The Institute of Science & Technology

The Professional Body for Technical, Specialist, and Managerial Staff

The Journal

Spring 2017

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The Journal

The Official Journal of The Institute of Science & Technology

Spring 2017

The Professional Body for Technical, Specialist, and Managerial Staff

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Editor's welcome

Welcome to the spring 2017 edition of the IST Journal.

Ian Moulson
Editor

This edition features an exciting range of really excellent articles. I hope that you enjoy reading them. There is also news and information about the IST, plus what we are doing and what we plan to do as we continue to actively support our members and the technical community.

We have news about our 2017 IST Technical Conference, which is in Leicester on the 14th of September. We are well advanced in its preparation. We have two exciting keynote speakers and also fifteen technical workshop/talks sessions for delegates to choose from. The number of delegates who have booked early to secure a place is growing quickly (people are taking advantage of our early-bird rate), and sponsorship interest has been excellent following the outstanding success of our previous two annual conferences. We do have a venue limit of 250 delegates this year so please book your place as early as possible.

Looking back at our 2016 conference we had a significant level of positive feedback regarding the high value that attendees felt they got out of being able to meet, learn, and communicate with other technical people face-to-face. I remembered this when I read a newspaper article recently about how the use of modern technology might be changing the way we interact and communicate at work. The article highlighted the many efficiency benefits of recent technology advances in communication, computing, robotics, and analytics for example. But it also questioned whether some areas of human interactions at work had in fact become less effective, mainly due to the diminishing use of face-to-face communication.

My good friend and colleague Kevin Oxley delivers a really engaging and informative talk on the IST's Leading Your Technical Team (LYTT) course about how we communicate. Kevin tells us that our human non-verbal communication can account for up to 93% of the meaning that people take from any interaction. So I can see how face-to-face interactions can, and often do, significantly raise the overall effectiveness of understanding.

I can recall when, many years ago now, I was working with a Chinese researcher who found it extremely difficult to grasp what can sometimes be the contradictory meaning of the English language. I began to understand why this might be so when I learnt that one of the reasons why it is particularly hard for speakers of atonal languages, such as English, to learn tonal languages, such as Mandarin, is because much of the expression and non-verbal communication in English is by tone. In tonal languages the tone actually changes the word, not just the non-verbal sense, and so isn't used to convey other meaning.

But now I come to think about it, the poor chap might also have been struggling with my South Yorkshire dialect too!

There is more about our LYTT training programme toward the end of this Journal.

Our online newsletter has been an outstanding success, and it is a great avenue for you to let us know your news and what's happening in your "technical world". Its editors are Natalie Kennerley **n.j.kennerley@istonline.org.uk**, and Kevin Oxley **k.m.oxley@istonline.org.uk**.

Twitter (@istonline) – we encourage ideas, feedback, and discussions using #istforum

Ian

Chairman's view

As we go into the spring of 2017 it's not just the sunshine that's making me feel good but also a variety of events that have taken place since our last Journal. These are events that continue to promote the technical and specialist staff community. They are events that demonstrate just how important you, our members, are to the success of every sector of education and industry.

Two of our recent events were separated by a time span of 74 years.

In early March I celebrated the National Apprenticeships Week 2017 on behalf of the IST. During that same week I was privileged to award Basil Boam an Honorary Fellowship of the IST.

Basil Boam (centre) receiving his Honorary Fellowship from me with David Smart (left)

There is so much in the news these days about apprenticeships and how they can lead to excellent careers. However, apprenticeships have been achieving these results for over 75 years. Basil's story starts in 1943 at the age of 16 when he started on his career pathway and became an apprentice at the University of Sheffield. This was short lived as at 18 he was called up for active service, eventually returning to the University in 1948. Over the coming years he learnt many skills in Physics, Genetics, and finally Botany. Basil rose to the top of the tree by becoming Laboratory Superintendent in the Department of Botany in 1972. He held this position until his retirement in 1986. However, he didn't stop there and he continued working part-time for the University's Environmental Consultancy Services bringing a wealth of experience to this fledgling company. One thing he is remembered for is the creation of UBMA (University Bioscience Managers' Association). In 1983 Basil and David Smart brought together bioscience managers from across the sector under the umbrella of "The University Biological Supervisors' Association (UBSA)" eventually changing its name to UBMA in April 2000. Basil was very influential in the sector and brought great recognition to the technical community throughout the UK; hence the award of Honorary Fellow. His is a great example of how a technician's career pathway has gone from starting at the apprentice level and advancing to that of Laboratory Superintendent.

A more recent event has been the first meeting of the Arts and Media Steering Group as part of the IST's push to promote the work of these specialist technicians and managers in this particular sector. With group members including Joan Ward from the IST, Katherine Forsey from HEaTED, Daniel Jagger from Cambridge School of Art, Anglia Ruskin University, and John Ayres from Glasgow School of Art, this enthusiastic group is looking at a variety of issues affecting this community from visibility to professional registration. So if you work in art or media then watch this space.

Moving on, in this Journal edition I would like to offer a voice to your children!

As you are aware Gatsby have been driving the "Technicians Make It Happen (TMIH)" initiative by showcasing the great work technicians do here in the UK. Now they have teamed up with the British Science Association to create a Technician Photo Competition for schools and clubs.

Young people are being challenged to create, photograph and share a representation of a technician at work. The IST has been successfully in supporting the "TMIH" campaign on a number of fronts and I would like you to also get involved with the youth of today - your children and grandchildren who will be the technicians of tomorrow - and support this campaign. You never know we may be highlighting a representation of you in the next Journal. See **www.britishscienceweek.org/technicians-make-it-happen/** for further details.

This is the time of the year that you may be planning ahead. You may be thinking about your first spring trip to the coast, or planning your annual summer holidays. Well please pause a while and firstly get your early bird registration sorted out for our annual IST Conference on the 14th September 2017 at the Mercure Hotel Leicester whilst places are still available. Unfortunately, there were a number of disappointed technical people last year, because we had to stop registrations early due to our reaching the venue's capacity. So please make sure you book now. Further details at **www.istonline.org.uk/conference.**

Last but not least, we really do value your input. If you have any ideas or issues concerning the technical community or would just like to play a role in YOUR Professional Body, either locally or nationally, then please do contact me at **t.croft@istoline.org.uk.**

Terry Croft

President's view

Helen Sharman OBE, FRSC, FIScT

In newspapers and radio broadcasts almost every week this year, the UK's need for technicians has been noted. Discussion often centres on apprenticeship schemes, various types of which have been pivotal in technical training over the years, and they look likely to become popular again. The big difference now is that the schemes rarely, if ever, pay for the apprentices' salaries so they are unlikely to provide a host of new vacancies. However, funding for training is another matter and we can expect this to open up development for apprentices and non-apprentices alike.

Machine skills are generally well provided for when it comes to training courses so my concern lies with other lab skills, which are often picked up "on the job". Of course, day to day experience is invaluable but if you have ideas of how your job could be better provisioned by training courses, do let us know! Whether it be one off day training sessions in the use of instrumentation, a prolonged classroom-based learning of theoretical concepts or anything in between (would more on-line courses be useful and if so, how should their quality and trainees' performance be assessed?).

We need to ensure that formalisation of some technical training does not stop informal training from happening where it is useful. Nevertheless, formal training does have the benefit of contributing to the professional nature of technical jobs, as well as ensuring consistent good quality of the courses and recognised development of the trainees.

To actively support the training requirements of people who work in technical roles the IST is currently engaged in discussions with the Technical Development and Modernisation (TDM) Team at the National Centre for Professional Technicians, the Higher Education and Technical Development (HEaTED) organisation, and the Science Council. Your feedback and views are important to us, and very welcome.

Best wishes,

Helen

Steven Hale Wins #TechniciansMakeitHappen National Photography Competition

Steven Hale from the University of Birmingham has been named overall winner of #TechniciansMakeitHappen, a campaign celebrating the UK's 1.5 million technicians. Steve is a member of the IST and we offer our congratulations to him.

The winning image captures a sunrise over the world-famous Mt Wilson Observatory in Los Angeles. Steven who works on cutting-edge robotic telescopes like the one in his picture will receive £1000, as well as career mentorship from industry experts.

The competition was launched last year by The Gatsby Foundation to encourage more young people to consider a career as a technician, as over 70,000 roles go unfilled each year in the UK. More than 300 photos were entered into the competition, showcasing the amazing things technicians build, make and create – from space equipment to sports kit, concerts and cars.

"I am delighted to have been selected as the overall winner of #TechniciansMakeitHappen. There's often very little recognition of the people working behind the scenes to build new technology or help make ground-breaking discoveries. I think campaigns like #TechniciansMakeitHappen are incredibly important to raise the public profile of technicians and showcase the diverse and exciting opportunities for young people who choose a technical career." - Steve Hale, CSci MIScT MInstP

Image with kind permission of Steven Hale, University of Birmingham

The competition was judged earlier last month by an esteemed panel, including Jez Brooks at tech giant IBM and photographer Leonora Saunders, whose work has featured in national publications like the Guardian and The Sunday Times.

