresman S. (eds), *CHALLENGES AND OPPORTUNITIES FOR SCIENCE EDUCATION,* London, PCP Ltd.

Dennick, R., (1993) Analysing multicultural and antiracist science education in Whitelegg, E., Thomas, J. and Tresman S. (eds), *CHALLENGES AND OPPORTUNITIES FOR SCIENCE EDUCATION,* London, PCP Ltd.

Fensham, P.J. (1993) Reflections on science for all in Whitelegg, E., Thomas, J. and Tresman S. (eds), *CHALLENGES AND OPPORTUNITIES FOR SCIENCE EDUCATION,* London, PCP Ltd.

Fletcher, K. (1997) Reflecting on practice: toward improving the delivery of future science lessons through collaborative reflection on previous lessons. Unpublished MA assignment (TMA04). Milton Keynes. The Open University.

Harlen, W (1993) Education for equal opportunities in a scientifically literate society in Whitelegg, E., Thomas, J. and Tresman S. (eds), *CHALLENGES AND OPPORTUNITIES FOR SCIENCE EDUCATION,* London, PCP Ltd.

Jenkins, E. (1993) Scientific literacy and college and school science education in Whitelegg, E., Thomas, J. and Tresman S.(eds), *CHALLENGES AND OPPORTUNITIES FOR SCIENCE EDUCATION,* London, PCP Ltd.

Purnell, R. (1993) Teaching science to children with special educational needs in Whitelegg, E., Thomas, J. and Tresman S. (eds), *CHALLENGES AND OPPORTUNITIES FOR SCIENCE EDUCATION,* London, PCP Ltd.

Roberts, D.A. (1988) What counts as science education? in Fensham, P.J. (ed) *DEVELOPMENT AND DILEMMAS IN SCIENCE EDUCATION.* East Sussex. The Falmer Press.

Solomon, J. (1993) Science teaching in areas of social deprivation in Whitelegg, E., Thomas, J. and Tresman S.(eds), *CHALLENGES AND OPPORTUNITIES FOR SCIENCE EDUCATION,* London, PCP Ltd.

Acknowledgements

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The images used in this article were taken from:

Photosynthesis: http://www.1ststeps.org/Science/Photosynthesis/photosynthesis-color.jpg

Laboratory: http://www.waze.com/blog/wp-content/uploads/2010/01/laboratory.jpg

http://www.dovepress.com/cr_data/journal_image/80/thumb_215_215_100.jpg

http://newstsoldier.com/images/pics/lab5.jpg

Windsurfer: http:// www.purbeck.gov.uk/images/windsurfer.jpg

Origins, part 1:
The special theory of relativity

Estelle Asmodelle ▶

The special theory of relativity is a little over 100 years old, and in five years' time general relativity will reach the century mark. Part 1 of this report will explore the origins of the *special theory of relativity*, while part 2 will cover the origins of the *general theory of relativity*. For many it is not clear what science went before relativity, for most believe Einstein constructed every aspect of relativity. In terms of special relativity it was really about a conceptual leap rather than constructing a whole new theory and mathematics, for all the science was there waiting for someone to properly interpret it. The situation with general relativity is a little different but we will explore that later in part 2, in another issue of this journal.

In order to understand the development of the special theory of relativity we must understand the means by which physical aspects of the theory were experimentally validated. The special theory of relativity is the most tested theory in physics, yet in the past couple of decades more stringent tests have been performed, looking for invariance in both the special and general theory as a means to unify quantum physics with relativity. The main focus of this report is to outline the most significant initial experiments or pre-validation tests. Many of these experiments and observations were performed prior to Einstein's publication of special relativity.

Ancient theories of light

Understanding the finite velocity of light is the primary precept of relativity, and many great minds of antiquity have conjectured theories of light, including: Pythagoras, Plato, Euclid, Alhazen, and many others, while some theories were correct and others were not. Many believed that the speed of light was infinite, yet some believed light had a finite velocity, such as Empedocles [circa 490–430 BC].

Galilean invariance

Galileo firmly believed that light travelled at a finite velocity and is credited with being the first scientist to try to measure the speed of light (Serway 2007). This method was introduced in *Dialogues Concerning Two New Sciences* (Galileo 1638), where Galileo described an experimental method to measure the speed of light. He goes on to claim that the experiment was tried but a time lag could not be detected and so he assumed that light travelled at least ten times faster than sound.

More significantly, by 1604 Galileo had begun experiments for the first time with accelerated motion, which led to his law of falling bodies; whereby Galileo developed the equivalence principal [all masses accelerate at the same rate in a gravitational field], and Galilean invariance or what would later be referred to as Galilean relativity (Holcomb & Hawley 2005).

Einstein in 1905: Photo taken at the time of Special Relativity (Image courtesy Wiki Commons)

Speed of light

In 1675, Ole Roemer calculated the speed of light, measuring the visibility of Juptier's moons as compared with their calculated position. He arrived at the startling figure of 3.07×10^8 m s^{-1} (Mannion & Grego 2010), which is reasonbly close to the correct value of 2.998×10^8 m s^{-1}. This was Galileo's old method on an astronomical scale and in a sense it was the first validated building block of relativity: the finite velocity of light.

Newton's corpuscular theory

Around the time of Isaac Newton, circa 1730, it was believed that an *ether*[1] permeated space through which light could propagate; later to be referred to as the luminiferous aether or aether, meaning light-bearing aether. In fact the aether concept had been around in various forms since antiquity; it has previously been referred to as the *plenum*, and had originated in the Hellenistic period in ancient Greece but it had taken an *ether* like form with Rene Descartes' theory of the plenum (Slowik 1997).

[1] Ether or Aether: Is the term for the cosmological medium. Michelson, Morley, and Einstein, used the 'ether' spelling.

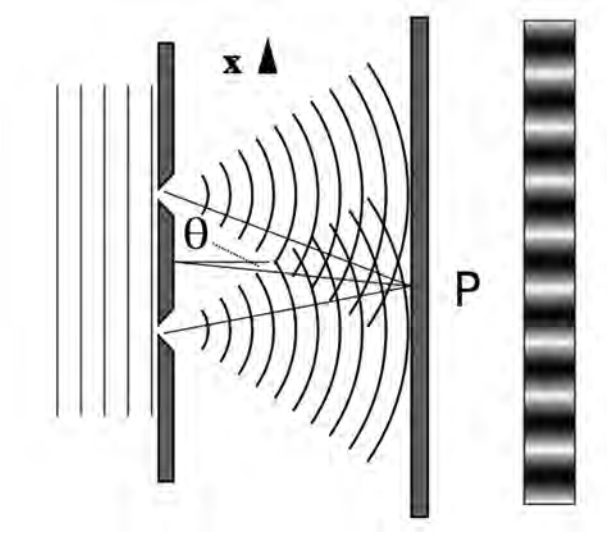
Although Newton's corpuscular theory of light did not require the existence of the ether, he preferred Pierre Gassendi's particle theory to Descartes' theory of the plenum. However competing theories of light, such as the wave theory of Christiaan Huygens did require the existence of the ether and were gaining support (Huygens 1678). Newton based his theory on absolute space and time and adhered to the principle of Galilean relativity (Newton 1687). Newton, by combining mechanics and the corpuscular theory of light, had the most comprehensive mathematical description of nature, albeit with some inconsistencies.

In Newtonian-Galilean space Newton's law of inertia holds, and it is referred to as an *inertial frame* of reference. From the laws of mechanics it follows that, if one such inertial frame exists, then an infinite number of them also exist. In all reference frames, only those frames moving with constant velocity with respect to a given inertial frame are considered inertial frames (Stachel 2001). And so in Galilean relativity the sum of velocities is a simple matter, for example if a ship is moving relative to the shore at velocity v, and a bird is moving with velocity u as measured on the ship. Then the velocity of the bird as measured on the shore, s, is simply as follows:

$$s = v + u$$

Early aether experiments & light theories

In the same year that Newton died, 1727, James Bradley noticed that he had to tilt his telescope in the direction of the movement of the Earth in order to see the bright star named γ Draconis in the constellation Draco (Maers & Wayne 2011). Draco is almost perpendicular to the elliptic path which the Earth takes in its annual revolution around the sun, showing that the images of stars move in small ellipses (Bradley 1728). This was explained correctly as *stellar aberration* due to the Earth's motion around the sun. However this is inconsistent with a simple model of light as waves in an ether which is dragged along by the Earth, but it is consistent with special relativity and probably one of the very first pre-validation observations.



Young's double slit experiment (Image courtesy Wiki Commons)

Long after Newton's death, circa 1803, Thomas Young put forth a number of theoretical reasons in support of the wave theory of light, and developed two enduring experiments to support his theory (Young 1803). In once such experiment he demonstrated the idea of interference using the double-slit apparatus, indicating that the interference of light could only be interpreted in the context of a wave theory of light.

The double slit experiment would later have more to do with Einstein's photoelectric effect (Einstein 1905 c) and the wave–particle duality of quantum theory, but it is highly significant and would lead to more complete theories. "Richard Feynman was fond of saying that all of quantum mechanics can be gleaned from carefully thinking through the implications of this single experiment," (Greene 999).

A few years later, in 1810, François Arago believed that variations in the refractive index of different substances, such as the air and in the glass of a telescope, as predicted by the corpuscular theory would provide a useful method for measuring the velocity of light (Arago 1858). He examined the expected change in focus of a refracting telescope due to Earth's motion around the sun, but Arago only observed ordinary stellar aberration.

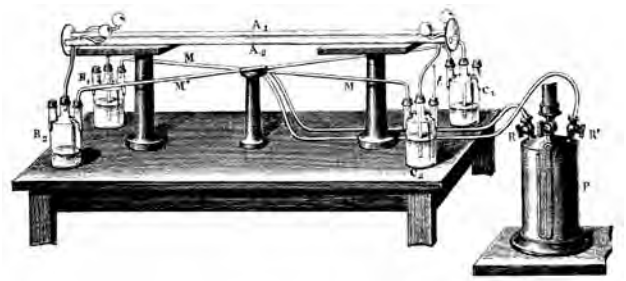
Eight years later in 1818 Augustin Jean Fresnel, building on experimental work by Thomas Young, extended the wave theory of light to a large class of optical phenomena and examined Arago's results within the context of a wave theory of light: that light propagates as a transverse wave in an elastic medium called the luminiferous aether. He understood if light were transmitted as waves through the different refractive indexes of the glass-air interface of a telescope, then, they should vary as the glass moved through the aether to strike the incoming waves at different velocities as the earth rotated and the seasons changed: referred to as the *aether drag*. He predicted this result to be represented by:

$$v_d = v \left[1 - \frac{e}{g} \right]$$

The aether drag adjustment is given by v_d, where ρ_e is the aether density in the air, ρ_g is the aether density in the glass and v is the velocity of the prism with respect to the aether.

Fresnel's aether drag hypothesis explained the null result of Arago's experiment. It also introduced the concept of a largely stationary aether which is dragged by dense substances such as glass but not by air or less dense substances. And so the wave theory of light was finally accepted after Fresnel's work, together with mathematical calculations and predictions, which largely supported Young's ideas (Holcomb & Hawley 2005).

In 1846, George Stokes suggested that Fresnel's complicated solution involving the partial dragging of aether was sufficient to explain stellar aberration, but it was not necessary if one took into consideration the friction that would be experienced by the Earth moving through a viscoelastic aether (Maers & Wayne 2011), exemplifying a fully dragged aether.

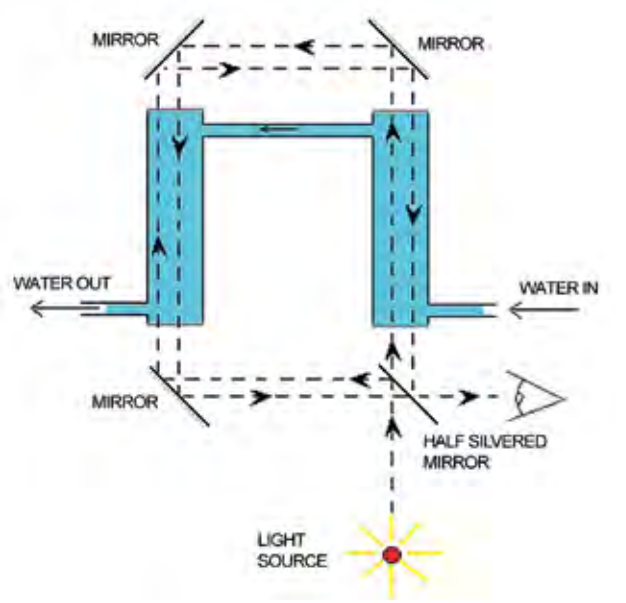


The apparatus used in Fizeau's experiment (Image courtesy Wiki Commons)

A couple of year earlier, Austrian physicist Christian Doppler, in 1842, had proposed that the change in frequency of a wave for an observer moving relative to the source of the wave would result in a shift: the *Doppler shift*. The received frequency would be higher [compared to the emitted frequency] during the approach, while it would be identical at the instant of passing, and it would be lower during the recession.

Interestingly, Hippolyte Fizeau independently discovered the same *shift* phenomenon in electromagnetic waves in 1848. Then a couple of years later in 1851 Fizeau, building on Fresnel's formula, which had been derived without experimental evidence, designed an ingenious interferometer that tested the aether convection coefficient (Fizeau 1859). The experiment was designed to evaluate the prediction by Fresnel that a moving dispersive medium should create a partial offset in the speed of any light moving through it, for the refractive index would be dependent on the entrainment of the luminiferous aether.

Fizeau's experiment (Image courtesy Wiki Commons)



This was the first such test of Fresnel's formula. The errors were quite large yet Fizeau assumed the result was indeed experimental confirmation. However Fresnel's hypothesis comprised of not one, but two postulates:

1. *the ether through which the Earth travels remains stationary;*
2. *the ether in moving transparent media travels more slowly than outside it.*

However, Fizeau's experiment only confirmed the second postulate and not the former. At the same time Fizeau worked with Jean Bernard Léon Foucault and created the Fizeau–Foucault apparatus, which was the first terrestrial experiment designed for measuring the speed of light, using a rotating mirror (Morizot et al. 2011).