"This image captured a stunning dawn that contrasted effectively with some impressive technology. This was a great 'point of view' shot that conveys the progressive and exciting work of a technician through an inspirational vista." - Leonora Saunders

"This competition has been an excellent opportunity to showcase the breadth of fascinating, intriguing - and even beautiful things that technicians make happen. In my role at IBM, I am focused on inspiring the next generation of IT professionals and technicians. The variety shown in the entries to the #TechniciansMakeitHappen photo competition demonstrates that a career as a technician is diverse, challenging and never dull!" - Jez Brooks, IBM Early Professionals Manager, Apprentice Scheme Leader, UK Foundation

As part of the campaign, more than 25 industry leaders have pledged their support including the BBC, Royal Air Force, Mercedes AMG and Siemens. Compelling case studies, photographs and artifacts are touring the UK to inspire the next generation.To find out more, visit **www.technicians.org.uk.**

New members and registrations

New members October 2016 - April 2017

Membership No.	Name	Grade
T15743	Mr M Oyeleke	MIScT
T15744	Mr J Cresswell	FIScT
T15745	Ms J Vaclavik	MIScT
T15746	Mr R Ransley	MIScT
T15747	Mr P Beavis	MIScT
T15748	Dr J E Fitch	MIScT
T15749	Mrs H Glenwright	MIScT
T15750	Mr M Watson	MIScT
T15751	Mrs L Tagle Lopez	MIScT
T15752	Dr C Christmas	MIScT
T15753	Dr A J Connelly	MIScT
T15754	Miss J Yea	MIScT
T15755	Ms C Unsworth	MIScT
T15756	Mr T O Leung	MIScT
T15757	Dr E J Shaw	MIScT
T15758	Dr R P Dunford	MIScT
T15759	Dr L Harrison	MIScT
T15760	Mrs E Kozhevnikova	MIScT
T15761	Miss C Wells	MIScT
T15762	Miss S Smith	MIScT
T15763	Mr C B Pemberton	MIScT
T15764	Dr H Chang	MIScT
T15765	Mrs V O Eboreime	MIScT
T15766	Mr S Le Geyt	MIScT
T15767	Mr N A Macfadyen	MIScT
T15768	Dr R J Peace	MIScT
T15769	Dr I S Tidmarsh	FIScT
T15770	Mr J Geng	FIScT
T15771	Mr P J MacKenzie	MIScT
T15772	Dr P Waines	MIScT
T15773	Dr M Glanville	MIScT
T15774	Mr A J Petrie-Pink	MIScT
T15775	Mr S R Spaull	MIScT
T15776	Mr M J Hunt	MIScT
T15777	Ms L Marjoram	MIScT
T15778	Mrs S Rao	MIScT
T15779	Mr D F Richards	MIScT

Membership No.	Name	Grade
T15780	Miss V Snow	MIScT
T15781	Miss A Barnard	MIScT
T15782	Mr H Muzaffar	MIScT
T15783	Miss S H Watson	AssocIScT
T15784	Mr L Lee	MIScT
T15785	Dr S Bagga	MIScT
T15786	Miss A Lesiuk	MIScT
T15787	Mr M Dorna	MIScT
T15788	Mr M E Ojo	MIScT
T15789	Mr J Winter	MIScT
T15790	Miss M McMenemy	MIScT
T15791	Mr R Cargill	MIScT
T15792	Mr J D Wright-Mullaney	MIScT
T15793	Mrs R H Bello	MIScT
T15794	Mr T B Boam BEM	FIScT
T15795	Ms H F Rigby	MIScT
T15796	Mr J Alker	MIScT
T15797	Mrs S Underwood	MIScT
T15798	Mr C D George	MIScT
T15799	Mrs K Trewellard	MIScT
T15800	Mr T Barton	MIScT
T15801	Mr B Keith	MIScT
T15802	Miss E Sear	MIScT
T15803	Miss R Shepherd	MIScT
T15804	Miss G E Bradshaw	MIScT
T15805	Miss H Khalid	MIScT
T15806	Mr Z S Zamir	MIScT
T15807	Miss H J Collier	MIScT
T15808	Miss G Garland	MIScT
T15809	Mrs M Higgins	MIScT
T15810	Mr A Bretherton	MIScT
T15812	Dr P Hundleby	MIScT
T15813	Mr O Austen	MIScT
T15814	Miss M La Trobe	MIScT
T15816	Mr K Ibrahim	MIScT
T15818	Mrs S Moss	MIScT

Total: 73

Science Council Registrations

Membership No..	Name	Grade
T10905	Mr T B Croft	CSci
T15587	Dr M S Gião	CSci
T15588	Dr S Krishnan	CSci
T15683	Mr J Ben-Awuah	CSci
T15707	Ms E J Rix	CSci
T15731	Mrs G Ashby	CSci
T15758	Dr R P Dunford	CSci
T15812	Dr P Hundleby	CSci
T14855	Mr S Franey	RSci
T15316	Mr J A Trout	RSci
T15318	Miss M A O'Brien	RSci
T15391	Mrs J C Fenton	RSci
T15483	Mr M I McIntosh	RSci
T15518	Miss W A Thomas	RSci
T15629	Miss H L Wright	RSci
T15649	Mr F Fletcher	RSci
T15690	Miss E T Braithwaite	RSci
T15696	Mrs R Savidis	RSci
T15712	Mrs S T Lidstone	RSci
T15721	Mrs K Bolden	RSci
T15738	Mr P Disdle	RSci
T15739	Mr B Crook	RSci
T15740	Dr G Anderson	RSci
T15749	Mrs H Glenwright	RSci
T15752	Dr C Christmas	RSci

Membership No..	Name	Grade
T15759	Dr L Harrison	RSci
T15760	Mrs E Kozhevnikova	RSci
T15761	Miss C Wells	RSci
T15762	Miss S Smith	RSci
T15777	Ms L Marjoram	RSci
T15778	Mrs S Rao	RSci
T15779	Mr D F Richards	RSci
T15780	Miss V Snow	RSci
T15781	Miss A Barnard	RSci
T15789	Mr J Winter	RSci
T15790	Miss M McMenemy	RSci
T15800	Mr T Barton	RSci
T15801	Mr B Keith	RSciTech
T15802	Miss E Sear	RSciTech
T15803	Miss R Shepherd	RSciTech
T15813	Mr O Austen	RSciTech
T14967	Mr P D Mason-Smith	RSciTech
T15467	Mr D Andrew	RSciTech
T15661	Dr W Bashir	RSciTech
T15714	Miss L Oldershaw	RSciTech
T15776	Mr M J Hunt	RSciTech
T15799	Mrs K Trewellard	RSciTech
T15809	Mrs M Higgins	RSciTech
T15818	Mrs S Moss	RSciTech

Total: 49

IST Organisation

IST Executive Board Members

President: Helen Sharman OBE, FRSC, FIScT

Helen is the Operations Manager for the Chemistry Department at Imperial College. She started her career with a degree in chemistry from the University of Sheffield before working in industry for GEC and then Mars Confectionery, where she was part of the team that created the Mars Ice Cream. After applying for a job that was advertised as, "Astronaut wanted," Helen trained at the Yuri Gagarin Cosmonaut Training Centre in Star City near Moscow, becoming the first British astronaut when she launched into space on board a Soyuz spacecraft on 18 May 1991. Helen became a science communicator after her space flight. More recently, she has started a new career in management, working at the National Physical Laboratory and at Kingston University London, before moving to Imperial College in the summer of 2015.

Chairman: Terry Croft MBE, FIScT

Terry is the Chairman of the IST and has a passion and commitment to the Technical Community. His work involves promoting the Professional Technician as a career choice. He brings a wealth of experience to the board through his involvement with the wider sector and as Director of the Catalyst Project, titled "Development of Career Pathways for Technicians across the Higher Education Sector."

E: t.croft@istonline.org.uk

Honorary Secretary: Natalie Kennerley FIScT, CSci

Natalie became the IST Secretary in May 2016,and has responsibility for ensuring that we comply with legislative requirements and that we maintain suitable official records. Natalie is also Public Relations Advisor, and in that role she represents the IST at events, conferences, exhibitions and open days. Planning PR campaigns and strategies as well as writing and editing marketing material are also key. In addition, she is a Senior Assessor, assessing applications for Registered Science Technician, Registered Scientist and Chartered Scientist.

E: n.j.kennerley@istonline.org.uk

Finance Officer: Joan Ward FIScT

As Finance Officer, Joan's primarily role is to control expenditure on behalf of the Executive and be responsible for ensuring that satisfactory accounts of all monies received and expended are maintained. Further to this, Joan provides advice as to how annual financial performance might be improved, within the context of the IST being a not-for-profit organisation. She carries out any tasks agreed by the Executive to maximise overall financial wellbeing.

E: joanward@istonline.org.uk

Education Officer: Philippa Nobbs BA (hons), MCGI, MIOSH, FIScT

As Education Officer, Philippa maintains knowledge of vocational training and qualifications for technical practitioners and participates in regional and national development programmes. She has a long history of involvement in the development and delivery of technician training and led the introduction of the IST's service to employers to validate their in-house training schemes.

E: education@istonline.org.uk

Marketing Officer: Ian Moulson FIScT

As Marketing Officer, Ian looks at new and existing ways in which the IST markets itself to its members, prospective members, and the science and technology community. Ian is also the Editor of the IST's biannual publication 'The Journal' and is chair of its editorial panel, which oversees the quality of its articles and other content.

E: i.moulson@istonline.org.uk

Membership Development Officer: Kevin Oxley FIScT, CSci

As Membership Development Officer, Kevin develops strategies for membership engagement with the IST. His role further includes developing, managing and implementing a communication strategy for members. A key element of this is to identify opportunities to recruit new members and upgrade existing ones. Working alongside the Marketing Officer and PR Advisor, Kevin develops the implementation of recruitment and retention campaigns and promotes the benefits of membership to Higher Education institutions and industry.

E: k.m.oxley@istonline.org.uk

Registrar: Michelle Jackson BSc, PhD, FIScT, CSci

As Registrar, Michelle oversees the registration schemes run through the IST and contributes to the development of associated strategic and operational procedures.

E: michellejackson@istonline.org.uk

Fellowship & Overseas Officer: Derek Sayers FIScT

As Fellowship & Overseas Officer, Derek coordinates the review of Fellowship applications, setting in place panels of other Fellows for peer review, and advises the Executive on the outcome of the reviews. He also maintains the documentation of those applications. Derek is point of contact for overseas inquiries for organisations wishing to work with the IST; he liaises with such organisations and reports back to the Executive..

E: dereksayers@istonline.org.uk

Executive support/advisors

IST administrator: Wendy Mason

Wendy supports our memberships, registrations, committees and meetings, and manages the IST's office. She deals with all our general enquiries and helps to organise our events, visits, and conference. Wendy manages all our event bookings and is also the Leading Your Technical Team programme's administrator, and coordinates the Institute's annual Higher Diploma Examinations.

E: office@istonline.org.uk

China Advisor/Representative: Geoffrey Howell MIScT, RSci

Geoffrey is a member of the IST Education Board and is one of the assessors for Professional Registration. His background is in technical training management, and he is now leading the first International HE technical training programme in China as part of an ongoing IST Project

E: g.howell@istonline.org.uk

Co-ordinator for HE Regional Champions: John Dwyer FIScT

As Champions Co-ordinator for professional registration (PR), John's aim is to develop a network of Champions around the UK HE Sector and the Environment Agency. A Champions network offers guidance and help with PR and promotes it within their institutions. John is a Fellow of the IST and until recently was a member of the IST Strategy Board as coordinator for Partnerships. One such partner is HEaTED through which he has been actively promoting (PR) of technical staff throughout the UK..

E: j.dwyer@lancaster.ac.uk

Social Media/Engagement Advisor: John-Paul Ashton MIScT, RSci

As the IST Social media/Engagement Advisor John-Paul assists the IST through its Executive in developing its profile/presence on Twitter, Facebook, and LinkedIn etc.

He's an IST member and a Registered Scientist (RSci) and works closely with the Technicians Network at TUoS

E: j.p.ashton@sheffield.ac.uk

Industry Liaison/Advisor: James Trout MIScT CMgr

James is the Laboratory Manager for the National Laboratory Site at Starcross in Devon. The NLS is a national service of the Environment Agency and provides analytical data for a range of sample types. James is a Chartered Manager and a Governor of Newton Abbot University Technical College. He will be helping the IST develop industrial links and promoting frameworks for professionalising science/technical staff working in that sector..

E: j.trout@istonline.org.uk

Art and Design Social science Medicine Robotics IT Life sciences Arts and Media Psychology Immunology

iST

Zoology Earth sciences Materials Biology Biomedical Physical sciences Neuroscience Marine biology nterdisciplinary Engineering Criminology Graphic design Applied science Environmental Healthcare Food Technology Chemistry Music Forensics Software Space sciences Textiles Technology Physics AI

Chartered Scientist
Registered Scientist
Registered Practitioner
Registered Science Technician
IST CPD Award

Application for IST membership

Membership

Kevin Oxley FIScT, CSci IST Membership Development Officer

Membership of the Institute is open to specialist, technical, and managerial staff 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. There are five grades of membership in the Institute. An applicant does not initially apply for a specific grade of membership, the grade offered by the Institute being dependent upon the qualifications and experience of the applicant.

Why Join?

To help us maintain, build and expand the (IST) community.

Together we are a voice that is heard and listened to.

IST can help by supporting and developing your:

- professional standing
- knowledge and skills
- network of contacts
- career and interests

Application for membership at Junior, Affiliate, Associate, and Member grades can be made by email or by post to the IST office using the standard application form which is available for download (http://istonline.org.uk/membership/). The form must be accompanied by a copy of each relevant certificate, diploma etc. (scanned copies sent electronically are accepted). Completed applications should be emailed through to memberships@istonline.org.uk or posted to our Sheffield Office. Membership Application Notes for those applying for membership are available (http://istonline.org.uk/membership/).

When an application has been accepted, the applicant will be notified of the grade offered, at which time a full subscription payment will be required (within one month of notification). After the subscription has been received the new member's name will be added to the Register of Members and a Certificate and member's card will be sent. Following entry on the Register members are entitled to use the designated post-nominal letters relevant to their grade.

Annual membership fees are:

- Junior: £5
- Affiliate: £20
- Associate: £35
- Member: £45
- Fellow: £58

*Retired or unemployed members can claim a reduction of 50% off the normal rate

Previous members whose membership may have lapsed can apply for reinstatement by completing and returning a Membership Reinstatement Form to **memberships@istonline.org.uk**

Payment of subscriptions can now be made online

Is it art, engineering, media, science or technology? And does it really matter?

Philippa Nobbs

If we accept:

a) that science is the body of knowledge of the physical and natural world,
b) that engineering is the application of that knowledge in order to design, build, and maintain technologies, and
c) that technology is the body of knowledge, systems, processes and products that result from science and engineering and can be used to describe almost anything created and made by humans to solve a problem or meet a need[1] ,

then are creative arts and media, which depend on the use of science, engineering and technology, for the benefit of the soul?

Screenprinting workshop (Credit: Manchester Metropolitan University School of Arts)

When I was working as a laboratory technician in Further Education (FE) alongside technicians from other disciplines, e.g. engineering, fashion, art, printing, construction, etc., I was continually impressed with the technical skills that they all possessed. I believe that these skills were not always appreciated – or even recognised – by their immediate colleagues sometimes! I am also aware that, in some cases, this situation is still no different. Therefore, I am attempting to analyse the knowledge and skills required and to show that technical professionals have similar capabilities irrespective of their working environment. By peeling away the outer layer of technical professionals, be it lab coat, smock, overalls, corporate polo shirt or 'work' clothes, will people with similar mind and skill sets be revealed? To quote the slogan adopted by the Gatsby Charitable Foundation, "Technicians make it happen" and, in my experience, they make it happen in creative arts and media too!

Generally speaking, technical professionals in any area of work are people who possess an enquiring mind. This comes into play not only when manipulating technology to make things happen but also applies to systems and procedures. This enquiring mind is also likely to occupy itself by seeking improvements and alternatives – but this can be successful only if accompanied by a working knowledge of the technology/system/procedure and an understanding of the desired outcome, both for the specific process and the ultimate requirement.

What is a technical professional?

Technical professionals in all disciplines are likely to manage technical resources. These could include equipment and apparatus, laboratory chemicals and commercial products, living material, gases, machine tools, energy sources, components, construction materials, craft materials, IT hardware and software and, of course, people. Management may involve selection, purchase, storage, preparation for use, deployment, maintenance/servicing/testing and disposal together with safety, health and environmental requirements and compliance.

Technical professionals are often used to provide specialist, technical guidance to colleagues and others. This may take the form of advice, demonstration, training or coaching and may relate to equipment, procedures and techniques. Communication techniques and skills are also important.

Technical professionals need to keep up-to-date with current practices, techniques and materials

and they need to be looking ahead to see what is coming. They may also be carrying out their own research and development based on requests or identified needs from within their workplaces.

Are you a technical professional?

Look at the following questions.

1. Is your work essential to enable others to undertake their activities?
2. Do you set up / use complex equipment or apparatus?
3. Do you design and make resources for your own use or for others to use?
4. Is the accuracy of your work essential for a required outcome?
5. Might you, your colleagues and/or users of your work be put at risk by your activities?
6. Are any of the materials that you use classified as hazardous?
7. Do any materials, equipment or waste products require special disposal methods?
8. Does your work involve using/creating physical hazards, e.g. heat, radiation, sound?

If you answer "yes" to question 1 and one other, then you are truly a "technical professional"!

To paraphrase the words of Vincent Van Gogh[2], **"Great things are done by a series of technical professionals brought together"** and this happens in art, engineering, media and science.

Author

Philippa Nobbs BA (hons), MCGI, MIOSH, FIScT. Philippa is the IST's Education Officer. She maintains knowledge of vocational training and qualifications for technical practitioners and participates in regional and national development programmes. She has a long history of involvement in the development and delivery of technician training and led the introduction of the IST's service to employers to validate their in-house training schemes.

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References

1. What is the relationship between science, engineering and technology? Philippa Nobbs, IST Journal, Spring 2016

2. "Great things are done by a series of small things brought together" [variant: "Great things are not done by impulse, but by a series of small things brought together".] Vincent van Gogh, October 1882, letter to Theo van Gogh

Beaker: a model technician

Andy Connelly

The 1970s was an important decade in the history of scientific communication. In 1972 "Cosmos: A Personal Voyage" the seminal television series featuring Carl Sagan was released; four years later Richard Dawkins published The Selfish Gene. However, these pivotal moments were eclipsed when Dr. Bunsen Honeydew and his technician Beaker burst onto our television screens.

These colossi of television science began their careers on Jim Henson's infotainment show "The Muppets Show"[1]. The show was designed to satisfy the increasingly sophisticated and knowledge-hungry children of the space age, combining serious theatrical criticism with refined musical and dance performances, classical theatre, culinary discussion, and hard-hitting in-depth interviews with major stars such as Rudolph Nureyev and Elton John.

Within this eclectic intellectual atmosphere, scientific input was vital and the "Muppet Labs: where the Future is Being Made Today" soon became pivotal to the show's success. The audience hotly anticipated the moment when Kermit the Frog would bring up the curtain on the white-coated Honeydew and his technician Beaker in one of their many impressively high-tech experimental laboratories.

It is often forgotten that Honeydew initially presented the Muppet Labs segments alone. However, Honeydew was criticized for being too cold and intellectually distant for even the sophisticated Muppet Show audience to relate to him; as well as struggling to perform experiments and talk at the same time. It was clear that an assistant was needed and so, a star was born. Beaker added practical knowhow but, more importantly, an empathic humanity to the feature. His nervous manner endeared him to audiences and his

characteristic bulging eyes and red hair made him an instantly recognisable personality. He became a great ambassador for science, particularly for the role of experimentation and the scientific method.

Dr. Bunsen Honeydew and Beaker (http://vignette4.wikia.nocookie.net/muppet/images/d/d3/VMX-Beaker%26Bunsen.jpg/revision/latest?cb=20091211232717)

Beaker was willing to risk life and nose in his commitment to the scientific method. A classic example of this was his willingness to be used as a target to demonstrate the ground-breaking banana sharpener. The Honeydew-Beaker collaboration also introduced the edible paperclip, magnetic carrots, and the electric nose warmer to an amazed world. While these inventions may fail to impress a jaded millennial audience, they were true wonders in the more innocent age of the 1970s.

Beaker and Bunsen's on-screen relationship was complex. Many have said that Beaker's apparently accident prone ways were, in fact, the result of his victimisation by increasingly jealous and bitter Honeydew, resentful of Beaker's instant fame. If this was so, Beaker showed the true phlegmatic nature of the technician by keeping his dignity throughout; notwithstanding one episode in which undergoing repeated cloning procedures pushed the fiery red head to the limit. In anger at the treatment, Beaker and his clones chased Honeydew around the lab throwing the whole show into uproar. Despite this, it is clear that their relationship was a close one that led to incredible fame and success for both parties.