A few years later Martinus Hoek carried out a similar experiment, using a similar instrument to Fizeau's interferometer, but with only one arm containing water (Hoek 1868), to utilize the speed of the Earth moving around the sun. Light passed through water in one arm and through air in the other; so that, light traveling in one direction around the interferometer propagated through the water parallel to the motion of the earth around the sun, while light traveling in the opposite direction propagated antiparallel to that motion. Hoek's finding was that the light propagated through the water in parallel to the velocity of the Earth at the same speed that it propagated through the water antiparallel to the velocity of the moving Earth, providing essentially a null result.

Hoek calculated a function ø that would compensate for the velocity of the water through the stationary aether and thus explain the vanishing optical path difference between the light propagating in the two directions. This function ø was identical to Fresnel's drag coefficient, further supporting the significance of the Fresnel drag coefficient (Maers & Wayne 2011).

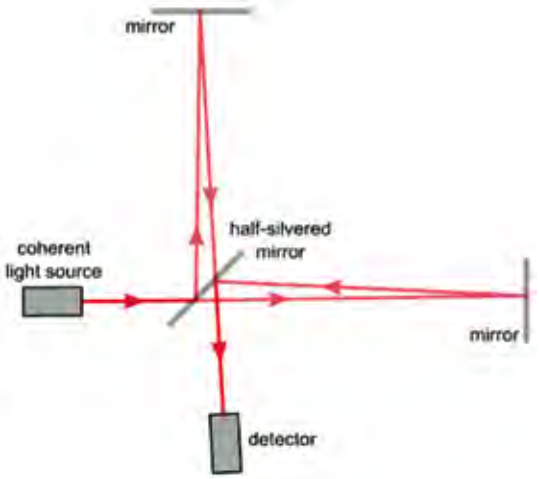
Around the same time, in 1864, James Clerk Maxwell had developed an accurate theory of electromagnetism by deriving a set of equations in electricity and magnetism now called Maxwell's equations. He first proposed that light was in fact undulations, or electromagnetic radiation, in the same aetherial medium which is the cause of electric and magnetic phenomena; namely, an all-pervading plenum in the universe.

However, Maxwell's theory was unsatisfactory regarding the optics of moving bodies, and while he was able to present a complete mathematical model, he was not able to provide a coherent mechanical description of the aether (Born 1964). However, it seemed possible to determine absolute motion relative to the aether and therefore disprove Galilean invariance. Most interestingly though, when Maxwell was calculating the speed of electromagnetic waves, he postulated that light exerted pressure, or radiation pressure, and carried momentum.

A few years later in 1887 Heinrich Hertz demonstrated the existence of electromagnetic waves, which consolidated academic acceptance of Maxwell's theory. In addition, Oliver Heaviside and Hertz further developed the theory and introduced modernized versions of Maxwell's equations. The Maxwell-Hertz or Heaviside-Hertz Equations subsequently formed an important basis for the further development of electrodynamics. It should also be noted that other important contributions to electromagnetic theory were made by George FitzGerald, Joseph John Thomson, John Henry Poynting, and Joseph Larmor. Then in 1871, Sir George Airy performed an experiment which had earlier been proposed by Ruđer Josip Bošković (Airy 1871), and showed that the angle of stellar aberration of γ Draconis did not change when the telescope was filled with water instead of air. In his

discussion he did not mention whether he thought that the aether was partially dragged by moving bodies as proposed by Fresnel or completely dragged as proposed by Stokes. A year later in 1872 Ed Ketteler performed an experiment on interference and polarization similar to Hoek, in which two rays of an interferometer were sent in opposite directions through two mutually inclined tubes filled with water (Kettler 1872). No change in the interference fringes occurred.

After this an experiment by Éleuthère Mascart (1872) was also performed. It was designed to find a change of rotation of the polarization plane, in quartz, when the light rays had the direction of Earth's motion, and then in the opposite direction. The experiment showed that the interference fringes of polarized light in calcite remained uninfluenced as well (Mascart 1872). In that same period Lord Rayleigh conducted similar experiments with improved accuracy, and obtained a negative result also.



Michelson interferometer (Wiki commons)

The Michelson and Morley experiment

Now we move to the crucial turning point in the search for the aether, with an experiment which was performed over a decade later in 1887 by Albert Michelson and Edward Morley. The Michelson-Morley experiment was designed to detect interference patterns in light caused by the drift in the luminiferous aether (Michelson-Morley 1887). The experimental apparatus was essentially an interferometer, a refined version of Fizeau's experiment, and would indeed become the most famous failed experiment in all of physics.

The original Michelson-Morley interferometer (Courtesy Case-Western Reserve University)

The Michelson interferometer was supposed to create alternating interference fringes on a detector caused by the anisotropy of the motion of the earth relative to the *aether drift*, but only a static interference pattern was produced. However it indirectly proved the constancy of the speed of light across different inertial reference frames, which removed the conceptual need for a luminiferous aether to provide a rest frame for light.

In a real sense the null result of the Michelson-Morley experiment was in fact the first pre-validation of special relativity; in that, it proved the speed of light was constant for all reference frames but no one had realized it at the time. Interestingly, this occurred when Albert Einstein was only 8 years old.

A year later Wilhelm Röntgen described an unsuccessful experiment, where he tried to measure the velocity of the Earth through the aether (Roentgen 1888). The experiment was a primitive version of the *Trouton-Noble experiment*, which was performed later in 1903, in an attempt to measure the velocity of the Earth's movement through aether by observing the rotation of a charged capacitor.

The Lorentz transformations

Almost a decade later Dutch physicist Hendrik Lorentz extended Maxwell's theory of electricity and of light, together with his own electron theory, and the classical theory of electromagnetism obtained a more complete form. At the time it was referred to as the Maxwell–Lorentz theory (Berends 2009). Furthermore, in a book by Lorentz in 1895, he demonstrated the invariance of Maxwell's equations in two inertial frames (Lorentz, *Attempt of a Theory of Electrical and Optical Phenomena in Moving Bodies* 1895), using a set of transformation equations, which were correct to the first order of approximation v/c. This is the first form where the velocity of light in a vacuum, c, is used as a constant within a reference frame with a given velocity, v.

During 1900-1904 Lorentz worked on describing electromagnetic phenomena (Lorentz 1904), namely the propagation of light in reference frames, in relation to moving electrons which moved relative to each other. Lorentz attempted to explain the null result of the Michelson-Morley experiment to detect motion through the aether, by developing a theory based on an immobile aether by proposing that moving bodies contract in the direction of motion, later to be referred to as *length contraction*. Lorentz was a firm advocate of the luminiferous aether and used his mathematics to describe the physical behaviour of an aether, which existed but was not detected by the failed experiment (Schaffner 1969).

Joseph Larmor (Larmor 1897) had also, quite independently and separately, worked on the phenomena. However, it was Lorentz who realized that the transition from one reference frame to another could be expressed by using a new time variable which he referred to as *local time*. The difference between the *local time* and the *true time* was vx'/c^2 for each point on the x' axis of the moving system. Lorentz's publications of 1895 and 1899 (Lorentz 1899) made use of the term local time without giving a physical interpretation of its relevance (Schaffner 1969). The *local time* depended on the universal time and the location under consideration.

In his paper: *'Electromagnetic phenomena in a system moving with any velocity smaller than that of light,'* (Lorentz 1903), Lorentz added *time dilation* to his transformations and published what Poincaré would later, in 1905, refer to as the *Lorentz transformations*.

The mathematical transformations resulted in what is referred to as the *Lorentz factor* and was used to describe both length contraction and time dilation:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

In addition, in Lorentz's 1904 paper he included a detailed treatment of the increase of the inertial mass of rapidly moving objects (Schaffner 1969).

Henri Poincaré

In 1895 the French mathematician, Henri Poincaré, expressed his dissatisfaction with Lorentz's ad hoc hypotheses to explain the null results of the Michelson-Morley experiment, and emphasized the need for a more general principle. On the 5th June 1905, based on Lorentz's aether theory, Henri Poincaré published a paper which proposed the *relativity principle* as a general law of nature (Poincaré 1905), including electrodynamics and gravitation. He discussed the *principle of relative motion* in two papers in 1900 (Poincaré 1900), and later in 1904 referred to it as: the *principle of relativity* (Poincaré 1904). Poincaré believed in the hypotheses of a *local time* and recognized its importance in the context of the principle of relativity. He showed that the concept of a *local time*, introduced by Lorentz, could be given a simple physical interpretation. Poincaré had described a synchronization procedure for clocks at rest relative to each other and so two events, which are simultaneous in one frame of reference, are not simultaneous in another frame. This is very similar to the one later proposed by Einstein.

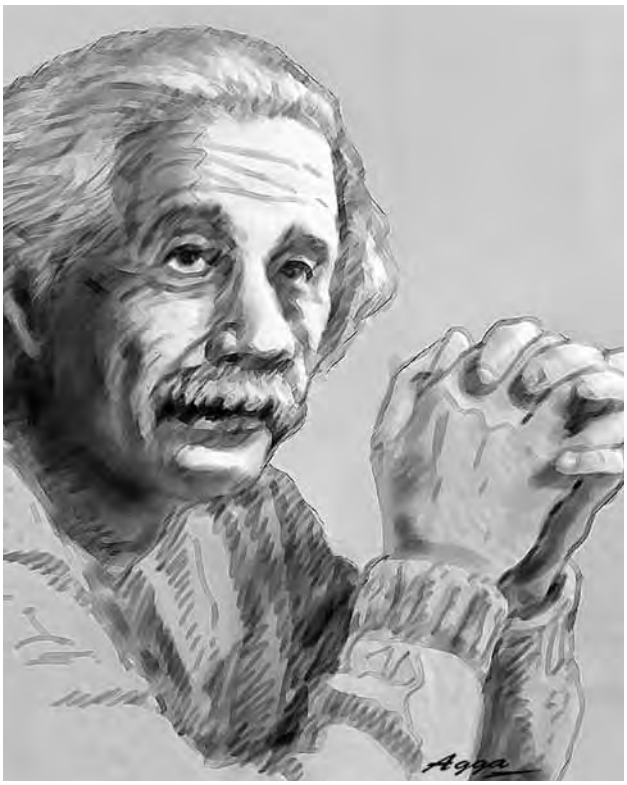
However, Poincaré made the mistake of distinguishing between *local time* of moving clocks, and the *true time* of resting clocks in the aether. This was a crucial mistake that prevented Poincaré from formulating *special relativity*. Consequently, he was not ready to take the important step of eliminating the aether, for he'd stated it was a convenient hypothesis. This concept was in conflict with the spirit of the principle of special relativity which is supposed to treat all frames as equal.

However, it cannot be understated that Poincaré was the first to recognize that the Lorentz transformation had the properties of a mathematical group, and named it after Lorentz. Although the Lorentz transformation was a homogeneous group, Poincare' went on to mathematically perfect and further develop the transformation into inhomogeneous Lorentz transformation, or what was referred to as the *Poincaré transformation*. In any case Poincaré had perfected the mathematics of relativity, even though he'd made some vital conceptual errors.

Additionally and quite intriguingly, in the paper of 1900, Poincaré said that radiation could be considered as a fictitious fluid with an equivalent mass of $m = E/c^2$ (Poincaré 1900). He derived this interpretation from Lorentz's theory of electrons, which also incorporated Maxwell's radiation pressure. This was the first form of $E = mc^2$ and it was published 4 years earlier than Einstein's papers.

During the same period, in 1901, Walter Kaufmann began to experiment with a custom cathode ray tube by applying electric and magnetic fields to measure the ratio of the charge and mass of electrons (Kaufmann 1901). Since the charge and speed of the electrons did not change, any change of the ratio must be the result of a change of their mass. These experiments by Kaufmann (1901–1903) appeared to show a slightly different mass increase confirming the relativistic mass relationship (Kaufmann 1903).

Einstein's relativity



Albert Einstein was born at Ulm, in Württemberg, Germany, on March 14, 1879. He attained intellectual fruition at a moment when the dilemma of the behaviour of light required a new interpretation, and all the mathematics and concepts where waiting ready. Time was ripe for a paradigm change. This would lead to the *special theory of relativity* and later the *general theory of relativity*. It's not unlike the problem that surrounds physics today: the resolution of general relativity with quantum theory. But was Einstein's conceptual enlightenment due to the enlarged inferior parietal region of his brain [the area associated with mathematical ability] (Abraham 2005), or simply a true conceptual understanding of all the experimental physics that had taken place some decades before? This author believes it's the latter.

1905 was Einstein's annus mirabilis or miracle year. He published four groundbreaking papers, and of particular interest is: *"Elektrodynamik bewegter Körper,"* translated: *"On the Electrodynamics of Moving Bodies,"* (Einstein 1905). This is essentially *Einstein's special theory of relativity* which took him five weeks to complete and contains no formal references to other literature, and most interestingly Poincaré is not mentioned, yet Einstein did cite Poincaré in another paper on special relativity written a year later. The 1905 paper was published on the 26th September, 3 months after the Poincaré relativity paper, in which Einstein radically reinterpreted Lorentzian electrodynamics by changing the concepts of space and time and abolishing the need for a *physical aether*.

Einstein was aware of many of the concepts and mathematical tools developed by Lorentz and in Poincaré's earlier work of 1902, but derived the Lorentz transformation equations independently, using the principle of constancy of velocity of light and the relativity principle. He was the first to argue that those principles, together other basic assumptions about the homogeneity and isotropy of space, were sufficient to derive the theory. And as a result this theory was initially referred to as the Lorentz-Einstein theory. He obtained all the same results as Poincaré, and also made mention of the fact that the Lorentz and associated transformations are the elements of a mathematical group.

Einstein transformed Lorentz's notion of *local time*, while retaining Poincaré's physical interpretation into a standard definition of time which was valid for all of nature without any preferred reference frame. This was complete relativistic invariance and was Einstein's main contribution to the principle of relativity: to recognize that there is no essential difference between a stationary and a moving frame of reference. Einstein was the first one to give up the idea of singling out a reference frame at rest relative to the aether. This paradigm shift enabled him to construct a simple logical structure based on the two basic postulates of relativity. Consequently, he was the first one to arrive at the exact transformation equations relating two inertial frames of reference.

Einstein had abandoned the luminiferous aether concept and talked of a *new aether*, pointing out that no substance and no state of motion can be attributed to that *new aether*. The new aether found little support in physics and was later abandoned by physicists. Einstein stated in 1950 that the observational results of stellar aberration and Fizeau's experiment *'were enough'* for him to develop the special theory of relativity (Shankland 1963). In fact, Einstein wrote that the Fizeau experiment, which could be viewed as a determination of the correct relativistic formula for the addition of velocities and which showed that the simple Galilean addition law for velocities was incorrect. It was a crucial test in favor of the theory of relativity. (Maers & Wayne 2011).