Beaker at his phlegmatic best. (https://en.wikipedia.org/wiki/Beaker_(Muppet)#/media/File:Beaker_(Muppet).jpg)

Unfortunately, in 1981 "The Muppet Show" was discontinued and Beaker and Honeydew's careers began to decline. The few cameo roles they took subsequently cast them as parodies of their former selves. Lapses in Beaker's judgement crept into his career choices: his ill-advised musical career was particular difficult with his covers of Queen's "Bohemian Rhapsody" and Morris Albert's "Feelings" meeting with general condemnation. There was also a brief and tragic affair with model Petra Němcová, the details of which are well known and best forgotten [2].

It is a credit to Beaker that the media and the adoring public are swift to forgive and forget. He and Honeydew are still cult figures, voted Britain's favourite cinematic scientists in 2004 [3]. The pair hold an important place in the history of science communication and I for one would not be the technician I am today without growing up under Beaker's influence.

Author

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The engineer Chas W. Cook – Part three

Alan Gall, IST Archivist

The story so far

Chas Cook's performance as a mechanic at the Royal Institution so impressed Dr Joseph Petavel[1] that it led to an appointment as official Instrument Maker to the University of Manchester. There, he witnessed the Rutherford period, a time when the renowned physicist attracted talented individuals to study radioactivity under his guidance. At Manchester, Cook would have come into contact with such figures as "the father of quantum mechanics" Niels Bohr, Charles Darwin's grandson (also called Charles), Hans Geiger and Osborne Reynolds.[2]

More a mechanical engineer than a constructor of delicate instruments, Chas Cook did however turn his hand to meeting the requirements of the new research group. A number of electroscopes (figures 1 & 2) were developed alongside the mainstay of the product range - furnaces and high-pressure equipment.

After seventeen years in the job, Chas Cook moved away from the industrial city. The disruption caused when two important employees of Chas W. Cook Ltd decided to set up their own business in competition may very well have influenced this decision.

Figure 1. Looking a little like a paraffin stove, a gold leaf electroscope said to have been designed by Ernest Rutherford (courtesy of Ted Cook)

Figure 2. A combined alpha-beta-gamma electroscope described as Dr Lazarus-Barlow type (courtesy of Ted Cook)

The last days at Manchester

During Chas Cook's tenure as Manchester's instrument maker his skills were being gradually appreciated by a wider audience. Soon after he arrived to take up the position, one of his high-pressure pumps found its way to the Solar Observatory at Mount Wilson, California.[3] And University staff departing for other academic posts carried with them the knowledge of Cook's capabilities. A furnace tested to 1500 atmospheres of hydraulic pressure is shown in *Monographs on Industrial Chemistry*.[4] The years 1905 – 1921 were very productive for Chas Cook & Sons (see the 1921 range of products, figure 3).

With the end of World War One came the departure of Ernest Rutherford for a prestigious post at the University of Cambridge. Glassblower Otto Baumbach returned from internment and found that his former assistant, Fritz Hartwig, had formed a new company to hijack all the customers. The difficulties imposed by the authorities to dissuade recent "enemy aliens" from setting up in business were overcome by Otto forming J. C. Cowlishaw Ltd, using his father-in-law to front the enterprise. It is believed that Chas Cook offered sympathetic advice about Otto's new venture as a thermometer maker away from the University.


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Figure 3. The Cook product range advertised in Nature 15 September 1921, shortly before leaving Manchester

In 1923 came a change of direction. At the end of 1922 the directors of Chas W. Cook Ltd were Chas himself and sons Alfred William, Charles Edgar and

Albert Leslie. The limited company was dissolved[5] and re-established as Chas. W. Cook & Sons, located (in modern terms) about 94 miles away down the M6 and A50 – at the small market town of Ashby de la Zouch. Chas Cook had evidently made a sound financial success of his business at Manchester.

Ashby de la Zouch

The contrast with the University of Manchester, surrounded by grimy terraced houses, air laced with industrial pollution, could hardly have been greater. Lars Öholm, a Finnish scientist who spent time in Rutherford's laboratory in 1913, described conditions. He wrote to Svante Arrhenius (the Swedish chemist remembered for his ionic theory) that he found both Manchester and the laboratory to be very dirty places, and returned home in the evenings looking like a chimney sweeper: "Soot and smoke have left footprints everywhere".[6]

Figure 4. Letterhead used in the 1920s

At Ashby, Chas Cook moved into a magnificent-looking hotel, originally built 1826-27 and set in spacious grounds. It went under the name of the Hastings Hotel until renamed as the Royal Hotel. To the rear of the building stood disused spa baths, promptly turned into workshops by Chas and sons. Once known as the Ivenhoe Baths, it became the Royal Hotel Works where new products were developed and manufactured.[7]

Sports activities featured highly in the social life of the Cook family. Chas acted as president of the Hastings Amateur Football Club, with son Charles Edgar as honorary secretary. They also hosted the Hastings Cricket Club on part of the estate and the few known pictures of Chas are those taken with members of the team (figure 5). Even the family (daughter and grandson) possess only one image, in the form of a newspaper cutting (shown in part one of this article).

The names of individuals involved with the Hastings Cricket Club in figure 5 are those provided by the Club. Some 70 years after the event, Margery Cook correctly identified all the same people, with the same unknowns. Note that the name "Hastings" features in place names and organisations because of the influence of the Hastings family on the early history of Ashby.

Figure 5. Ashby Hastings Cricket Club in the 1920s. (1) Mr Rumley, (2) Reg Tetley, (3) unknown, (4) Alfred William Cook (umpire), (5) unknown, (6) unknown, (7) George Ridgeway, (8) Mr Brend (scorer), (9) Charles Edgar Cook (captain), (10) unknown, (11) unknown, (12) Charles William Cook, (13) unknown, (14) Les Sampson, (15) Paul Webster (courtesy of Ashby Hastings Cricket Club)

The Cooks receive visitors

While at Ashby, Chas (or his wife) extended an invitation to the Baumbach family with the offer of an evening meal. Over 70 years later, Geoffrey Baumbach could still recall the anxiety felt when it looked like they might be late for tea. The presence of two brightly coloured parrots at the hotel also left an indelible print on his memory. Margery Cook has confirmed the existence of the parrots, even if she could not add further details about the visit.

A visitor who Margery did remember came after some weeks of eager anticipation by Chas. During his employment at the Royal Institution, he worked under the supervision of Dr Alexander Scott. The pair (Chas14½ years younger) got on well together and had kept in touch. What made Scott's arrival memorable was the chauffeur-driven car. No doubt the conversation covered Dr Scott's examination of the British Museum's treasures for damage after storage in London's underground during WWI.[8]

Figure 6. The splendour of the Royal Hotel as shown in Brown's Annual for 1925 (courtesy of Ken Hillier)

Figure 7. A modern view of the Royal Hotel, Station Road (courtesy of Stephanie Dearing)

Figure 8. An 1837 map of Ashby de la Zouch showing hotel, baths and grounds (courtesy of Ken Hillier)

Writing to Ludwig Wittgenstein (the philosopher we have already met in connection with the meteorological station run by the University of Manchester) on 28 July 1926, William Eccles mentions a trip to Chas Cook's premises. The letter reads in part, "I found Charles Cook when out for a motor run at Whitsuntide. (You remember the maker of your turbine nozzles [a reference to the novel aeroplane engine that Wittgenstein had patented]. He has a combined Workshop, Garage and Hotel at Ashby de la Zoreche [sic] (near Derby). One son manages the Workshop & Garage & the other looks after the hotel. Cook lives in the hotel and does nothing except be discontented!"[9]

Margery Cook took great exception to the statement above. As far as she was concerned, her father arose early each morning eager to start work at his drawing board on various new designs. As shown in figures 13 – 16, manufacture of a number of items can be dated to the time at Ashby.

Figure 9. This engraving is from the 1830s. According to advertisements of the day, water came from "an overflow of the strongest medicinal springs" and "The Ashby Medicinal Waters naturally combine the Chlorides of Sodium, Magnesium, and Calcium, with the Bromides of Potassium and Magnesium, in extraordinary proportions; and they contain a far greater quantity of Bromine, a newly-discovered alkaline substance with very energetic properties, than any similar water in the kingdom.[10]

Equipment from the Ashby period

Figure 10. Patrick Maynard Stuart Blackett (1897-1974) later Baron Blackett of Chelsea, pictured in the science magazine Discovery January 1949

Around 1934, Chas Cook received instructions from future Nobel Prize-winner[11] Professor Patrick Blackett at Birkbeck College, London to manufacture a large cloud chamber. According to daughter Marjory, her father spent many anxious hours over the design and construction of the device. Blackett's interest centred on measuring the energy spectrum of cosmic rays. To create a sufficiently powerful magnetic field for operating the cloud chamber, he commissioned an electromagnet from Metropolitan Vickers at Trafford Park, Manchester. The iron yoke weighed about 8000 kg and the copper windings 3000 kg. Because of the large mass, the College had a wooden hut constructed to house the experiment. The cloud chamber's internal dimensions were 27 x 3.5 cm.[12] A bigger version used by G. Herzog, also at Birkbeck College, and made at the Ashby works, measured 50 cm x 25 cm (figure 11). On a more mundane level, but showing the diversity of products and quality of manufacture, a Morse code key sold on eBay a few years ago (figure 12).

To be continued.

Figure 11. Enclosed in a gun-metal casing, a Cook cloud chamber used by G. Herzog at Birkbeck College[13]

Figure 12. A Morse code key made at the Ashby de la Zouch works, shown on eBay

Figure 13. The Cook laboratory hydraulic press, available in various versions up to 50 tons pressure (courtesy of Ted Cook)

Figure 14. A hefty piece of kit. Three hundred kg of iron and 100 kg of copper wire went into the construction of this electromagnet, giving a magnetic field of two tesla (courtesy of Ted Cook)

Figure 15. An apparatus for measuring the wear resistance of rubber by checking the weight of a sample after a number of rotations against an abrasive wheel. It was particularly aimed at tyre manufacturers (courtesy of Ted Cook)

Figure 16. Apparatus based on the work of R. A. Henry for determining the washability of coal (courtesy of Ted Cook)

Figure 17. This advertisement from Nature 12 December 1925 states "first introduced by the present makers in 1900". Chas Cook was employed by the Royal Institution at that date

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Matt Longley, chairman of the Ashby Hastings Cricket Club.
Professor Robin Marshall FRS of the University of Manchester.

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Graphene electrochemical capacitors

Charles Osarinmwian

In response to the needs of modern society and emerging ecological concerns, it is now essential that new, low-cost, and environmentally friendly energy storage systems are found. To this end, a key objective of a recent £20 million UK energy storage innovation programme was to strengthen investor confidence in energy storage at all scales [1]. The 2D material graphene (Fig. 1) is a rapidly rising star on the horizon of materials science and condensed-matter physics [2,3] with promising applications in electrochemical energy storage [4]. Conventional materials in energy-related applications (i.e. graphite, carbon black and activated carbon) will only be replaced if graphene is proved to be superior in terms of both performance and cost. Developing defect-engineered graphene for electrochemical capacitor applications is novel and timely because it could hold key advances in energy conversion and storage both of which are vital in order to meet the grand challenges facing society.

Fig. 1: Graphene - monolayer of carbon atoms packed into a dense honeycomb crystal structure. This is viewed as an individual atomic plane extracted from graphite (Source: Wikipedia image)

Background

Electrochemical capacitors store electrical energy by separation of ionic and electrical charges at the interface of a solid electrode and electrolyte (electrochemical double-layer) and/or fast, reversible Faradaic surface redox reactions (pseudo-capacitance) while filling the gap between batteries and conventional solid state and electrolytic capacitors [5,6]. These devices are used for energy recovery and when high power demands are needed. They are highly durable (lifetime > 10,000 cycles) with power densities (10 kW kg^{-1}) that are an order of magnitude larger than batteries but have low energy densities (10 Wh kg^{-1}) relative to batteries which limits their practical use [7]. In the search for appropriate electrode materials for electrochemical capacitors, carbon-based electrodes such as activated carbons and carbon nanotubes have been widely used in industry owing to their high surface area and good electrical conductivity. However, their electrochemical capacitance is still not sufficient for many applications [8].

Graphene is regarded as an attractive candidate for next-generation electrode materials in electrochemical capacitors (Fig. 2) because of high electrical conductivity and theoretical specific surface area (~2630 $m^2 g^{-1}$) which sets an upper limit for electrical double layer capacitance of ~550 F g^{-1} (~21 μF cm^{-2}) if the entire surface area can be fully utilized [7,9]. Despite these favourable qualities, practical implementation of graphene has been limited by poor volumetric surface area and/or accessibility to the electrolyte [10]. Nanostructured materials for electrochemical capacitors need to reach a compromise between specific surface area and defect (or hole) size distribution [5]. The discovery that ion de-solvation occurs in defects smaller than the solvated ions led to higher capacitance for electrochemical double layer capacitors using carbon electrodes with sub-nanometre defects while opening the door to designing high-energy-density devices containing a variety of electrolytes [6].

Fig. 2: Graphene electrochemical capacitor. Two high-surface-area graphene-based electrodes (blue and purple hexagonal planes) are separated by a membrane (yellow). Also shown are anions (white and blue merged spheres) and cations (red spheres) of the electrolyte(Source: reference [4])

Disorder has a profound impact on the extraordinary properties of graphene and is often intentionally introduced to modify the performance of functional graphene-based devices. The interfacial capacitance in graphene electrochemical capacitors is strongly dependent on electrochemical double-layer capacitance and the electrode quantum capacitance. In theory, the presence of point-like topological defects disrupts the π system of graphene electrodes leading to quasi-localized states of varying degrees near the Fermi level and an enhanced quantum capacitance (higher interfacial capacitance) compared to pristine graphene [10]. Experimentally, increasing the defect density in graphene could potentially increase its electrochemical capacitance capability [11].

Quantifying defects in graphene is crucial to gain insight into fundamental properties as well as future applications. Using different ion bombardment doses in the range 10^{11} Ar^+ cm^{-2} (1 defect per 4×10^4 carbon

atoms) to 10^{15} Ar^{+} cm^{-2} (1 defect for every 4 carbon atoms), it was found that tuning bombardment exposure could be used to manipulate the distance between defects and the ratio between the D and G peak intensities in Raman spectra [12]. Although defects in graphene are the prototype example of resonant impurities, changes in the electronic properties of graphene induced by noble-metal adatom impurities could share similarities with that of defects. A high density of Ag adatoms in graphene leads to strong resonances in quantum capacitance[13] and observation of negative quantum capacitance[14]. In the latter, signatures of negative capacitance at Landau level positions of ±1 and -2 broaden and gradually disappear as the temperature increases from 2 K to 200 K. Also, the resonant peak of quantum capacitance near the Dirac point becomes intense with decreasing temperature.

National Importance

UK societal challenges: Energy storage could result in savings of around £2.4 billion per year in 2030 for the UK electricity system and, if 50 % of this saving was passed on to domestic customers, it could reduce the average electricity bill per household by around £50 per year [1]. The UK Government forecasts that total behind-the-meter energy storage will rise dramatically from around 400 MWh in 2016 to nearly 760 GWh in 2040. Although graphene electrochemical capacitors have witnessed rapid developments and substantial achievements in recent years, there are still many challenges to be addressed to realize their practical energy storage applications [9].

Emerging industries: The rigidity of existing batteries and electrochemical capacitor technology is susceptible to damage and electrolyte leakage. Thus, the market for flexible and printed electronics using graphene is rapidly growing, with emerging products ranging from flexible energy-storage devices to flexible displays and wearable electronics [9,15]. Graphene-based electrochemical energy storage has spurred research into its applications in emerging systems such as Mg-ion batteries which have been proposed as a high-energy-density and environmentally friendly replacement for Li-ion batteries [16].

UK economic success: Energy storage systems are considered a highly valuable resource in power systems today due to the wide range of services it can provide across the electricity sector [17]. Given that storage is a technology that "could help fire a smart power revolution", the UK Government has allocated at least £50 million innovation funding to smart technologies including storage [1]. The significant investment in energy storage around the globe has placed the UK in something of a technology and deployment race. Graphene-related systems showcase several key properties that can address emerging energy needs, in particular for the ever growing market of portable and wearable energy conversion and storage devices. Such discovery and innovation in the mathematical and physical sciences will be a major driver of economic growth and efficiency across all regions and sectors of the UK.

World leading research: Defects in graphene not only modify its properties but also extend its functionality by providing sites for chemical reactions, which enables intentional heteroatom doping at specific points. The rich chemistry between carbon and nitrogen allows the introduction of nitrogen dopants into the graphene lattice in order to increase quantum capacitance while allowing fast diffusion rates for electrolyte ions through pyridinic-like hexagonal defects [7,8]. More importantly, heteroatom doping of graphene has been established as one of the preferred approaches to expanding the family of 2D materials [18].

Strategic Priorities: Electrochemical capacitors using defect-engineered graphene fits with and compliments previous EPSRC funded research: development of "graphene-augmented" smart integrated devices on flexible/transparent substrates for energy storage [19a], practical performance of graphene electrodes within an electrochemical capacitor device [19b], and the development of a graphene-enabled Na-ion battery [19c]. It also aligns with the EPSRC Challenge Themes of "Electrochemical Sciences", "Materials for Energy Applications" and "Energy Efficiency". Innovative materials science lies at the heart of the advances that have already been made in energy storage. UK success will be driven by as yet unimagined, new materials as well as innovative, more cost-effective ways of delivering existing products through transformational technologies.

Academic Impact

Unlike a traditional metal electrode, graphene electrodes have a capacitive performance that is limited by a small quantum capacitance at low applied voltage [10]. Although efforts to rectify this involve either increasing active surface area or pseudo-capacitance, there is a lack of pragmatic methodologies which resolves the intrinsic bottlenecks that impede the emergence of high-energy-density electrochemical capacitor devices [7] and ambiguity concerning identification of the mechanistic role that graphene morphology plays in capacitance enhancement [20]. This is important because defect-engineered graphene electrodes could significantly increase device performance while being individually tailored for

operation as either the positive or negative electrode since charge is stored asymmetrically near the Dirac point [10]. Although defects have been perceived to limit performance, the challenge is to develop graphene electrodes by tailoring the defect size distribution in order to achieve optimal capacitance.

Defect-engineered graphene could alleviate existing bottlenecks, without compromising its intrinsic properties, and so lead to a new paradigm in energy storage. To refine previous theoretical results on defect-engineered grapheme [10], it is important to experimentally investigate how the quantum capacitance (proportional to the density of states) can be altered by local modification of electronic structure caused by electrode-ionic liquid electrolyte interactions. The possibility of tuning the electronic structure and quantum capacitance of graphene on demand using defects could pave the way to the commercialization of graphene electrochemical capacitors. The future competitiveness and creativity of the UK economy requires the successful development of energy storage devices based on discovery and innovation.

Academic Beneficiaries

Graphene uniquely combines extreme mechanical strength, exceptionally high electronic and thermal conductivities, impermeability to gases, as well as many other supreme properties, all of which make it highly attractive for numerous applications [4]. Defects underpin changes in the band structure of graphene where the appearance of sharp peaks is expected in the density of states near the Dirac point or changes in electron/hole scattering efficiency at grain boundaries and line defects [21]. This will impact chemical and process engineers because defects occur predominantly during the graphene production process. In fact, the properties of a particular grade of graphene (and hence its applications) strongly depends on factors such as material quality and type of defects, which are strongly affected by the method of production [4].

Measuring the interfacial capacitance of defect-engineered graphene could serve as a powerful tool for electrochemists in understanding aspects of the interfacial capacitance of carbon electrodes. This will contribute to addressing the lack of a reliable battery that still holds back electric vehicles from being readily adopted over vehicles using an internal combustion engine [9]. The rise of such vehicles will drive down the cost of Li-ion batteries, making them increasingly attractive for deployment alongside UK residential and commercial solar systems [1].