Lastly, according to Einstein's special theory of relativity, the frame of reference for the ship, in our former example, has a different clock rate and distance measure, and the notion of simultaneity in the direction of motion is altered, and so the addition law for velocities is changed. This change isn't noticeable at low velocities but as the velocity becomes relativistic it becomes important. The addition law is also called a composition law for velocities. For collinear motions, the velocity of the bird relative to the shore is then given by:

$$s = \frac{v+u}{1+\frac{vu}{c^2}}$$

Consequentially, in 1905 Einstein was the first to suggest that when a body lost energy, either in the form of radiation or heat, of amount ΔE, it's mass decreased by the amount $\Delta E / c^2$. Interestingly, the famed Einstein equation: $E = mc^2$ was published in his paper on mass–energy equivalence (Einstein 1905 b), and derived from his special relativity equations, but the formula did not appear in the special relativity paper of 1905 (Einstein 1905).

Relativity priority dispute

During the time that Einstein formulated his special theory of relativity he was aware of the failed Michelson-Morley experiment, Lorentz's work, and Poincare's 1902 book (Poincaré, *La Science et l'Hypothèse* 1902), yet many suggest he'd also read Poincare's relativity paper (Poincaré 1905) and plagiarised it, but Einstein had always emphatically denied reading it. He'd also read the work of the Scottish philosopher David Hume about the nature of space and time, which seemed to contribute to his conceptual understanding.

Many suggest that it was Poincaré who really developed relativity theory (Whittaker 1910), but as outlined above this is not entirely true. However, Poincaré did contribute greatly as did Lorentz. Einstein was awarded the Nobel Prize for his work on the photoelectric effect (Einstein 1905 c), not relativity, but if he had been awarded the prize for special relativity, then perhaps he would have shared it with Poincaré, and perhaps even Lorentz. But Einstein's greatest feat was not *special theory of relativity* but the *general theory of relativity* which by many is considered the greatest intellectual achievement of all time as we shall see in part 2 (Ashtekar 2005).

However, there are many scholars who feel that Einstein's role in formulating the special theory of relativity was limited to elaborating on the theoretical insights of Poincaré and Lorentz and that Einstein had little to contribute in terms of originality. This is the essence of the relativity priority dispute which has contentiously resurfaced since Einstein's time and even now many scholars still believe that Einstein was a plagiarist, yet they ignore the fact that Einstein has publish several other very important papers, for a plagiarist is not someone who can develop ground breaking theories in several areas of physics at the same time.

It is true that Einstein's unique and radical point of view established the universal validity of the *principle of special relativity*, while many great physicists and mathematicians, Poincaré in particular, came very close to anticipating the subtleties and had collimated the mathematics therein. Yet it was Einstein who dispensed with the aether and adapted a purely physical theory.

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Estelle is active in writing about astrophysics, is an associate member of the *Institute of Physics* (UK) and a member of the *Australian Society of Authors*.

Bibliography

Abraham, C. *Possessing Genius.* Icon Books, 2005.

Airy, G.B. *Proc. Royal Soc.* 20 (1871): 35.

Arago, François. *Oeuvres complètes.* Paris: Tome Huitieme , 1858.

Ashtekar, A. *New Journal of Physics* 7 (2005): 198.

Berends, F. *J. Phys.: Condens. Matter* 21, no. 16 (2009).

Born, M. *Einstein's Theory of Relativity.* Dover, 1964.

Bradley, J. *Phil. Trans.* 35, no. 406 (1728).

Einstein, A. *Annalen der Physik,* no. 17 (1905): 891-921.

Einstein, A. *Annalen der Physik,* no. 18 (1905 b): 639–641.

Einstein, A. *Annalen der Physik,* no. 17 (1905 c): 132–148.

Fizeau, H. "Hypotheses on luminous ether." *Ann. de Chim. et de Phys.,* no. 57 (1859): 385-404.

Galileo, G. *Dialogues Concerning Two New Sciences.* 1914. Translated by Crew & Salvio. Macmillan, 1638.

Greene, B. *The Elegant Universe.* New York: W.W. Norton., 1999.

Hoek, M. *Archives Neerlandaises des Sciences Exactes et Naturelles,* no. 3 (1868): 180.

Holcomb & Hawley. *Foundations of Modern Cosmology.* London: Oxford University Press, 2005.

Huygens, C. *Treatise on Light.* Translated by 1912 Thompson. University of Chicago Press, 1678.

Kaufmann, W. *Physikalische Zeitschrift* 3 (1901): 9-15.

Kaufmann, W. *Göttinger Nachrichten* 3 (1903): 90-103.

Kettler, E. *Pogg. Ann.,* no. Bd. 144 (1872): 370.

Larmor, J. *Phil. Trans.* Roy. Soc., no. 190 (1897): 205-300.

Lorentz, H. A. *Proc. Acad. Science Amsterdam* 1 (1899): 427–442.

Lorentz, H. A. *Proc. Acad. Science* 6 (1904): 809–831.

Lorentz, H. A. *Koninklijke Nederlandsche Akademie van Wetenschappen Proceedings* 6 (1903): 809-831.

Lorentz, H. A. *Attempt of a Theory of Electrical and Optical Phenomena in Moving Bodies.* Leiden: E.J. Brill, 1895.

Maers & Wayne. "Stellar Aberration and the Fizeau Experiment." *The African Physical Review,* no. 5 (2011).

Mannion & Grego. *Galileo and 400 Years of Telescopic Astronomy.* New York: Springer, 2010.

Mascart, A. *de l'Ecole Normale* T.1, no. 2e ser. (1872): 210-214.

Michelson-Morley. *American Journal of Science* 34, no. 3rd series (1887): 203.

Morizot et al. Eur. *J. Phys.* 32 (2011): 161.

Newton, I. *Principia.* 1st American Edition ed. Translated by Motte. New York: Daniel Adee, 1687.

Poincaré, H. *Compte rendus de l'Académie des Sciences de Paris,* no. 140 (1905): 1504-1508.

Poincaré, H. *The Foundations of Science,* 1904: 297–320.

Poincaré, H. *Archives néerlandaises des sciences exactes et naturelles* 5 (1900): 252-278.

Poincaré, H. La *Science et l'Hypothèse.* Paris: Flammarion, 1902.

Roentgen, W.C. *Annalen der Physik* 35 (1888): 264.

Schaffner, K. F. *Amer. J. Phys.* 37, no. 5 (1969): 498.

Serway, R. A. *Physics for scientists and engineers - Vol 1.* 007. Brooks Cole, 2007.

Shankland, R. S. "Conversations with Albert Einstein." *Am. J. Phys.* 31 (1963): 47-57.

Slowik, E. *Synthese* 112, no. 2 (1997): 247-269.

Stachel, J. *Einstein from 'B' to 'Z'.* New York: Birkhauser, 2001.

Whittaker, E. T. *A History of the theories of aether and electricity.* Dublin: Longman, Green and Co, 1910.

Young, T. *"Experiments and Calculations Relative to Physical Optics." Phil. Trans.* 94 (1803): 1-16.

VMware virtual servers

Geoff Howell ▶

So what is a virtual server? In simple layman's terms it is the virtual creation of a physical server, which incorporates hardware and software, allowing it to run on a physical host along with other virtual servers. Special server software divides one physical dedicated server into multiple virtual private servers (VPSs). VPSs have their own operating system and can be installed independently from each other. Therefore they function just like multiple, small, dedicated servers. Virtualisation has been around since the 1960s when IBM introduced virtualisation on its mainframe to reduce the cost of expensive hardware for simple tasks. Modern day computers are now facing a similar problem with computer and server been underutilised.

A virtual server is a server that is not entirely dedicated to running server software and is also involved in other activities. Such servers are known for their ability to provide low-cost web hosting services. It is possible to run several virtual servers at the same time in a single computer. But this may decrease the speed of the computer.

Virtual servers are created and managed with the assistance of a web-based interface. There are several virtual servers including those by Microsoft. Virtual servers depend on virtualisation to work and this is based on the technique of virtualisation which hides the physical characteristics of computing resources from the way in which other systems, applications, or end users interact with other resources. Thus virtualisation is a broad term and encompasses a lot of activities.

In 1998 Dianne Greene, Mendel Rosenblum, Scott Devine, Edward Wang, and Edouard Bugnion started to work on virtualisation and introduced its first product VMware virtual platform in February 1999. This was based on work they had done earlier at Stanford University. In 2001 they released VMware server on two platforms, the GSX server which was hosted and the ESX which was host-less. In 2003 VCenter and VMotion were lunched and are considered by many IT administrators as 'must have' applications. VMware is now one of the premier suppliers for virtual server systems worldwide and they have continued to develop new ground breaking applications ever since.

A usual sight when entering any computer server room would be a large number of individual physical servers, accompanied by uninterruptible power supplies (UPS) and air-conditioning units (see figure 1). The physical space and energy demands are very high and therefore costly. However, under the current tight economic climate many IT departments now have to find ways to do much more with less. As IT budgets tighten, they need to find ways of increasing their hardware utilisation and minimising the hardware/power costs without effecting performance or compromising efficiency. Virtualisation of the server room has been one aspect that has helped IT departments to achieve this through reducing the required number of physical

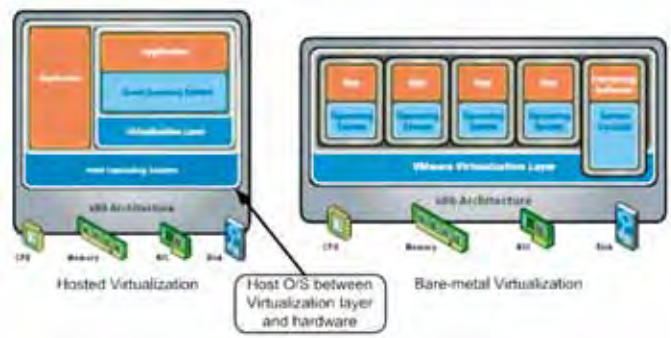
Figure 1 (Image courtesy Wiki Commons)

servers, UPS and air-conditioning units, while also significantly cutting their carbon footprint. There are numerous products on the market, such as Microsoft's Hyper V, Xen, and Virtualiron but the current market leader is VMware.

Traditionally IT departments had developed the simplistic approach of one application per server (i.e. SQL or Exchange) primarily to decrease the number of conflicts such as resources or the failure of an application which would result in the complete rebuild of a server. But it also severely underutilised the servers' resources such as the CPU and memory. What VMware allows is the separation of the software from the physical hardware allowing multiple instances of a guest operating system, it also manages the resources such as CPU, memory, network adapters and storage devices between each guest resulting in less physical devices and thus space (see figure 2).

Figure 2 (Image courtesy Wiki Commons)

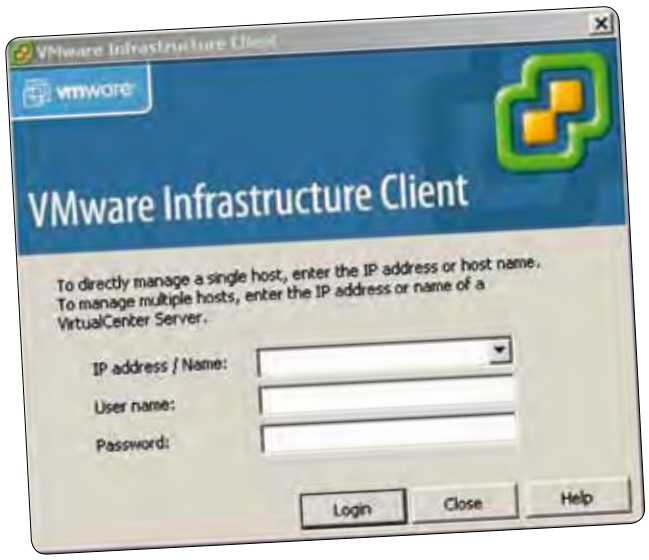
VMware esxi server (vSphere) is known as a bare metal hypervisor which allows the installation directly on to the hardware, unlike other products which need to be installed on a host operating system. This makes it extremely effective in terms of performance and installation.

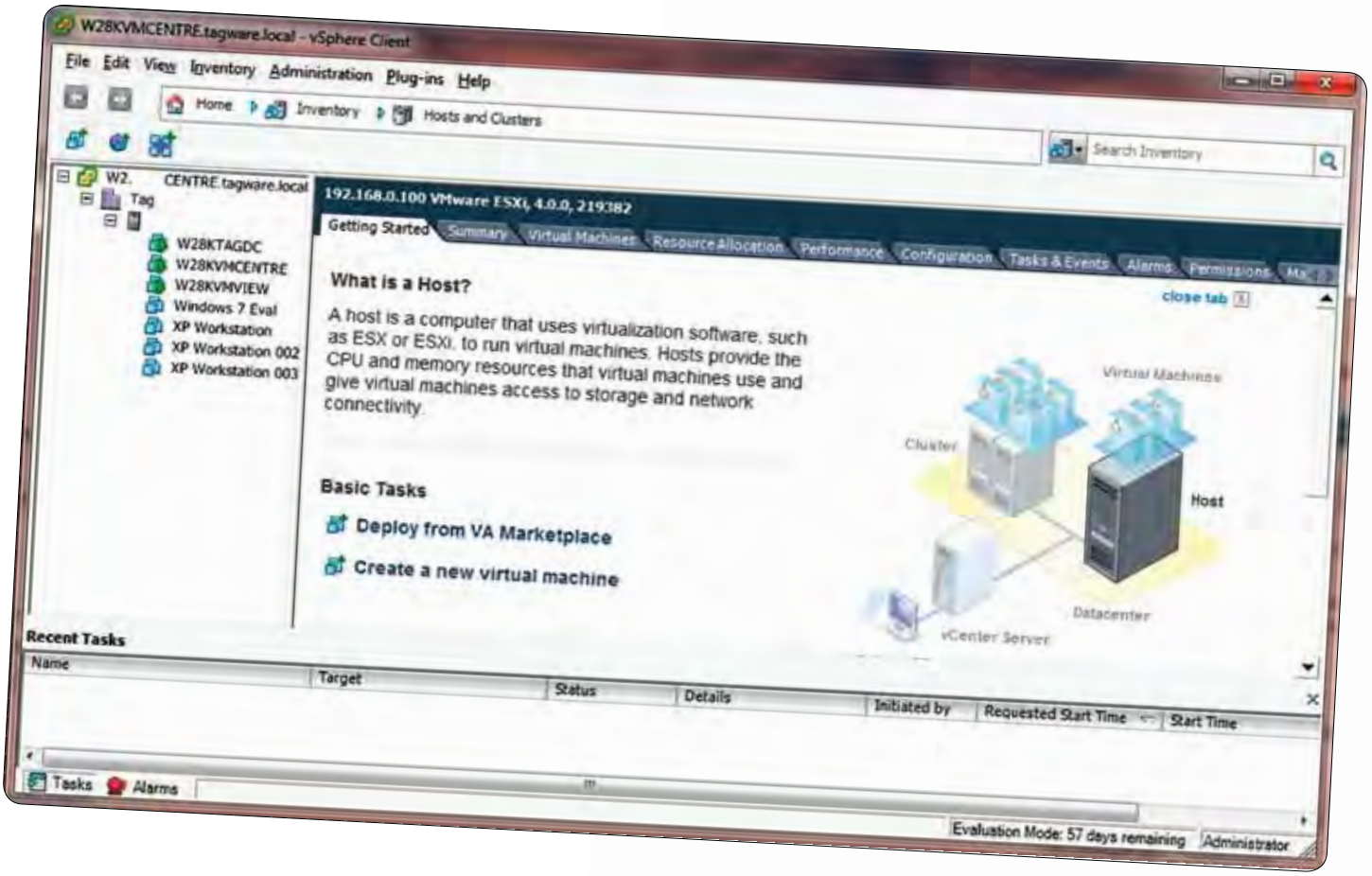


VMware Esxi (vSphere) allocates the hardware resources from the physical machine, such as memory and processor power for use on multiple virtual machines. This is controlled by the hypervisor, also known as the virtual machine manager; its client can be accessed from any standard computer. VMware also introduced 'Converter' which allows a physical server to be converted into a virtual server; this is a very useful application especially when converting older servers running software no longer available. It also allows multiple conversions at the same time which can save IT departments many hours and money on third party applications.