Atomic-level structural modification of graphene has the potential to generate tailor-made devices with enhanced performance thereby opening a new paradigm for energy storage. For physicists, the interaction effects among electrons and defects can be realised experimentally using quantum capacitance methods with defect engineering providing a powerful route to controlling magnetism in graphene without the presence of transition metal elements [22]. Similar to other resonant impurities, the modification of electronic properties in defect-engineered graphene near the Dirac point is useful for designing new device structures involving band-structure engineering.

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Applications of liquid chromatography-mass spectrometry in clinical analysis

Raffaele Conte

Abstract

Liquid chromatography-tandem mass spectrometry (LC-MS/MS) has seen enormous growth in clinical laboratories during the last decade. This is due to the fact that it offers analytical specificity superior to that of immunoassays or conventional high performance liquid chromatography (HPLC), and has higher throughput than gas chromatography-mass spectrometry (GC-MS). A few years ago LC-MS/MS started to penetrate into smaller laboratories, with most chemicals and metabolites now assayed with this instrument. However, the high costs and complexity of the instrumentation's operation are hindering its widespread adoption.

Introduction

Liquid chromatography–mass spectrometry is a powerful analytical technique that combines the physical separation capabilities of liquid chromatography with the detection specificity of mass spectrometry.[1] Briefly, liquid chromatography separates the sample components and then introduces them to the mass spectrometer that creates and detects charged ions. The LC/MS data gives information about the molecular weight and quantity of specific sample components. Such a technique has very high sensitivity and is used for the detection, identification, or purification of chemicals in complex mixtures.[1] LC/MS significantly expands the effective analytical use of mass spectrometry to a much larger number of organic compounds. It is suitable for the analysis of large, polar, ionic, thermally unstable, and non-volatile compounds.[2] Figure 1 shows a mass analyser.

Figure 1. LC-Mass analyser

In the liquid chromatography part of the instrument the sample is forced by a liquid at high pressure (the mobile phase) through a column that is packed with a stationary phase generally composed of irregularly or spherically shaped particles. Components of the mixture elute according to their relative affinity between the stationary and mobile phases. These elutes are then pumped through a nebulizing needle and undergo vaporization. These components are ionized due to the fact that the produced spray goes through an electrode which is at a high potential. The potential difference between the needle and the electrode produces a strong electrical field and this field charges the surface of the liquid forming a spray of charged droplets. The charged droplets undergo a counter flow of heated nitrogen drying gas which shrinks them and carries away the uncharged material. As the droplets shrink, the electrostatic forces exceed the cohesive forces and the analyte ions are desorbed into the gas phase. These gas-phase ions pass through the capillary sampling orifice into the low pressure region of the ion source and inside the mass analyser where they are separated by electromagnetic fields according to their mass-to-charge ratio. Mass spectrometers can operate in either scan mode or a selected ion monitoring mode. In the scan mode the instrument detects signals over a mass range (e.g. from 50–2000 m/z) during a short period of time. During this scan period the MS electronics sequentially read the signals detected within narrower mass intervals until the full mass range is covered. This mode of operation is typically selected for qualitative analysis or for quantification when analytes' mass are not known in advance. In the SIM mode mass spectrometers are set to monitor a single mass to-charge ratio (m/z). This technique is used for target compound analysis. A more accurate SIM analysis is accomplished by a process called collision-induced dissociation (CID), in which ions break apart as a result of collisions with other molecules. Spectra of fragments are then produced derived from the selected ions, which lead to a more specific detection of the analyte. LC-MS\MS is currently used for the identification of unknown compounds, the determination of the isotopic composition of elements in a molecule, and the study of the structure

of a compound by observing its fragmentation. It is commonly used in analytical laboratories that work on physical, chemical or biological properties of molecules.[3] Figure 2 is a schematic representation of LC-mass workflow.

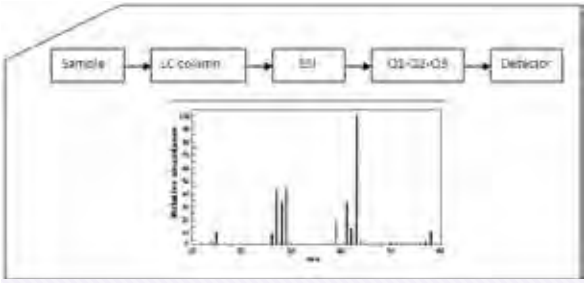

Figure 2. Schematic representation of LC-mass workflow

Clinical use of LC-mass

Clinical use of LC-MS/MS has risen during the last few years due to the fact that it combines high analytical specificity with high analytical sensitivity, allowing relatively short chromatography run-times. The advantages related to mass chromatography when compared to immunoassays are easier workflows and a higher throughput than conventional HPLC or GC-MS, along with significantly lower equipment costs. Even when used on automated instruments immunoassays suffer from a limited dynamic range and differing measures for the same analyte that are often in poor agreement with each other. Finally, if no commercial immunoassay is available for the substance of interest designing and validating a new in-house analysis is difficult, especially compared with the much easier development of a new LC-MS/MS assay. However, several key limitations of LC-MS/MS have become apparent with the exponential increase of its use in clinical laboratories. These are highly manual workflows, complexity of operation, maintenance of instrumentation, sample throughput limits, insufficient detection sensitivity for some analytes, and problems with detection specificity.[4]

The following four paragraphs list tests in which LC-MS/MS express all its potential as routine instrument for clinical laboratories.

Vitamin D - Vitamin D indicates a group of thirty metabolites functional for bone health that are often in low concentration in the European population.[5] The majority of vitamin D circulates bound to the transport protein called vitamin D-binding protein. Its hydroxylation in the liver forms the 25-hydroxy vitamin D (specifically, D2 and D3 are the most diffused isoforms). This form is inactive (biological activity is conferred by the hydroxylation step catalysed in the kidney by the 1-α-hydroxylase that results in the production of one 25-dihydroxy vitamin D) but is the most abundant circulating and is therefore what is measured.[6] HPLC, RIA, automated chemiluminescence immunoassays and LC-MS\MS are used in clinical laboratories for the measurement of 25-OH-D in biological fluids.[6] However, the strong variability encountered between these methods led to development of quality control materials (human serum containing 25-OH-D2, 25-OH-D3, and their respective 3-epi isomers at four different concentrations) used for standardisation. These standards were developed and characterised by LC-MS/MS.[7,8] LC-MS/MS then allows unequivocal differentiation and accurate quantification of all these compounds, offering greater sensitivity and specificity.[8]

Drugs quantification - The simultaneous, quantitative, and rapid analysis of plasma concentrations of multiple drugs is important to determine the prognosis of patients under drug therapy and effect a clinical decision.[9] This is because every drug has a specific therapeutic index (TI; also referred to as therapeutic window or safety window) that is a comparison of the amount of a therapeutic agent that causes the therapeutic effect to the amount that causes toxicity.[9] In an established clinical setting TI refers to the ratio of the dose of a drug that causes adverse effects, divided by the dose that leads to the desired pharmacological effect. In contrast, for a drug in a development setting the TI is calculated on the basis of plasma exposure levels.[9] For many drugs there are severe toxicities that limit the maximum dose. A higher therapeutic index is therefore preferable to a lower one, and drugs with a narrow therapeutic range must have their dosage adjusted according to measurements of the actual blood levels achieved in the person taking it. This may be achieved through therapeutic drug monitoring (TDM) protocols. Such protocols are based on the measure of drug plasma concentration. LC-MS/MS represents the gold standard in drug analysis due to its high sensitivity.[10] Examples of drugs routinely quantified are antihypertensive drugs (Levetiracetam, Furosemide, Verapamil), Benzodiazepine psychoactive drugs (Carbamazepin, Oxacarbazepin), anticancer drugs (Capecitabine, Fluoropyrimidine, Irinotecan, Tamoxifen, Cis-platin, ciclophosphamide, Antraciclins, Methotrexate, Trastuzumab, Simvastatin)

Hormones - Liquid chromatography–tandem mass spectrometry is currently the method of choice for routine determination of steroids in clinical laboratories. It substituted immunoassays that suffer from problems of cross reactivity with similar analytes, standardisation issues between labs, and low sensitivity.[11] However, LC–MS/MS can be used

as a gold standard when used in the appropriate manner under highly regulated conditions[12],[13] in order to standardise the interpretation of test results by making data comparable between laboratories.[14] Examples of already diffused hormone measurements are aldosterone, cortisol, Oestrogens, Testosterone, 17-hydroxyprogesterone, androstenedione, pregnenolone, 17-hydroxypregnenolone, deoxycortisol, and deoxycorticosterone in serum or plasma.

Catecholamines and Metanephrines - The testing of catecholamines and metanephrines in urine or plasma, or of vanillylmandelic and homovanillic acid in urine, are commonly used to screen for phaeochromocytoma in patients who have difficult to treat hypertension or show symptoms of a chromaffin tumour. These metabolites are usually measured by HPLC with electrochemical detection but GC-MS and LC-MS/MS are more recent alternatives that offer higher sample throughput and improve analytical specificity.[15] Metanephrines are present in urine mainly as sulfate and glucuronide-conjugated metabolites produced from free metanephrines by the actions of conjugating enzymes.[16] There is the need to set an acid hydrolysis step to liberate the free metanephrines and to separate by the use of normal phase chromatography after solid-phase extraction or through precipitation using isopropanol.[17]

Improving LC-MS/MS workflows and ease of use

The manual nature of LC-MS/MS workflows and the high complexity of the instrumentation's operation and maintenance are the key factors hindering more rapid adoption of LC-MS/MS. For smaller laboratories entry into LC-MS/MS is not easy due to the high initial cost of the equipment. In addition a laboratory scientist will have to spend 3–6 months to acquire a solid understanding of the underlying technologies and to have basic skills to successfully start implementing new LC-MS/MS assays. Finally, at least two individuals should be largely dedicated to LC-MS/MS utilisation.[18] Despite these hurdles, the analytical advantages of LC-MS/MS for many low molecular weight analytes and the cost savings on reagents compared to commercial immunoassays have prompted many laboratories to consider LC-MS/MS. Manufacturers of LC-MS\MS instruments are now making their devices more functional for pre-analytical and analytical workflows. The design of integrated sample clean-up or extraction devices, of instrument interfaces, and the software has improved the user-friendliness.[18]

Future challenges

The next challenge for clinical LC-MS/MS is peptide/protein analysis. Such use is already diffused in research as shown by the use of "peptide mass fingerprinting analysis" in its forms of structural, differential and functional proteomics.[19] Manufacturers are designing bio analytic software able to assess and interpret data in a more functional way for clinical applications. This will probably result in similar research growth of clinical protein/peptide LC-MS/MS as those that has been seen for chemicals and metabolites. For example figure 3 reports the search page of "MASCOT Peptide mass fingerprinting" analytical tool.

Fig.3 MASCOT Peptide mass fingerprinting

Summary and conclusions

Clinical LC-MS/MS has seen incredible success and growth for a wide range of analytes during the last 10-15 years. From the initial use in biochemical screening and drug and toxicology testing it has quickly expanded into endocrine testing, where it now forms the reference test for steroid and biogenic amine, being capable of high sensitivity and specificity quantification of these analytes in large numbers of patient samples. However, with the exponential growth in use limitations of LC-MS/MS have become apparent. The growing research is aimed toward solving these issues. Finally, expansion into targeted peptides and protein detection is expected to grow in scope and importance exponentially, further expanding the clinical applications of LC-MS\MS.

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The development of cleanrooms: an historical review – Part 2– The path towards international harmonisation

Tim Sandle

Introduction

Cleanrooms are highly controlled environments where the air quality is monitored to ensure the extreme standards of cleanliness required for the manufacture of pharmaceutical, electronic and healthcare goods. These stringent standards usually require high fresh air rates, extensive filtering, temperature and humidity control - all of which results in increased energy usage. Protection from uncontrolled ingress of external ambient air is achieved by creating a pressure differential between the cleanroom and its surroundings.

Contamination control is the primary consideration in cleanroom design; however the relationships between contamination control and airflow are not well understood. Contaminants such as particles or microbes are primarily introduced to cleanrooms by people although processes in cleanrooms may also introduce contamination. During periods of inactivity or when people are not present, it is possible to reduce airflow and maintain cleanliness conditions.
To design the cleanroom, the following factors must be accounted for:

- Minimize clean space
- Correct cleanliness level
- Optimal air change rate
- Consider use of mini-environments
- Optimize ceiling coverage
- Consider cleanroom protocol and cleanliness class
- Minimize pressure drop (air flow resistance)
- Location of large air handlers – close to end use
- Adequate sizing and minimize length of ductwork
- Provide adequate space for low pressure drop air flow
- Low face velocity
- Use of variable speed fans
- Optimizing pressurization
- Consider air flow reduction when unoccupied
- Efficient components
- Face velocity
- Fan design
- Motor efficiency
- HEPA filters differential pressures (ΔP)
- Fan-filter efficiency
- Electrical systems that power air systems

While cleanrooms are an established and expected feature of healthcare and pharmaceutical operations, their development has been gradual and the origins, in terms of the idea of a 'clean space' date back several hundred years.

In part one of this article, the early designs, driven by industrial (often military) and healthcare needs were discussed and the history of cleanrooms and standards was described up until the 1960s. This second part considers developments from the 1970s and the issuing of the first international standard for cleanrooms and clean air devices – ISO 14644.

1970s: pharmaceuticals

During the 1970s the cleanroom technology began to be used to a greater extent by the pharmaceutical industry. Although a sterility requirement for the preparation of aseptically produced injectable medicines was established in the 1920s and the requirement for biological preparations to be produced under relatively "clean" conditions had become generally accepted post-World War II [1], the increased application of laminar airflow technology in the 1970s allowed medicines to be produced under far cleaner and more controlled conditions. This development was driven by both technology and by regulatory developments (which had begun with the FDA Good Manufacturing Guidelines of 1963) [2]. For example, the UK published its first GMP standards (colloquially termed as the "Orange Guide") in 1971, where the use of cleanrooms was specified. However, the initial coverage given to cleanrooms was limited and referred to only very broad environmental cleanliness requirements. There was no inclusion, for example, of air supply or air filtration requirements.

Other developments which took place were with the development of microbiological safety cabinets, in the early 1970s. This centred on research undertaken within the U.S. National Institute of Sanitation and by the U.K. Medical Research Council [3]. This research led to the development of safety cabinets with different safety features depending upon the nature of the biological hazard (typically three different classes of cabinet used appropriate for one of four different biohazard categories) [4].

1980s: GMP standards

The main development with cleanrooms during the 1980s was no so much with technology but instead with an increase in GMP standards relating to pharmaceutical processing (although improvements with cleanroom design continued during the decade)[5]. There was little co-ordination between the different bodies responsible for standards, regulations and guidelines, which created considerable drift between the national standards for cleanrooms and the GMP requirements for pharmaceutical processing in terms of the operational and testing requirements [6].

The first significant GMP "guidance"' was with the publication by the Parenteral Drug Association in 1981, which pre-dated the regulatory guideline on this subject, from the U.S. Food and Drug Administration (FDA), by six years. The FDA issued its first guideline on aseptic manufacturing in 1987: the "Guideline on Sterile Drug Products Produced by Aseptic Processing". The guideline made reference to Federal Standard 209 for the purposes of particle classification, and contained the most detailed regulatory information to date relating to sterility assurance, cleanroom control, and to microbiological testing. In relation to cleanrooms, the document defined a "critical area", where the sterilized dosage form, containers, and closures are exposed to the environment, as well as support areas, and areas for component preparation. Despite advances with cleanroom technology, most notably the wider use of isolators, the standard was not updated again until 2004.

The microbiological limits in the FDA Guidelines, in a similar way with those in the European GMPs, appeared similar to the NASA standards for microbiological testing.

1990s: towards a global standard

The 1990s saw major changes to cleanroom standards and considerable technological changes to cleanrooms with the advent of isolation technology.

In examining cleanroom standards first, the decade initially saw a further increase, in terms of numbers and stringency, of cleanrooms standards. This was driven, primarily, by the demands of the microelectronics industry [7]. A revised edition of the Federal Standard was published in 1992 as FS 209E[8]. The major change with the standard was that the airborne concentrations of particles in a cleanroom were given in metric units, (particles per m^3) for the first time, and the classifications of the room were defined as the logarithm of the airborne concentration of particles (in relation to the 0.5 µm size) [9]. This was to be the last edition of this standard as several nations began the process towards constructing a global cleanroom standard.

Figure 1: CEN/TC 243 meeting at AFNOR, Paris, 8 Oct. 1993 (image courtesy of Schicht Hans H.: 40 years of cleanroom technology - some historical remarks. In: Proceedings of the 17th International Symposium on Contamination Control, Bonn/ Germany, 6-9 Sept. 2004, p. 1-10. Edited by: Verein Deutscher Ingenieure (Association of German Engineers), Düsseldorf/ Germany (2004))

The genesis of a single international cleanroom standard, covering all industries which used cleanrooms, began in 1991 at a meeting of the International Confederation of Contamination Control Societies. The objective of the meeting was to replace the competing national and supranational standards for cleanrooms with an international standard for the technical and performance specification of cleanrooms. Quite why the direction was not taken towards international acceptance of the Federal Standard 209 is unclear, although some speculate that this related to a desire by some European nations for a degree of independence from the USA [10].

A year later, in 1992, the International Standards Organisation (ISO) Technical Secretariat established Technical Committee ISO/TC 209 "Cleanrooms and associated environments", with a view to progressing a new cleanroom standard. The lead participant was Europe, through its CEN/TC 243 body for "Cleanroom Technology". The USA entered the process a year later. The first draft of the new 'international' standard was issued in 1993 [11]. During this embryonic stage the possibility of one standard combining both particulate

levels and microbial limits was considered [12]. This was quickly abandoned, and the development of a biocontaminaiton standard was later developed (what was to become ISO 14698: Cleanrooms and Associated Controlled Environments – Biocontamination Control). ISO 14698, in its current form, is generally regarded as secondary to GMP guidance.

The international cleanroom standard - ISO14644 – was issued in 1999 [13]. The standard introduced a new classification system (ISO Class n, with cleanrooms classified on scale of decreasing cleanliness from class 1 to class 9, across three different room occupancy states: as built, at rest and in operation). There were noteworthy similarities and differences to the Federal Standard 209. What was most similar was that the class name indicated the maximum allowed number of particles of a given diameter. What was different was that the number of classification states was greater. Standard 209 contained six classes, whilst the ISO 14644-1 classification system added two cleaner standards and one dirtier standard (so that ISO class 3 was approximately equal to FS209E class 1, and ISO class 8 approximately equalled FS209E class 100,000). With the ISO classification the reference particle diameter was across a scale of 0.1 µm and larger, which was different from the Federal Standard which used the given class number as the maximum allowable concentration of particles, with a reference particle diameter of 0.5 micron.

The standard was adopted by most nations during 1999, although the USA did not adopt the standard until 2001 [14]. The adoption of ISO 14644 led to various other national standards being superseded, including: UK: BS 5295, Australia: AS 1386, France: AFNOR X44101, Germany: VD Guideline 2083 Sheet 3 - Messtechnik in der Reinraumluft I.2083 and Japan: JIS B 9920. These major national standards had each referenced FS 209 for particulate levels.

In relation to cleanroom design, a European wide standard for HEPA filters was introduced in 1998, which replaced several national standards. This was the EN 1822 and was driven by the need to make trade across Europe easier between member nations [15]. EN 1822 was later revised, and expanded to five parts, to included ULPA (Ultra Low Penetration Air) filters.