VMware esxi is offered free as a single host and gives IT departments the opportunity to build their own simple virtual infrastructure adding virtual machine and storage devices immediately. A number of paid upgrades are available to VMware esxi (vSphere) the most notable been VCenter which greatly improves the management of the virtual infrastructure.

VCenter is a centralised application that serves as proxy for managing esxi hosts and virtual machines allowing the esxi hosts to be aware of each other. VCenter can be added as a physical or virtual server but requires a 64 bit operating system this then allows the installation of 64 and 32 bit virtual machines unlike the free version that only allows 32bit systems. Other plug-ins such as High Availability (HA) and V-motion can then be used which greatly improving any IT infrastructure.





High Availability (HA) monitors all the virtual machines on the physical host of the VCenter cluster sending out 'heart beats'. If a failure is detected or a 'heartbeat' is not returned it restarts the virtual machine on another host in the cluster. All Physical hosts must be able to access the same storage device for this to work, and backing up virtual images must be done on a regular basis. While there will be some downtime it is only minutes compared to what would have been hours or days rebuilding a physical server.

VMotion also allows the migration of a running virtual machine from one physical server to another without any downtime and also identifies the best destination for the virtual machine in the cluster. This process takes only about thirty seconds and does not affect the end user in anyway. This can be useful when a physical host reaches its resource limits as it enables the administrator to move virtual machines quickly without interrupting the end users. In addition to High Availability (HA) and VMotion alleviating the resource pressures on many IT departments they also play unique roles in offering seamless disaster recovery of the virtual infrastructure.

To conclude, virtual servers give IT Departments the opportunity to simplify their IT Infrastructures making them more flexible, reliable and more compact with server resources being properly utilised. Over a short period of time they will dramatically reduce the cost of hardware even thought the initial outlay can seem expensive, and with good backup procedures in place will significantly aid the IT Administrator. End users should also benefit from a much less problematic system that can operate efficiently with very little down time.

Author

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Geoff works as IT Support Officer and IT Trainee coordinator at the University of Sheffield and works across departments in the Faculty of Engineering. He has an HNC in computing and business studies and has been at Sheffield for the past 11 years. Previous to his time at Sheffield he was a supervisor in warehousing, but following a prolonged recovery after a serious car crash Geoff has successfully changed his hobby of computers in to his new career, recently becoming a full member of the IST. This is his first published article.

References:

http://en.wikipedia.org/wiki/VMware 27/05/2011

http://www.101datasolutions.co.uk/manufacturers/vmware/vmware-esxi/ 03/06/2011

http://coldelm.com/Virtual-Server/virtual-server-explained.aspx 03/06/2011

http://www.vmware.com/virtualization/virtual-infrastructure.html 03/06/2011

http://www.vmware.com/products/high-availability/overview.html 06/06/2011

http://www.webhostingresourcekit.com/295.html 07/06/2011

http://www.hongkiat.com/blog/how-to-measure-front-end-website-performance/ 08/06/2011 (fig 1)

http://www.propertyweek.com/data/specialist-cost-update-services/3070763.article 08/06/2011 (fig 2)

http://www.virtualizationadmin.com/articles-tutorials/vmware-esx-and-vSphere-articles/VMotion-d

http://www.vmware.com/technical-resources/security/overview.html 10/06/2011

The design of a Peltier cryostat for laboratory and vacuum-line use

Kevin Scott ▶

The Peltier Cryostat as a convenient vacuum trap

There may be, in the laboratory, the occasional demand for a convenient source of refrigeration but this requirement is of such infrequency that the storage of liquid nitrogen or solid carbon dioxide is hardly justified. The Peltier cryostat described here is intended to meet the infrequent need of a convenient refrigerant, and although it can reach only between -30C and -40C, this can be sufficient in many circumstances where depressed temperatures are needed. It has been designed so that a small vacuum trap can be accommodated or it can be used on the laboratory bench for custom cooling of samples prior, say, to their being sealed into ampoules. It is used by the author in the manufacture and calibration of thermometers.

Design Principles

Some preliminary experimentation identified the critical design features of a Peltier cryostat. Peltier elements are widely available in the form of a "ceramic sandwich", typically 40mm square and about 4mm thick. They are available in a range of electrical specifications, typically carrying up to about 10 amps, having a resistance of 1-3 ohms. The Peltier elements can be configured in parallel or in series or in a series-parallel combination. Parallel configurations confer thermal transfer capacity while series arrangements confer higher temperature differentials between source and sink. A series- parallel configuration was first tried and is depicted in Figure 2.

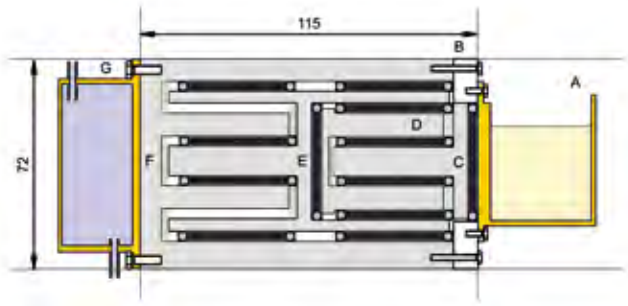

Figure 2 - A series-parallel multiple element cryostat. A brass bath containing acetone A is closely thermally coupled to a Peltier element and thence to aluminium alloy element C which, in turn has two peltier units connecting with Alloy element D. This in turn has three Peltier units connecting it with alloy element E. Element E has 6 Peltier units connecting it with alloy element F, which is thermally coupled with the watercooled brass envelope G. The performance of this combination was disappointing: a minimum temperature achievable of about -8 degrees C. The poor performance was probably due to the long thermal paths between the elements.

The design eventually adopted was a parallel design using 9 Peltier units depicted in the Figure 3.

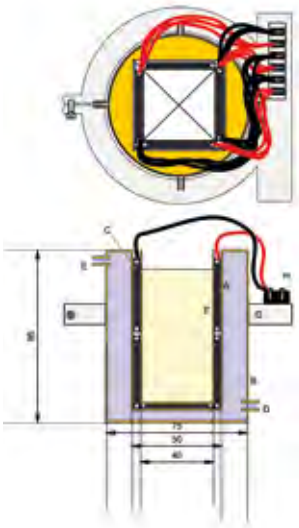

Figure 3 - A 9-element parallel design

A length of 50mm square brass box section tubing A, was fitted with a brass plate, silver soldered in place at the lower end and soldered into a top plate, in turn soldered into a 3 inch diameter tube B, also closed at the lower end. Brass inlet and outlet pipes, D & E were fitted to permit a flow of water to course through the annular void between tube A & jacket B. The inside of tube A was lined with TEC1-12706 Peltier units, cemented to the inside walls and floor of A using Loctite 315 high thermal conductivity cement. An inner, square section brass vessel F was fashioned from 0.5mm brass sheet and silver soldered to form a leak-tight reservoir. This reservoir was a tight push fit between the Peltier units and lubricated using thermally conductive silicone grease. A perspex block G was clamped to the exterior of A and fitted with a barrier connector strip H to which the fly leads from the Peltier units were secured. They were arranged in electrical parallel in groups of three and the groups were connected in series with a Hewlett Packard 6274B Power Supply. This was capable of delivering 15 amps at 60 volts if required and was programmable.

In use, the inner reservoir was filled with acetone and the outer jacket supplied with a current of mains water between 1 and 9 litres per minute. Current from the power supply was regulated between 4 and 13 amps.

Performance

The temperature of the acetone in the inner reservoir was measured using a Copper-Constantan thermocouple connected to a calibrated Comark electronic thermometer feeding a Yokogawa potentiometric recorder. The temperature of the outlet water was measured by Mercury in glass thermometer readable to 0.1 deg C.

The variation of temperature in the inner reservoir with the total current supplied through the array of Peltier elements was determined for currents between 4 amps and 13 amps. Table 1 gives the results.

Table 1 - Peltier Cryostat Performance

Current	water temp	cryostat temp	Temp Diff	voltage	power
amps	deg C	deg C	deg C	volts	watts
4	12.8	-13.65	26.45	10.8	43.2
5	13	-17.5	30.5	13.25	66.25
6	13	-20.7	33.7	16.07	96.42
7	13.3	-23.3	36.6	18.54	129.78
8	14	-25.4	39.4	21.2	169.6
9	14.1	-26.8	40.9	23.8	214.2
10	14.2	-26.9	41.1	26.2	262
11	15.2	-27.2	42.4	28.9	317.9
12	16.5	-26.9	43.4	31.8	381.6
13	17.3	-25.8	43.1	34.5	448.5

The data of table 1 is plotted in Figure 4, showing reservoir temperature against current in blue and total temperature difference against current in red. The water flow rate was 1.135 litres/minute. The minimum attainable temperature was -27.2 C with an outlet water temperature of 15.2 degrees. As expected, with currents in excess of about 11 amps, the heating contribution of the current offsets and exceeds the extra Peltier cooling the current provides. The red points in the graph show the total temperature difference which reaches a maximum at about 43 degrees at about 12 amps current.

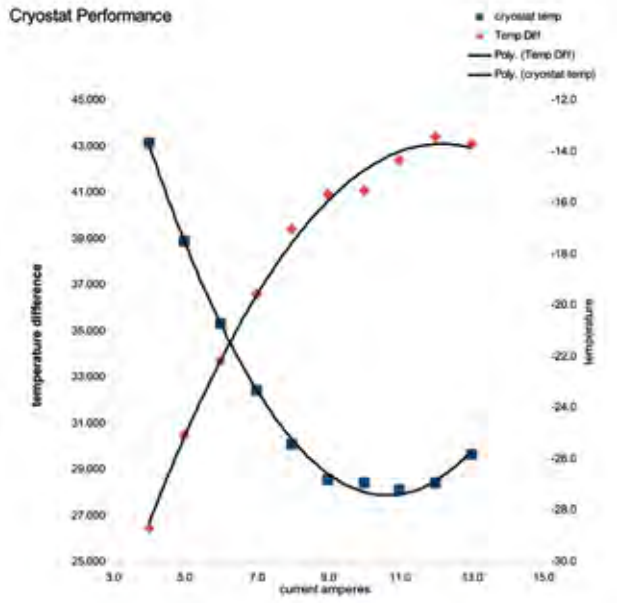

Figure 4 - Cryostat temperature and temperature difference plotted against Peltier Current

At constant current, the variation of the minimum attainable temperature with cooling water flow rate is shown in table 2 and plotted in Figure 5

Table 2 - Variation of minimum temperature with water flow rate Current = 9A, Volts = 23.8, Power = 214.2 Watts.

Flowrate	Tw	Tc	Temp Diff
litres/min	deg C	deg C	deg C
0.824	17.2	-22	39.2
0.925	16.6	-23.4	40
1.415	14.9	-24.7	39.6
1.875	14.4	-26.1	40.5
2.500	13.8	-27.3	41.1
3.409	13.3	-27.9	41.2
5	12.9	-28.3	41.2
8.3	12.7	-28.7	41.4

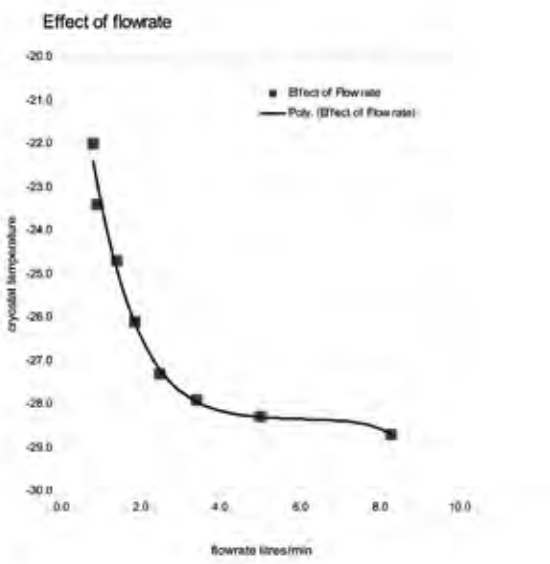

Figure 5 - Minimum achievable temperature plotted against water coolant flow rate

As might be expected, the minimum temperature achievable at 9 amps current falls with increasing water flow rate, rapidly up to about 4 litres/minute and then only very slowly thereafter.

The temperature of the cooling water has a direct effect upon the minimum achievable temperature, although adding extra cooling to water flowing at that rate would require a fairly large and costly plant.

Best Performance

OFFSET	Tc	Current
mV	deg C	amps
190	1	2.5
180	-3.2	2.8
170	-4.8	3
150	-8	4
130	-12	5
120	-14	6
110	-15.5	6.5
100	-17	7.5
80	-19.8	9.1

With a flow rate set at 3.125 litres/minute, a further adjustment of the current enabled the point of optimum performance to be determined. The results are shown in Table 3.

Table 3 - Voltage control of the Peltier Cryostat

Power Consumption

Peltier Coolers are very energetically inefficient. Reference to table 1 will show that in the case under consideration, at the water flow rate of 1.125 litres/ minute, little advantage in minimum temperature is to to be gained by dissipation of more than about 200 Watts. However, at higher flow rates dissipations of up to 320 Watts can be justified in reaching a lower minimum temperature. The cryostat as constructed did exhibit considerable capacity to remove heat: water in a test tube was fully frozen in less than a minute on immersion and very little change in the cryostat temperature was observed during the freezing process.

Current	Tc	Tw	Temp Diff
amps	deg C	deg C	deg C
10.0	-29.4	13.0	42.4
11.0	-30.2	13.4	43.6
12.0	-30.7	13.6	44.3
13.0	-30.8	14.0	44.8

The Peltier Cryostat described in this paper can be controlled to enable stable refrigeration temperatures to be maintained at any chosen value within the range of which the device is capable. Although the design of custom electronics to do this would be reasonably straightforward, an alternative procedure is to exploit the programmability of the HP 6274B power supply used for testing. In the configuration described here, the voltage control of the current was chosen as the most appropriate mode. In this case, a voltage lying between 0 and 500 mV is applied to two terminals on the rear of the instrument via a 1.5k resistor and the output current is then delivered at a rate of 1 amp per 33.3mV. In practice, this control worked well above about 2 amps but below this was somewhat less stable than could be desired. Nevertheless, it was found that satisfactory control of the cryostat temperature could be obtained from about zero C down to -25 C.

The Control System

The diagram in figure 6 shows the control system. The cryostat A is provided with a Chromel Alumel thermocouple Tc which is connected to the input terminals of a Comark 1601 electronic thermometer. These analogue instruments are obsolete but still occasionally available and perform excellently. They are equipped with a 1 volt recorder output which, in the case of the 1601 model on range A (-80 -+20 C) provides a signal of 10mV per degree. This is fed to a differential amplifier C set to a voltage gain of 5. The output of this instrument lay in the range of 0- 2 volts and was attenuated by R1 and R2 to provide a voltage of 0 -500mV. It is important not to exceed 600 mV control voltage into the HP6274B. R1 was 300 ohms and R2 was 100 ohms. The Attenuated voltage was fed to the control input of the power supply via a 1.5K resistor. The output of the supply was taken to the peltier elements in the cryostat.

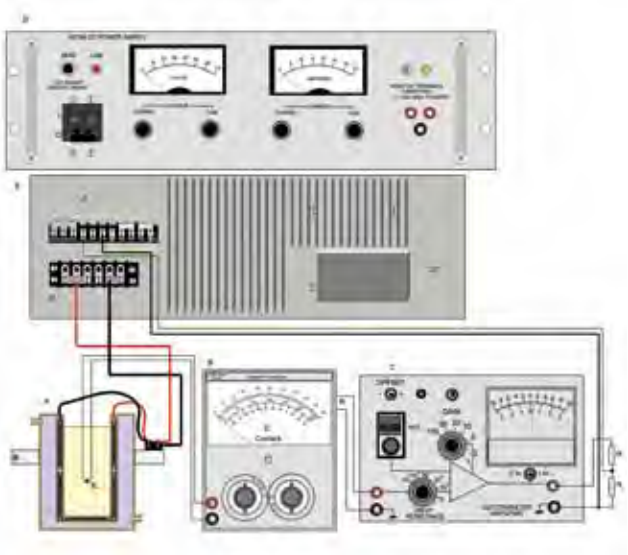

Figure 6 - The Peltier Cryostat Control system

Performance

The cryostat was allowed to equilibrate for a series of settings of the offset on the differential amplifier. Table 3 shows the results which are also presented graphically in Figure 7.

The cryostat responded well when thermal disturbances were applied to it. A test tube of water froze rapidly and the cryostat current increased for a short time to maintain the set temperature. More quantitative estimates of it performance can be obtained by using an electronic microcalorimeter to apply known amounts of heat while the temperature is monitored.

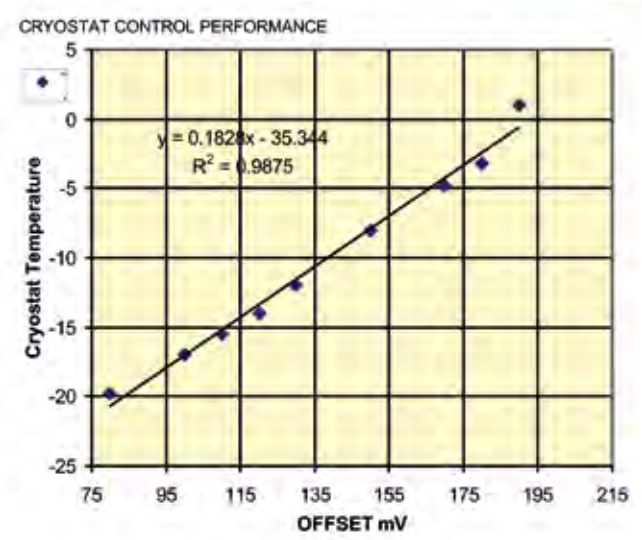

Figure 7- Cryostat Control Performance: A plot of Cryostat Temperature against control voltage.

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UK-India research collaboration deepens

Engineering and Physical Sciences Research Council ▶

Developing fuel cells and researching how to make rural living more sustainable are two challenges being tackled together by the UK and Indian Governments.

Bridging the Urban and Rural Divide (BURD) projects address the research challenges of making living rurally a sustainable option - a topic that was agreed to be of importance to both countries. The BURD panel held in London was chaired by Dr Rajagopala Chidambaram, Principal Science Advisor to the Government of India. Over £7 million from Research Councils UK, with resources from the Department of Science and Technology (DST) in India, will fund successful projects. Those recommended for funding are:

- 'Rural Hybrid Energy Enterprise Systems' Led by the University of Nottingham and IISc Bangalore. Research into small scale energy generation systems in rural areas that can be adapted for local needs in the UK and India to enable communities to tackle energy poverty, increase revenue generation, create new opportunities etc.
- 'Development and Integration of Biomass and Concentrating Photovoltaic System for Rural and Urban Energy Bridge: BioCPV' led by Heriot-Watt University and Visva-Bharati University. Developing an integrated system of solar energy, biomass and waste power generation and hydrogen generation and storage to provide low-cost integrated renewable energy to rural areas.
- 'Scaling the Rural Enterprise' led by University of Nottingham and the Society for Economic and Social studies. Establishing the next generation of enterprise where mobile devices are used to empower rural communities and scale up the activities of rural businesses.
- 'TRUMP: A Trusted Mobile Platform for the Self-Management of Chronic Illness in Rural Areas' led by University of Aberdeen and IIM Ahmedabad. Exploring the potential of mobile technologies in the development of a platform to support chronic disease management in rural areas of the UK and India.
- 'Distributing Industrial Optimization Tasks to Rural Workers' led by University of Strathclyde and IIT Allahbad. Developing a 'business model' which demonstrates that a large number of industrial tasks can be outsourced to rural workers providing a sustainable source of skilled employment.

In addition, fuel cells have been identified by both India and the UK as an area of significance in providing solutions to the problem of meeting future energy needs. At least £3 million from the Research Councils UK Energy Programme with resources from India through the DST has been committed to collaborative research projects addressing this area. The four projects recommended for funding under the **India-UK Collaborative Research Initiative in Fuel Cells** are:

Courtesy of www.indiafreeimagesdownload.com

- 'Performance Opimization of IT-SOFCs by Inkjet printing on Porous Metal Substrates (JETCELL)' led by The University of Cambridge and the Non-Ferrous Materials Technology Development Centre in Hyderabad will focus on developing solid oxide fuel cells, using ink-jet printing technology, that operate at much lower temperatures than they currently do in order to address issues such as cost reduction, durability and reliability of the fuel cell.
- '"Mind the Gap" - jumping the hurdles limiting polymer fuel cell performance and commercialisation' led by Imperial College London and the Centre for Fuel Cell Technology in Chennai will work to address issues limiting polymer fuel cell performance and commercialisation. The team conduct research into reducing the necessary quality of fuel needed for the fuel cell, reducing the cost and robustness of the catalysts in the system and improving the overall efficiency of the fuel cell.
- 'Advancing Biogas utilization through Fuel Flexible SOFC' led by The University of St Andrews and the Central Glass and Ceramic Research Institute in Kolkata will look to improve the performance of solid oxide fuel cells electrodes for converting biogas into electricity thus generating energy from waste. The use of fuel cells in this way could potentially significantly increase the efficiency of this process compared to the process of thermal conversion currently employed.
- 'Modelling Accelerated Ageing and Degradation of Solid Oxide Fuel Cells (MAAD-SOFC)'led by Keele University and the Indian Institute of Technology in Madras will be modelling accelerated ageing and degradation of solid oxide fuel cells. A model validated with experimental evidences can serve as a useful tool to understand the degradation mechanism of SOFCs. The understanding gained on degradation from these experiments and the developed model can be utilized to develop materials which give improved performance or can perform at lower temperatures, reduced degradation and better tolerance to contaminants in the fuel.

The UK Government's ongoing focus on India underlines the importance it places on the bilateral relationship across a wide range of policy areas. From security, defence, business and trade, to development, education, science and research these projects are an excellent example of working together to improve areas of mutual interest.

World first for synthetic organ scientists

Engineering and Physical Sciences Research Council ▶

Surgeons in Sweden have carried out the world's first synthetic organ transplant using a windpipe 'grown' from the patient's stem cells. The replica organ was designed and developed by EPSRC-sponsored scientists.

The surgeons successfully implanted a synthetic windpipe 'scaffold' into the throat of a cancer patient. Without the new windpipe (trachea), the patient, whose own windpipe had been blocked by an inoperable tumour the size of a golf ball, would have died.

The artificial organ was designed and developed by a multi-disciplinary team led by Professor Alex Seifalian at University College London. EPSRC sponsorship of the project began in 2006.

The team used 3D computerised tomography (CT) scans of the patient to craft a perfect copy of his trachea using a glass mould, from which they developed a replica 'scaffold' using a novel nanocomposite polymer.

The full-size Y-shaped replica was taken to Karolinska University Hospital in Sweden where stem cells taken from the patient's bone marrow and linings from his nose were incorporated to it (or 'seeded') by Professor Paolo Macchiarini, who co-developed the scaffold with Professor Seifalian and also performed the surgery. After two days, the millions of nano-scale holes in the porous windpipe had been seeded with the patient's own tissue.

The full biological trachea was grown in a bioreactor – a device designed for the procedure which provides the correct environment for the tissue to grow, and very effectively simulates the growth of natural tissue. The result: a synthetic windpipe with the same properties as a 'real' trachea.

The 12-hour operation was a complete success. One month on, the patient, a 36-year-old student, is looking forward to returning to his studies, safe in the knowledge that he will not need to take the strong anti-rejection drugs that other transplant patients have to, as the trachea was grown from his own tissue.

Professor Seifalian says: "Professor Macchiarini has previously performed successful transplants of tissue-engineered tracheas, but on those occasions the tracheas used were taken from organ donors and then reseeded with the patient's own stem cells.

"What makes this procedure different is it's the first time a wholly tissue-engineered synthetic windpipe has been made and successfully transplanted, making it an important milestone for regenerative medicine. We expect there to be many more exciting applications for the novel polymers we have developed.

"Thanks to nanotechnology, we are now able to produce a custom-made windpipe within two days or one week. The beauty of a synthetic windpipe is there is no delay – and this technique does not rely on a human donation."

The science

Nanocomposite: A material containing some components that are less than 100 nanometres in size. A human hair is about 60,000 nanometres in thickness.

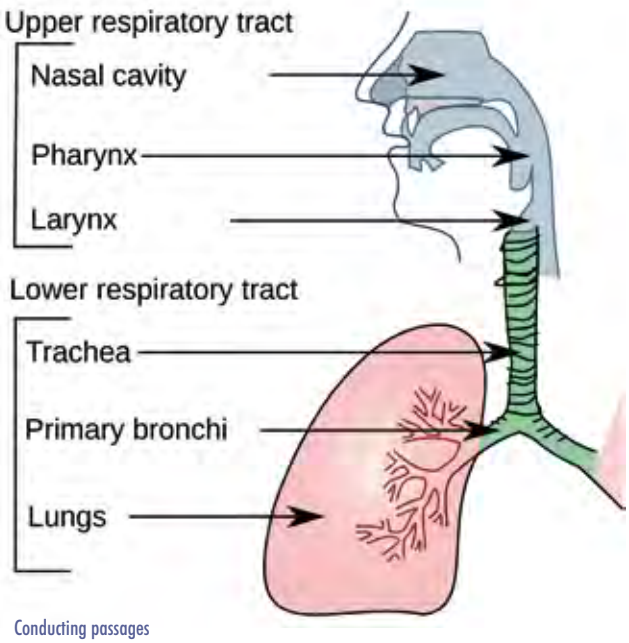
Polymer: A repeating chain of small, identical molecules which are linked together. Polymers are already used in medical devices, but the properties of the novel polymers invented by Professor Seifalian reduce the risk of rejection, rupture, or the need for repeat surgery. They have better elasticity, strength and versatility and are formulated to encourage cell growth.

CT: Computerised tomography, a method of examining body organs by scanning them with X-rays and using a computer to construct a series of cross-sectional scans along a single axis.

Regenerative medicine: A field that includes the study and development of artificial organs, specially-grown tissues and cells (including stem cells), laboratory-made compounds, and combinations of these approaches for the treatment of injuries and disease.

Tissue engineering: Perhaps best defined as the use of a combination of cells, engineering materials, and suitable biochemical factors to improve or replace biological functions.

Scaffold: A material that spans a healing wound and provides structure for young cells as they grow into mature tissue.



Conducting passages

New discovery throws light on blood pressure regulation

Biotechnology and Biological Sciences Research Council ▶

Researchers have discovered that a protein found in the walls of blood vessels plays a key role in maintaining healthy blood pressure; a discovery that could one day lead to new treatments for people with high blood pressure.

The research, funded by the Biotechnology and Biological Sciences Research Council (BBSRC) and the British Heart Foundation (BHF), shows that malfunction of the protein - a potassium channel called Kv7.4 - contributes to the maintenance of high blood pressure.

Dr Iain Greenwood from St George's, University of London led the study. He said "High blood pressure is one of the most common diagnoses in the UK and one in three adults have it - that's around 16 million people. People with high blood pressure are at much greater risk of heart attack, heart failure, and kidney disease and it's the main risk factor for stroke.

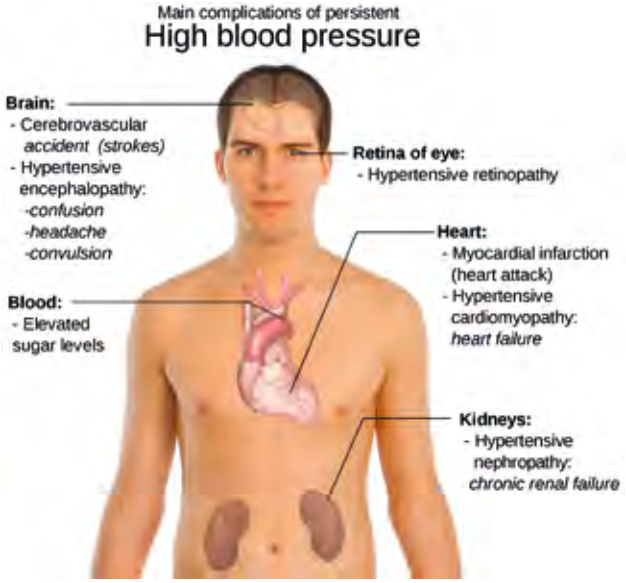
"We are trying to understand how our bodies go about regulating our blood pressure under normal circumstances - the more we understand, the better we can get at spotting what is going wrong and intervening when someone has this common chronic health issue. This discovery is an important part of the puzzle and might one day lead to new treatments."

Dr Greenwood and his team have shown that Kv7.4 plays an essential role in maintaining the extent to which arteries are constricted or dilated. He said "We have to be able to change our blood pressure at the drop of a hat - quite literally! If you dropped your hat and bent over to pick it up, your body would automatically reduce your blood pressure to account for the position of your head relative to your heart and the effect of gravity and then when you stood up again, your body would adjust it back up.

"The muscles in the walls of your blood vessels play a role in adjusting blood pressure and if they need to increase it, they squeeze the blood vessels more tightly to literally put mechanical pressure on your blood."

The researchers examined rodents that had high blood pressure and discovered that in some cases the Kv7.4 channels weren't working properly. These channels allow the passage of potassium out of the muscle cells in our blood vessels and they have to be open and closed at the right times so that the muscles can contract or relax when we need them to. In the animals that had high blood pressure and malfunctioning Kv7.4 channels, the problem was that the channels were blocked. This caused an imbalance in the finely controlled chemical environment of the muscle cell.

"The problem is," continued Dr Greenwood, "if the Kv7.4 channels cannot function, the muscle cells overreact to the signals the body is giving to increase blood pressure. We think that in the animals we studied the redundant Kv7.4 channels contributed markedly to their high blood pressure."



Overview of main complications of persistent high blood pressure

Whilst it is extremely unlikely that most people with high blood pressure have defective Kv7.4 channels, the researchers hope that by understanding the key role they play in maintaining healthy blood pressure we can use this knowledge to develop new strategies for adjusting blood pressure using drug treatments in the future.

Professor Douglas Kell, Chief Executive, BBSRC said "If we are to have long, healthy lives, we need to understand how our bodies cope with the demands we place on them. Increasing our knowledge of the biology that underpins normal, healthy processes will pave the way for future strategies to prevent or treat health problems. Maintaining healthy blood pressure is an important part of keeping us all well and so this research could be of great benefit to many people in the future."

Professor Jeremy Pearson, Associate Medical Director at the British Heart Foundation, said "Physical activity, maintaining a healthy weight, reducing the amount of salt and alcohol you consume, and increasing the amount of fruit and vegetables you eat can all play a part in lowering your risk of having high blood pressure. However, we still do not fully understand what causes the condition in most people - and current medicines to treat it are often not fully effective. Crucial research such as this could lead to new medical treatments for high blood pressure."

Helping deaf people to enjoy music again

Arts and Humanities Research Council ▶

Arts and Humanities Research Council (AHRC) funded researchers from the University of Southampton are investigating how to help deaf people, who have received a cochlear implant, to get more enjoyment from music.

Music professor David Nicholls and Dr Rachel van Besouw from the University's Institute of Sound and Vibration Research (ISVR) are working with patients from the South of England Cochlear Implant Centre, based at the University.

Cochlear implants allow people with severe-to-profound hearing loss, who do not substantially benefit from conventional hearing aids, to perceive and understand speech. However, the current technology often cannot cope with the complexities of music.

"Hearing people speak again changes lives but many of our patients tell us they still can't enjoy music," explains Dr van Besouw. "They say they can hear rhythm but have problems distinguishing notes. We want to investigate ways we can help them."

Through a series of innovative music workshops, in conjunction with Southampton Community Music Project (SoCo), this project has been exploring aspects of music that can be appreciated by cochlear implant users through a variety of listening, computer-based and practical activities.

This knowledge is now being used to guide the development of music rehabilitation materials and compositions specifically for cochlear implant users. The two-year project will conclude in 2012 with a public seminar and performance at the University of Southampton.

The final set of workshops for the project recently took place and was focused on strategies and techniques for listening to live music. The workshops included performance as well as having the attendees revising and rehearsing a piece of music, and then performing it with the musicians from the University.

Cochlear implant

Resilience amongst the long term ill

Economic & Social Research Council ▶

People who have a long term debilitating physical illness demonstrate mental resilience according to *Understanding Society,* the world's largest longitudinal household study. The first findings reveal that people diagnosed with cancer, diabetes, respiratory disease or cardiovascular disease report similar mental health scores to those without physical illness. The survey's findings suggest that those people who may not be able to function well physically because of an illness do not necessarily suffer problems with their mental health - for example with their concentration, confidence and feelings of strain.

Another surprise finding from the study is that over half (52 per cent) of those indicating high levels of distress and anxiety, and therefore identified as at risk of suffering minor mental illness, still report fairly positive overall mental well-being.

Professor Amanda Sacker, Institute for Social and Economic Research, who analysed the findings, commented: "Initial findings regarding mental health may appear counter-intuitive but it is good to see such resilience amongst those with long term physical illnesses. *Understanding Society* will continue to follow the same people in years to come as they get older. As they change their health-related behaviours and experience different health, work and family challenges this will give us a good insight into the factors that cause mental health problems and how to provide the best support."

Initial analysis of the data collected in the first survey also found that:

- self rated mental health did not differ between England, Scotland, Wales and Northern Ireland
- there are no differences between males and females, with 50 per cent rating their overall health as either 'excellent' or 'very good'
- thirty-seven per cent of males and 38 per cent of females have a long term illness; of these 68 per cent of males and 71 per cent of females reported limitations in the last month. Climbing stairs as well as the amount and kinds of work that can be done were the most common stated, with women tending to report recent limitations more than men
- asthma, arthritis and high blood pressure are the three most prevalent conditions, each affecting over 10 per cent of the sample
- overall figures indicate that seven per cent of the total population (approximately 25,000 respondents) have at some point in their lives been diagnosed with clinical depression and that of those people the majority (69 per cent), currently suffer from depression.

Understanding Society is following 40,000 UK households over many years and will revisit health, family life, employment and a range of other aspects of people's lives. The survey is funded by the Economic and Social Research Council (ESRC) and managed by the Institute of Social and Economic Research (ISER) at the University of Essex.

Zebrafish pinpoint the route to mending a broken heart

Medical Research Council ▶

Researchers funded by the Medical Research Council (MRC) have shown that a protein called Fibroblast growth factor (Fgf) can influence whether stem cells become either new heart muscle or new blood vessels. The research, which was carried out on zebrafish, brings researchers one step closer to being able to generate tissues to repair the human heart after damage inflicted by a heart attack.

The scientists, based at the MRC Molecular Haematology Unit (MHU) at the University of Oxford, have identified Fgf as the controlling factor over whether developing heart cells become muscle or blood vessels. They found that manipulating levels of the Fgf protein in zebrafish embryos could determine how many of each cell type was made.

Dr Filipa Simoes, from the MRC Molecular Haematology Unit and one of the first authors of the study, said:

"Our study shows how having the correct concentrations of Fgf in the developing zebrafish heart ensures that the different cell types form properly. Crucially, we were able to convert blood and blood vessel cells into heart muscle cells by flipping genetic switches controlled by Fgf. The important next step to this research will be to identify the relevant cells in the human heart and take this finding to the next level."

Professor Roger Patient, who leads the research lab at the MRC Molecular Haematology Unit at the University of Oxford, said:

"If we can manipulate these heart cells in fish embryos, in the longer term we can look to try and do the same in human hearts – even adult hearts – if we can identify the equivalent cells. This could bring significant benefit to heart attack patients or people with heart defects. At the very least, our research will help the production of these cells in the laboratory for use in heart repair."

"Mending a damaged heart requires new muscle and the associated blood vessels, therefore there is great interest in identifying and manipulating cells that make both. The Medical Research Council recognises that supporting early stage studies in the lab like this is crucial in order to turn the potential of stem cells into effective treatments that can help patients recover from heart attacks."

The researchers, who were also funded by the British Heart Foundation, propose that this finding in the fish has identified the cells which became responsible, over millions of years in evolution, for the increase in amount of cardiac muscle that enables the heart to grow in size from two chambers in zebrafish to four chambers in humans

Professor Jeremy Pearson, Associate Medical Director at the British Heart Foundation which co-funded the study, said:

"This excellent study throws new light on how our four-chambered hearts evolved from the simpler structures we see in other animals. The results significantly increase our understanding of the origins of stem cells found in the adult heart. This provides important clues to researchers working towards the goal of mending broken hearts after heart attack."

Wildfires hold key to improving air pollution forecasts

Natural Environment Research Council ▶

An experiment to measure pollution from Canadian wildfires could help scientists improve air quality forecasts.

A team of researchers are setting off for Canada this weekend. They will spend three weeks taking daily flights in a specially equipped atmospheric research aircraft along the eastern coast of Canada, chasing plumes of pollution emitted by wildfires over North America.

The researchers will seek to better understand how emissions from such fires - sparked by dry, hot summer conditions - affect levels of atmospheric pollutants, such as ozone, which is linked with respiratory illnesses.

Such naturally occurring forest fires are likely to become more frequent amid changing climates, and have a greater impact on air quality around the world.

The aircraft, a converted BAe146 managed by the UK Facility for Airborne Atmospheric Measurements, will use on-board equipment to measure gases and particles emitted by wildfires. The scientists will seek to better understand how the pollutants disperse in the air over time, and anticipate that their findings will help estimate the role of North American forest fires on air pollution in Europe and beyond.

Professor Paul Palmer of the University of Edinburgh is leading the project and said, "Fires are widespread at high latitudes during the summer months and have a significant impact on air quality and climate in the northern hemisphere. Understanding more about how these air pollutants evolve will help us forecast the implications for air quality, as forest fires become more frequent."

The research, carried out in a collaboration involving the Universities of York and Leeds and Dalhousie University in Canada, is supported by the Natural Environment Research Council.

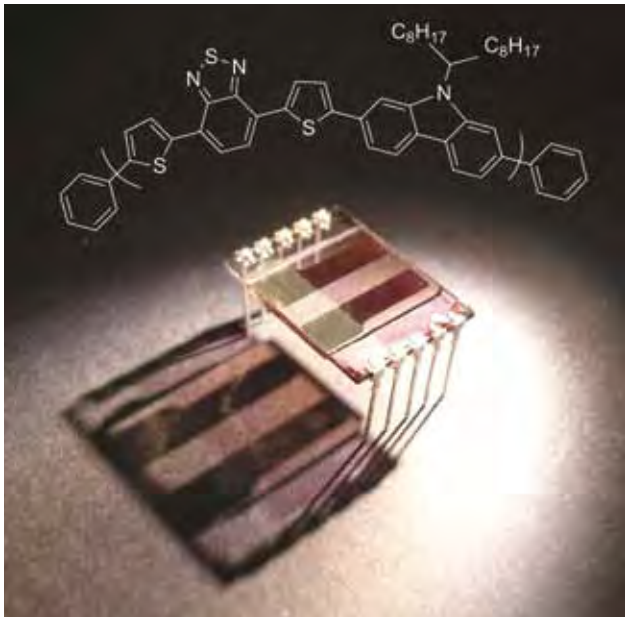
'Cling-film' solar cells could lead to advance in renewable energy

Science & Technology Facilities Council ▶

A new study shows that even when using very simple and inexpensive manufacturing methods - where flexible layers of material are deposited over large areas like cling-film - efficient solar cell structures can be made.

The study, published in the Journal Advanced Energy Materials, paves the way for new solar cell manufacturing techniques and the promise of developments in renewable solar energy. Scientists from the Universities of Sheffield and Cambridge used the ISIS Neutron Source and Diamond Light Source at STFC Rutherford Appleton Laboratory in Oxfordshire to carry out the research.

Plastic (polymer) solar cells are much cheaper to produce than conventional silicon solar cells and have the potential to be produced in large quantities. The study showed that when complex mixtures of molecules in solution are spread onto a surface, like varnishing a table-top, the different molecules separate to the top and bottom of the layer in a way that maximises the efficiency of the resulting solar cell.



A polymer solar cell ready for testing (Courtesy of Andrew Parnell)

Dr Andrew Parnell of the University of Sheffield said, "Our results give important insights into how ultra-cheap solar energy panels for domestic and industrial use can be manufactured on a large scale. Rather than using complex and expensive fabrication methods to create a specific semiconductor nanostructure, high volume printing could be used to produce nano-scale (60 nano-meters) films of solar cells that are over a thousand times thinner than the width of a human hair. These films could then be used to make cost-effective, light and easily transportable plastic solar cell devices such as solar panels."

Dr Robert Dalgliesh, one of the ISIS scientists involved in the work, said, "This work clearly illustrates the importance of the combined use of neutron and X-ray scattering sources such as ISIS and Diamond in solving modern challenges for society. Using neutron beams at ISIS and Diamond's bright X-rays, we were able to probe the internal structure and properties of the solar cell materials non-destructively. By studying the layers in the materials which convert sunlight into electricity, we are learning how different processing steps change the overall efficiency and affect the overall polymer solar cell performance."

"Over the next fifty years society is going to need to supply the growing energy demands of the world's population without using fossil fuels, and the only renewable energy source that can do this is the Sun", said Professor Richard Jones of the University of Sheffield. "In a couple of hours enough energy from sunlight falls on the Earth to satisfy the energy needs of the Earth for a whole year, but we need to be able to harness this on a much bigger scale than we can do now. Cheap and efficient polymer solar cells that can cover huge areas could help move us into a new age of renewable energy."

The research was funded with a grant from the Engineering and Physical Sciences Research Council (EPSRC).The collaboration has just been allocated a new grant to carry out further studies into the structure and function of polymer solar cell materials, as well as examining new materials and innovative processes for high volume manufacture and future commercialisation.

STFC owns and operates the ISIS neutron Source and is the majority shareholder in Diamond Light Source.

Science & technology news *additional photographs courtesy of Wikipedia (Creative Commons Licence)*

FROM THE ARCHIVES

Alan Gall - IST Archivist

A contemporary account of industrial and academic chemistry up to the time of World War One is given in Sir William Tilden's *Chemical Discovery and Invention in the Twentieth Century*. The relatively high cost of books in those days made them a useful gift item, such as a leaving present from work colleagues. And what better token of esteem than a weighty tome inscribed with friends' good wishes on the flyleaf? In fact, the copy of Tilden's book I have in front of me contains a declaration that reads:

In appreciation
To Albert Edward Watts
with every good wish for
future success from
T.A.Torrance L.D.S.
and Albert Redgwell

90 Park St. W1.
15th June 1918

Before delving inside and describing some of the contents, what of the original owner and his well-wishing friends?

Torrance, Redgwell and Watts

T.A.Torrance has left the most visible trail, mainly through his golfing exploits. *Time Magazine* covered the Walker Cup event at the Chicago Golf Club in 1928:

As everyone expected, eight long-trousered, pipe-smoking Britishers were too weak to walk off with the Walker Cup, which eight be-knickered, cigaret-smoking golfers retained for the US…

Thoroughly trounced, the British lost all but one of the twelve matches played, the one exception being the game between American Chick Evans and T.A.Torrance.

The Scottish golfing team. T.A.Torrance is standing on the far right (Illustrated London News, 30 May 1925)

Trust me, I'm a dentist (Picture by Stephanie Taylor)

Thomas Arthur Torrance was born in Edinburgh on 13 March 1891, son of Alexander and Sophia Campbell Torrance (née Fletcher). He was apprenticed to Dr Frederick Turnbull, a local dental surgeon, and registered as a dental student in April 1908. The Royal College of Surgeons of Edinburgh (see elsewhere in this journal for a history of dentistry at the RCSEd) provided tuition in anatomy, science and medicine. Practical training came under staff at the Edinburgh Dental Hospital. T.A.Torrance successfully completed all the required elements for the Licentiateship in Dental Surgery (LDS) in 1914.

Shortly after qualifying he moved to London. At the time of the book's dedication, T.A.Torrance had been on the Dentists Register for less than six months. The Dentists Act of 1878 aimed to prevent treatment by unqualified practitioners but left a loophole whereby people not on the register could still offer dental services, as long as they avoided describing themselves as a "dental surgeon" or "dentist". Over forty years were to pass before the Dentists Act of 1921 required everyone practising dentistry to be fully qualified in the profession.

Torrance Cup, awarded by George Watson's College to the winner of the golfing championship

George Watson's College can be found to the south of Edinburgh's city centre. Notable ex-students include Olympic cyclist Sir Chris Hoy, 1991 Masterchef winner Sue Lawrence and the Rt Hon Sir Malcolm Rifkind. Associated with the college is the Watsonian Golf Club. As a prominent club member, T.A.Torrance donated the Torrance Cup in 1933 for presentation to the winner of the school golfing championship. By this time, Torrance had established himself as one of the leading amateur golfers. His brother W.A.Torrance also made his mark on the game and the pair featured much in the sporting press. Nicknamed "Tony", T.A.Torrance was praised by George W. Greenwood in the May 1923 issue of *Golf Illustrated:*

Quite recently "Tony" defeated Duncan in a match at Sandy Lodge, one of the best London courses. Duncan was so greatly impressed by the young amateur's play that he afterwards declared that in his judgement Torrance was the best amateur golfer in Britain. While not endorsing this opinion I can, however, say that "Tony" is a class golfer with a style almost as easy, as effortless and as natural as that of Bobby Jones[1].

"Tony" went on to play for Scotland against England on numerous occasions and captained the Walker Cup team in 1932. Notable wins were the Irish Open and the German amateur championships. His enthusiasm for Golf extended to less prestigious events when he competed in matches organised by the Medical Golfing Society.

The second person to record his appreciation of Albert Edward Watts, Albert Redgwell, probably acted as dental technician to the practice at 90 Park Street. He was born Albert Digby Redgwell at Chelsea in 1872 and is listed as a dental mechanic in the 1911 census. He died at the age of 52 in 1925.

Unfortunately, I have not been able to identify Mr Watts. The 1911 census records an Albert Edward Watts in Kensington, a schoolboy aged 11. Since entries under Albert E. or just Albert are also viable, and there are many, a positive sighting remains illusive. He does not seem to have joined the ranks of the dentistry profession.

The book

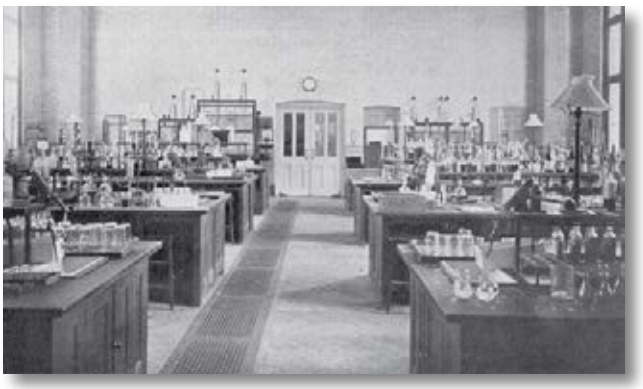
Tilden describes in some detail the work of the Government Laboratory. This organisation began life as a department mainly to provide the Inland Revenue with facilities for checking on possible tobacco adulteration. It then expanded considerably in scope to examine a wide variety of products. Low-alcohol content beers were tested during 1911-12:

The percentage of spirit was determined in 444 samples of herb beers and other imitation beers, beer substitutes and temperance beverages. In 300 of these the percentage did not exceed the legal limit of 2% of proof spirit, 107 contained less than 3%, 30 between 3% and 5%, and 6 between 5% and 8%, while 1 sample contained 10.6% of proof spirit.[2]

Tobacco was analysed for the presence of adulterants like sugar and liquorice, although there were some products using "offal tobacco[3]" allowed for export: "The articles examined under this head included "joggery" – a mixture of tobacco and opium with sugar and molasses – used by Asiatics."

One of the Acts then in force imposed a duty on certain medicinal preparations specifically for treating human ailments. Single composition drugs were exempt but not mixtures, and it was an offence to sell them without paying the Inland Revenue.

In one case brought before magistrates, a pill said to reduce obesity fell foul of the law as it was held that obesity constituted an ailment under the Act, and the seller was convicted.



Customs & Excise main laboratory (Tilden)

An unusual duty of the Government Chemist concerned the validation of hand-written birth dates. Even after 1837, when it was required to register a birth, not everyone did. There were no penalties until 1875 when a £2 fine was introduced. As a result, some people found themselves applying for an old-age pension without a birth certificate.

In the absence of the Registrar-General's certificate, reliable evidence as to age is sometimes obtained from entries of the date of birth in old Bibles or Prayer Books, from names and dates written in books received as gifts in childhood, and from marriage certificates and other documents. Sometimes there is reason to suspect that such entries have been made recently, or that the original writing has been altered for the purposes of deceiving the authorities.

The periodic table

Shown here is the last version of the periodic table produced by Mendeléeff[4] in 1904, not long before his death. The arrangement of groups and the ranking by atomic weight caused a number of problems. As can be seen, manganese appears in the same group as the halogens; copper, silver and gold are grouped with the alkaline metals. Later, sub-groups were introduced so that manganese joined new elements technetium and rhenium in group VIIA. Alkaline metals occupied group IA and the trio headed by copper came under group IB.

Mendeléeff's Periodic Table (Tilden)

Iodine and tellurium are assigned the same atomic weight in Mendeléeff's table but iodine is positioned correctly with the halogens. More precise measurements[5] later gave a higher value for tellurium, but the two elements maintained their apparently

[1] Robert Tyre Jones (1902-1971) an American golfing legend who retired at the age of 28 but had considerable influence on the game afterwards. Reputedly, Jones and T.A.Torrance were instrumental in promoting regulations that reduced the number of clubs carried by caddies from, sometimes, over 20 to 14.

[2] This is not quite as strong as it seems. 100% of proof spirit corresponded to 57.15% alcohol by volume using an arcane system based on the most dilute solution of alcohol that would still allow gunpowder to ignite when the two were mixed. Hence, 10.6% of proof spirit is a paltry 6% alcohol by volume.

anomalous positions in the ascending list of atomic weights until the work of Henry Moseley[6] showed that the ordering should be made by atomic number not atomic weight. Moseley's groundbreaking paper appeared in the *Philosophical Magazine* of 1913 but had not become established enough to be considered by Tilden. The death of Moseley in 1915 caused Ernest Rutherford to comment, no doubt rather less strongly than he might have liked, "It is a matter of great regret that the services of Moseley could not have been utilised for the war in some scientific capacity rather than as a combatant in the firing line".

Dmitri Ivanovich Mendeléeff' (Tilden)

Group zero in the table contains the inert gases and the "elements" marked x and y. Mendeléeff proposed that x corresponded to the all-pervading medium called the "ether" that physicists used to explain how light could propagate as a wave motion. He suggested that y was an analogue of helium, with an atomic weight of 0.4, that might be the element coronium.[7] Mendeléeff thought that there were missing elements representing the first members of his groups II to VIII. Not known at the time was the existence of neutrons to account for the jump from hydrogen with atomic weight 1 to helium with weight 4[8]. The hypothetical intermediates were supposed to have atomic weights of 1.4, 1.8, 2.2, 2.8, 3.0 and 3.4. Further missing elements with weights approximately 44, 70 and 72 were given the provisional names of eka-boron, eka-aluminium and eka-silicon in Mendeléeff's paper of 1871 – later identified and called scandium, gallium and germanium, respectively. Another prediction was eka-manganese, not isolated until 1937 and christened technetium.

Oil

The fame of Alfred Nobel, with his dynamite and prizes, has eclipsed the activities of his two brothers. Tilden recounts the influence of Robert and Ludvig Nobel on the Russian oil industry. Prior to the brothers' involvement, oil had been carried in barrels from well to refinery to customer. Bulk transport and tankers were one of their legacies. Not mentioned is the humanitarian aspect: as well as generating profits, the Nobels' oil company at Baku[9] funded a hospital, a school, a park and recreational facilities for the workers.

[3] Material unsuitable for the production of snuff and normal smoking tobacco.

[4] Dmitri Ivanovitsch Mendeléeff (1834-1907) using the same spelling given by Tilden. It is more common to see the form Mendeleev.

[5] International Atomic Weights for 1916 given in Tilden's book.

[6] Henry Gwyn Jeffreys Moseley (1887-1915) who established that the elements followed a progression as the number of protons (and hence the electrons) increased by unity from one element to the next. His graph of the square root of the frequencies found from X-ray spectra gave a straight line when plotted against the atomic number. He died at Gallipoli during WWI.

[7] Supposedly identified in the sun's coronal spectrum in 1869, it turned out to be due to highly ionised iron.

Damage caused by an oil fountain in southern Russia (Tilden)

One of the great oil disasters of the time happened in the Baku region to a small Armenian outfit, the Droojba (or Droozhba) Company. A "gusher" is a well that releases oil uncontrollably and can be very difficult to cap. In 1883, what came to be called "the Droojba fountain" erupted. Unfortunately for the company, they occupied only a small piece of land and most of the oil fell on the property belonging to others. Tilden says:

This oil volcano was estimated to have thrown up from 1,600,000 to 2,000,000 gallons of oil every day from the first outburst which occurred on the 1st of September. In the middle of November it was still spouting at the rate of 240,000 gallons a day.

The well was finally capped at the end of December 1883. In the aftermath, the Droojba Company suffered financial ruin.

Gas v Electricity

At the time of Tilden's book, the most common means of illumination was by gas.

The invention of the incandescent mantle by Baron Auer von Welsbach helped to keep electric lighting at bay, at least for a while. This innovation, when fully developed, allowed relatively non-luminous gas to produce a strong white light.

Premier amongst mantle manufacturers was The Volker Lighting Corporation[10] of Wandsworth and their process was surprisingly complex.

First, a rotary knitting machine formed a length of hose out of a fabric thread.[11] The hose was collected in

Gas mantle manufacture: Sewing gas mantles at the Volker Lighting Corporation (Tilden)

[8] A periodic table of 1911 due to A.Werner of the University of Zurich provides three spaces for missing elements between hydrogen and helium.

[9] Then in Russia, it is the largest city and port in Azerbaijan.

[10] Said to produce from 18 to 20 million mantles per year. The total world production was estimated at about 250 million.

[11] Typically ramie, one of the oldest natural fibres.

bundles and washed in a dilute caustic alkali solution, then rinsed in water. A dip in dilute hydrochloric acid and further washing followed. After drying, the stocking was cut into shorter pieces. The heads required reinforcement by attaching a length of cotton with thread before dipping into a strong solution of thorium nitrate with 1% cerium nitrate and a few other additives. They were then passed through rollers to expel excess solution, dried on glass formers and the heads treated with a solution of hardeners to give further strength. The mantles were dried and the heads sewn with asbestos thread. After this, the stockings were shaped over wooden formers and burnt in a very controlled fashion, leaving a fragile white ash that hardened as the oxides partially fused. A coating of nitrocellulose and oil was applied and after drying in a steam oven, the mantles could be tested before being finally packed. This constituted the procedure for "upright" mantles. The production details given for "inverted" mantles differ a little, but are equally lengthy.

Like other companies with German-sounding names, Volker disavowed any connections with the enemy once war started:

Volker Mantles are British made by a British Company. There are no German Directors, Shareholders, or German Connections whatever. The Company offer £50 reward for information enabling them to take legal proceedings against any person or persons circulating statements to the contrary.[12]

Nobel Prize winners

Chemical Discovery and Invention in the Twentieth Century is illustrated with pictures of selected scientists. Of the 11 portraits shown, 7 are of Nobel Prize winners: Emil Fischer (1902 for chemistry), Svante Arrhenius (1903 for chemistry), Lord Rayleigh (John William Strutt) (1904 for physics), Sir William Ramsey (1904 for chemistry), Joseph John Thomson (1906 for physics), Marie Curie (with Pierre Curie and Antoine Becquerel in 1903 for physics and in 1911, on her own, for chemistry) and Theodore William Richards (1914 for chemistry).

Emil Fischer (Tilden)

The Nobel award to Emil Fischer (1852-1919) was "for his synthesis in the groups of sugars and purines" and he went on to develop, with Joseph von Mering, the first commercial barbiturate. Introduced as a hypnoticum, it became available under the brand name Veronal in 1904. One of Germany's leading chemists, he became depressed after the defeat of his country in 1918. Combined with the loss of two sons, and suffering from cancer, it was all too much. He committed suicide on 15 July 1919.

[12] Newspaper advertisement of 1916.

[13] John Campbell (1996, p. 325)

Svante Arrhenius (Tilden)

The Swedish chemist Svante Arrhenius (1859-1927) formulated a theory of how electrolytes behave in solution and most of his ideas are still valid today. He is also remembered for the Arrhenius equation that gives the rate constant for chemical reactions as a function of temperature and the activation energy for the reaction. Yet when Arrhenius presented his doctoral thesis in 1884, laying down the basics of his electrolyte theory, the academics at Uppsala University failed to appreciate that a brilliant mind was at work. Indeed, they awarded the lowest possible grade for a pass, seriously under-rating the quality of the work. The authorities at Uppsala changed their tune when leading chemists came out in support of Arrhenius and his novel concepts.

Lord Rayleigh (Tilden)

Lord Rayleigh (1842-1919), alias John William Strutt, worked in many areas of physics but one of his outstanding achievements was the discovery of the inert gas argon. He noticed that the nitrogen obtained from air by removing moisture, oxygen and carbon dioxide always had a slightly higher density than nitrogen liberated from its compounds. Eventually, in collaboration with William Ramsey, the discovery of the new element was announced in a joint paper after Ramsey had removed the nitrogen by reaction with magnesium and found the residue to have a spectrum of no known gas.

Sir William Ramsey (Tilden)

Sir William Ramsey (1852-1916), a personal friend of Tilden's, died on 23 July 1916, just before publication. Tribute is paid to Ramsey's "skill as a manipulator … of the emanation and gas from radium …" Ernest Rutherford and co-workers, also engaged on studying the disintegration of radium, had an entirely different opinion of Ramsey's abilities when it came to researching radioactivity. In a letter to Rutherford, American chemist Bertram Boltwood sarcastically commented: "… I wonder why it hasn't occurred to him [Ramsey] that radium emanation and kerosene form lobster salad."[13]

J.J.Thomson (Tilden)

J.J.Thomson (1856-1940) had identified the electron in 1897 and proposed the so-called "plum pudding" model of the atom in which electrons were distributed in a sphere of uniform, positive electric charge. By the time of Tiden's book, Rutherford had already demonstrated that the positive charge must reside in a central nucleus that was minute compared to the overall atomic size. Tilden remained neutral by saying "There is a difference of opinion as to whether the positive mass is a kind of shell or skeleton in which the electrons are imbedded, or whether the positive charge is concentrated at the centre …"

Marie Curie (Tilden)

Anyone interested in the life of Marie Curie (1867-1934), born Marya Sklodowska, is recommended to read the biography by her daughter Eve, first published in 1938. The account of Madam Curie's isolation of radium is probably one of the most familiar stories in the annals of science. Eve Curie's book brings home how little, in the way of rewards, her mother expected out of life. When asked by the American magazine editor Mrs Marie Meloney in 1920 what she most desired, the reply was "I need a gramme of radium to continue my researches, but cannot buy it." Apart from Nobel Prize money, the element's discovery had provided Marie Curie with no significant financial gain and the price of that much radium had reached one hundred thousand dollars in the US. Mrs Meloney was determined to find the money so that the precious gramme could be provided. A fund-raising tour of America by the Curie's, mother and two daughters, followed. In the States she was showered with honours but suffered a punishing schedule such that one paper commented: "Any circus or variety manager would have offered Mme Curie much more money for half as much work." Both radium and Marie sailed back to France after what her daughter described as "… a campaign of magnificent begging across a whole continent."

Theodore William Richards (1868-1828) received his Nobel Prize for the "… exact determinations of the atomic weights of a great number of chemical elements." A rather less glamorous area of research, it involved meticulous and painstaking operations that often had to be repeated many times, for example when

Theodore William Richards (Tilden)

15,000 recrystallizations were performed to purify thulium bromate. This gave a level of accuracy not achieved before. The differing atomic weights found for the same element from different sources indicated the existence of isotopes.

The author

William Augustus Tilden (1842-1926) began his career in chemistry with an apprenticeship to a pharmaceutical chemist. After successfully completing a BSc in 1868 and a DSc in 1871, he was appointed Senior Science Master at Clifton College. He later joined what would become the Imperial College, London as a professor of chemistry. He was elected a Fellow of the Royal Society in 1880 and awarded the Davy Medal in 1908. Much of his later research centred on the terpenes and he studied the reactions leading to synthetic rubber. He also did important work on atomic heats. Tilden died on 11 December 1926.

Sources

Campbell, J. (1996), *Rutherford: Scientist Supreme,* New Zealand: AAS Publications.

Curie, E. (1943), *Madame Curie,* London: William Heinemann.

Farber, E. (1962), *Nobel Prize Winners in Chemistry 1901-1961,* New York: Abelard-Schuman.

"J.C.P" (1928), "Obituary Notices of Fellows Deceased: Sir William Augustus Tilden, 1842-1926, *Proceedings of the Royal Society of London. Series A,* 117(778), pp. i – v.

Porter, R. (ed) (1994), *The Hutchinson Dictionary of Scientific Biography,* Oxford: Helicon Publishing.

Rutherford, E. (1917), "Obituary Notices of Fellows Deceased: H.G.J.Moseley, 1887-1915", *Proceedings of the Royal Society of London. Series A,* 93(655), pp.xxii-xxviii.

Tilden, Sir W.A. (1917), *Chemical Discovery and Invention in the Twentieth Century,* London: George Routledge & Sons.

Acknowledgements

Thanks to David McMurray, Secretary & Treasurer of the Watsonian Golf Club for the picture of the Torrance Cup and for checking the script.

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What is the IST?

The Science Technologists Association was formed in 1948 and granted a certificate of incorporation in 1954 to become the Institute of Science Technology (IST). Its past traditions lay in the promotion and development of the science and practice of laboratory science technology. A further name change was agreed in 2007 to the Institute of Science & Technology in order to broaden our focus area.

As we know, the world of science and technology moves forward at a tremendous pace and is one of continual and rapid change. Our modern technology-driven world has opened up many new and exciting fields of science. Where, increasingly, the multi-disciplined approach towards developing new and innovative solutions is changing the face of industry, research and education.

The IST itself has continued to move forward and expand its own horizons so that it can best position itself to support its members and their needs in the 21st century.

So who is the IST for?

We now reach out to provide individual and focused professional support to a wide group of specialist, technical, and managerial colleagues in a broad range of environments such as science, engineering, industry, local authorities, schools, FE, HE, research/analytical/health facilities, government departments, and many more in the UK and overseas.

Our aim is to make the Institute all embracing and, in order to achieve this, help/advice networks, skills training, specialist forums, recognised qualifications, continuing career development opportunities and guidance will be available to the membership.

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- knowledge and skills
- network of contacts

Help us maintain, build and expand the (IST) community. **Together we can be a voice to be heard and listened to.**

To join or learn more about the IST go to Web: **www.istonline.org.uk**
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We welcome

article submissions from all areas of science and technology, including article submissions which cover new technological advances, diverse technology and unusual aspects of science. We particularly encourage submissions from people who may wish to publish for the first time, and can offer help and assistance in putting a first article together.

Contact the editor: i.moulson@shef.ac.uk

Or the IST office: office@istonline.org.uk

The guidelines for article submissions to the IST Journal are as follows:

1. Article submission deadlines;
   - Summer edition is **31st May.**
   - Winter edition is **30th September.**
2. Articles should be submitted electronically in Microsoft Word .doc format with images sent separately as JPEG files. This is our preferred option; please contact the Editor for other formats.
3. **Short articles:** these can be submitted in any length up to roughly 1500 words.
4. **Major articles:** these should normally be no longer than roughly 4000 words. Please contact the Editor for longer submissions as they may need to be serialised.
5. All accepted articles will be edited into the IST Journal's house-style.
6. All articles must be written in UK English. *(If English is not your first language, you should ask an English-speaking colleague to proofread your article.)* Articles that fail to meet basic standards of literacy may be declined by the editors.
7. Articles should be submitted as separate email file attachments. The email should clearly state "Journal Article Submission" and be sent electronically to office@istonline.org.uk

IST New Members

November 2010 – June 2011

New Members List

Membership no.	Members name	Grade
T14731	Miss O Obarisiagbon	MIScT
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T14745	Mr C K Olasehinde	MIScT
T14746	Mr C Conroy	MIScT
T14747	Mr A M Wiese	MIScT
T14748	Mr M J Field	FIScT
T14749	Dr G Abbas	FIScT
T14750	Mr R T F Navin	Assoc IScT
T14751	Mr I Atia	MIScT
T14752	Mr V J Victor Jerry	MIScT
T14753	Mr G Howell	MIScT
T14754	Mr O Akintola	MIScT
T14755	Mr O K Amowie	MIScT
T14756	Mr D I Omoruyi	MIScT
T14757	Mr L Francis	MIScT
T14758	Mr O O Akinyemi	MIScT
T14759	Mr M J Conboy	MIScT
T14760	Mr A P Adenuga	MIScT
T14761	Mrs L L Moilwa	Assoc IScT
T14762	Mrs J L Tonkin	MIScT
T14763	Miss P A Okosun	Assoc IScT
T14764	Mr J T Kane	MIScT
Total 34		

Reinstated Members

Membership no.	Members name	Grade
T14218	Mr C R J Simpson	MIScT
T14229	Mr E A Akuffo	MIScT
T14252	Mr M K Amoo-Gyasi	MIScT
T14263	Mr M A Aniyeloye	MIScT
T14321	Dr V A Ajibade	MIScT
T14596	Mr B O Adeoye	MIScT
T14599	Mr A K S Arobieke	MIScT
T14648	Mr C J Martin	MIScT
Total 8		

Higher Diploma Awards

Membership no.	Members name	Grade
T14364	Mr James Jerry Oddoye	Pass
T14700	Mr Edem Kwami Amedorme	Pass
Total 2		

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*Have we got your email address? Please contact the IST Office at Email: office@istonline.org.uk if you are unable to log on as it could be because we haven't got your current email address.

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Before completing this form please read the Notes for Guidance for Applying, available at www.istonline.org.uk. All relevant sections of the following form must be completed, even when additional information is provided on a separate sheet. New members apply to join on the basis that the appropriate grade of membership will be awarded by the Institute on acceptance, and that the level will be determined by the details supplied on this form.

When the applicant is notified of the grade of membership offered by the Institute a request for the appropriate membership fee will be made. Personal details collected in respect of applications will be treated in the strictest confidence and every effort is made to ensure that data is held securely.

I agree to my details being passed onto individuals involved in the application review process.

Please accept my application for membership. If accepted I agree to abide with the By-Laws of the Institute.

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Surname: .....

Other Names: .....

Date of Birth: .....

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.....

Telephone: .....

Address for correspondence: .....

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.....

A. DETAILS OF PRESENT POST

Job Title: .....

Date of Appointment: .....

Employer Name: .....

Employer Address: .....

.....

Email: .....

Type of work or discipline: .....

.....

Brief details of practical work undertaken in the year prior to application: .....

.....

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.....

B. PREVIOUS EMPLOYMENT HISTORY

Date	Employer	Type of Work/ Status/Title/Discipline
.....	.....	.....
.....	.....	.....
.....	.....	.....

C. QUALIFICATIONS

Give details below of any examinations passed, prizes or scholarships awarded etc. (Documentary evidence must be forwarded with this form, scanned images in jpg format are acceptable)

Date	Examinations/Prizes/ Scholarships etc	Institution
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....

D. COURSES & OTHER RELEVANT DETAILS

Give details below of any courses you have, or are attending, membership of other professional bodies, published work etc.

Date	Courses/Professional Bodies/Publications etc
.....	.....
.....	.....
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Continued overleaf

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Give name, qualifications and full address of your manager or Head of Department/Supervisor, who need not be a member of the Institute, who knows you personally and who would confirm the particulars on this form and who would support your application for membership of the Institute.

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Since 1987, the Institute of Science & Technology has operated a Register of competent and qualified technical practitioners. As the professional body for specialist, technical and managerial staff, we are actively involved in improving the status of, and the services offered by, technical staff in education, research, government and industry and it is our view that the Registration Scheme for laboratory and other technical practitioners is essential if their status, career prospects and expertise are to be recognised and enhanced, or indeed maintained.

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- NVQ/SVQ level 3 or 4 in an appropriate occupational area
- Completion of the HEaTED/IST CPD award
- Appropriate experience (in terms of breadth, depth and length)

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ii) there is evidence that their professional conduct falls below the standard expected, or

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There is a fee for admission to the Register and a nominal annual renewal fee.

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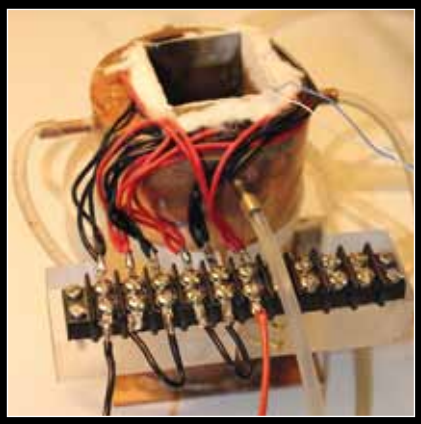
The Institute of Science & Technology

The Journal

Summer 2011



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