Into the Twenty-First Century

In terms of technical innovations, the major shift in cleanroom operations during the 2000s was the more widespread use of isolation technology. Isolators, like conventional cleanrooms, are primarily a post-World War II technology. The origin of isolators was as glove-boxes manufactured to be containment devices. Barrier devices, as rigid wall constructs, began to be used in the 1940s for the holding of animals undergoing medical testing or to be reared "pathogen free" [16], as well as in the emerging nuclear industry[17]. In both instances the object was containment: of pathogens or radiation. These glove-box isolators were relatively small and did not contain air filtration systems. The pace of isolation technology was relatively slow with a flexible isolator (an actual closed environment rather than a barrier device) developed in the late 1950s and an isolator with an attached air-handling system manufactured in the 1960s. It was during this decade that the concept of an isolator being used to minimise contamination inside, as an addition to preventing contamination from getting outside, began to be progressed.

One of the reasons for the wider use of isolators was the drive to reduce cleanroom operating costs in the electronics industry. This led to increased investment in "minienvironments" or "contained environments" which utilised barrier technology so that the product was kept relatively cleaner, whilst also allowing for a lower cleanroom class for the surrounding environment.

Figure 2 Isolator protected ampoule filling machine (Copyright: Cilag AG, CH-8201 Schaffhausen, image courtesy of Schicht Hans H.: 40 years of cleanroom technology - some historical remarks. In: Proceedings of the 17th International Symposium on Contamination Control, Bonn/Germany, 6-9 Sept. 2004, p. 1-10. Edited by: Verein Deutscher Ingenieure (Association of German Engineers), Düsseldorf/Germany (2004))

Revisions to the ISO 14644 standard

After several years of protracted discussion, in December 2015, Parts 1 [18] and 2 [19] of ISO 14644 were revised. The more substantial changes relate to Part 1. As part of the change process, the title of the second part of the standard standards was altered to: "Specifications for testing and monitoring to prove continued compliance by ACP" (with ACP representing 'airborne particulate contamination').

A significant change with the standard is the method for selecting the number (and position) of particle counter locations within a cleanroom. The 1999

approach was that the user calculated the surface area of the cleanroom in square metres. From this the square root was taken and the number generated provided the number of particle counter locations. These are then placed at equidistant intervals within the cleanroom.

With the 2015 revision, the method is based on a look-up table. The table uses a range of cleanroom sizes and provides the number of locations required (if the exact room size is not listed, the user select the next largest room size and pick the appropriate number of locations). These numbers are based on a statistical method called hypergeometric distribution. This is very different to the square root approach, which was based on bionominal distribution. Without going into statistical detail, the former approach assumed that in each location a particle counter was placed, the particles in the cleanroom were normally distributed. In contrast, the revised approach is based on particles not being normally distributed. The new approach allows each location to be treated independently.

Figure 3: Operator working in a pharmaceutical cleanroom where medicines are dispensed (Photograph courtesy of Tim Sandle).

For the user, the approach is simpler because no calculations are required. In addition, for rooms with less than 9 particle count locations, the requirement to perform a 95% upper confidence level check has been removed. With the assigned numbers there is an in-built confidence interval of 95%. This means when a cleanroom is monitored there is a 95% level of confidence that 90% of the cleanroom complies.

In general, the new approach leads to an increase in particle count locations compared with the previous standard.

Once the number of locations has been selected, the room is divided up into sectors and a particle counter placed in each sector. With the previous standard, these sectors were equal in size and a counter placed in approximate centre. With the revised standard, the position where the counter is placed within each sector is determined by the user. The standard allows counters always to be placed at the same point within the sector; randomly placed within the sector; or evenly distributed; or selected by risk.

The risk based approach would be the best one to adopt. A risk based decision could be based on variables like: room layout; equipment type; airflow patterns; position of air supply and return vents; air-change rates; and room activities.

The reason for not selecting the centre of the location relates back to the issue of particle distribution: particles counts no longer assumed to be homogenous within a sector.

A further change is with the volume air that requires sampling in each location. The theory behind this is that the volume of air sampled needs to be sufficient to detect at least 20 particles of the largest particle size selected. The revised standard supplies a formula to be used. The outcome is the number of litres that need to be sampled in each location. The standard requires a minimum of 2 litres per location; the application of the formula can result in this being higher. Generally the lower the particle count limit, the greater the volume to be sampled.

With ISO 14644 part 2, there are fewer changes. The revision of ISO 14644-2 emphasizes the need to consider a monitoring strategy in addition to the initial or periodic execution of the classification of a cleanroom or clean zone in accordance with ISO 14644-1:2015.

The main points are:

- Reclassification is now a minimum of annual (this is a change from some areas to be assessed six-monthly). However, it should be noted that GMP sometimes requires higher frequencies to be selected.
- Requirement for an on-going monitoring strategy in addition to cleanroom classification. This should be by risk assessment. Those working in GMP facilities should be following this already.
- There is a note that particulate levels are likely to be higher during processing, when compared with classification.
- The tubing length to the particle counter should be less than 1 metre (it was formally 3 metres maximum).

In addition, there is a recommendation that particle counters should meet a standard titled ISO 21501. It appeared, at one stage through the revision process, that this would become mandatory. This standard requires particle counters to have an error rate, at each particle size, of not more than ±20%). Counters assessed against this standard must be certified.

Summary

Cleanrooms are an important feature of contamination control across a range of industrial sectors, and an understanding of how modern cleanrooms evolved requires a techno-historical overview of both industrial and medical advances. Cleanrooms, along with a multitude of other technological innovations, were a feature of the post-war reconstruction and industrial growth. The advances with cleanroom technologies were driven by a desire to minimise contamination in order to reduce costs, be that a damaged semiconductor or a rejected pharmaceutical preparation, and to protect people from harm, be that on an operating table or through a contaminated parenteral product. These drivers have led to the cleanroom technology and associated operating issues.

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Joseph Clement: engineering technician

Andy Connelly

Joseph Clement loved making things. Son of a hand-loom weaver, he took his passion for manufacturing to the highest level, becoming one of the most respected machinists and tool makers of the Industrial Revolution. So when computer pioneer Charles Babbage was looking for a technician to help him build his famous Difference Engine, Clement was the obvious choice. Unfortunately, a combination of status, class, and stubbornness meant the project was to end in acrimony and dispute.

Clement's father was a weaver who loved working with his hands, even building his own lathe to make the bobbins his work required. Joseph followed in these footsteps, also building his own lathe, but, as was to become a pattern in his life, Clement was not satisfied with simple bobbins. He machined complex musical instruments and built his father a microscope to help him follow his passion for natural history, a passion that Clement shared and possibly sparked the development of the technical drawing skills for which he became famous.

Clement's first employment was as a weaver, like his father, but the increased mechanisation of weaving meant there was not enough work to live on. This meant he had to become a thatcher in his home village of Great Ashby, Cumbria, but the work didn't interest him for long. He left home, moving as far as Aberdeen and Glasgow to become a loom maker. True to form, Clement did not just make looms but also redesigned many of the tools of his trade. Eventually, in 1807, aged 28, he moved to London where he worked for various engineering firms, impressing with his rare combination of mechanical knowledge and drawing skills. He won prestigious awards from the Society for the Encouragement of Arts for his inventions and within four years his reputation (and savings) was such that he could open his own business in Lambeth offering machining services and first-class technical drawing.

In snobbish Georgian London, Clement's strong Cumbrian accent did not easily endear him to potential clients, but he knew the quality of his work and seems to have been unintimidated by rich and illustrious customers. When Isambard Kingdom Brunel commissioned Clement to make an improved train whistle, the result could be heard for miles around. However, when the bill came, Brunel was shocked as the price was six times that he had previously paid. Clement replied, "That may be, but mine are more than six times better. You ordered a first-rate article and you must be content to pay for it." [1] Brunel had to pay up. Clement's high prices meant that the new workshop's income was initially modest, but the arrival of Babbage would change that forever.

Babbage: the irascible genius. (Credit: wikipedia.org)

Charles Babbage, mathematician and philosopher, was frustrated by inaccuracies in human-calculated mathematical tables, which were vital in navigational and astronomical work. Believing absolutely in mechanisation and mass production, his answer was to break these complex calculations down into simple addition calculations and automate them. Babbage was not shy about his reasoning: "It [mechanisation] affords against the inattention, idleness or the dishonesty of human agents."[2]

Although mechanical calculators had existed since the 17th century, Babbage's idea was to create something on a totally different scale. The Difference Engine would have been the first automatic calculator—the first machine to continuously use the results of the previous operation for the next one. This would constitute the first important step towards developing the first computer. However, to achieve this level of complexity required engineering skills way beyond those possessed by Babbage. More than that, it was at the limits of what was possible at the time.

Brunel's father recommended Clement to Babbage as the only technician with the skills and tools capable of building the Difference Engine [3]. From 1823, Clement and Babbage worked together on the project. It rapidly became difficult to know where Babbage's work ended

Lathe made for Babbage by Clement (Credit: Science Museum)

and Clement's began. Clement had to invent many new tools for the project - such was the complexity of the design, he even had to design and construct a new, bigger drawing table.

This was a major engineering project and as such very expensive. The determined Babbage managed to gain government support even getting the project nationalised. However, money was not the only problem. By 1832, after nine years' work, they had only a simple working model that could achieve only very basic versions of the calculations required – it could only handle six digits rather than the 20 required. The model itself was one of the finest examples of precision engineering of the time and impressed many important visitors to Babbage's home. However, it also highlighted the painfully slow progress of the project. Clement's attention to detail and innovation was proving both a blessing and a curse.

It did not help that in 1828, Babbage's father, two of his children, and his wife died. As part of his recovery his friends took him on a European tour for nearly two years. His absence was at a crucial time for the project as it was rapidly expanding from the initial design stages. On his return Babbage tried to regain control over the work, but his approach was undiplomatic and divisive. Eventually Babbage and his friends turned against Clement, claiming that he was mendacious, greedy, and was using time that was meant to be for the project on other work. Babbage eventually went to independent arbiters, who examined the project and found no fault by Clement. Finally, Babbage tried to wrestle from Clement the project, the drawings, and the tools he had developed. The belligerent Clement successfully resisted, but by this point relationships had soured to such an extent that there was only one outcome. Confusion over Clement's status, technician or collaborator, destroyed their relationship and in 1833 they parted company.

The "beautiful portion" (Photo by Hugh Talman http://library.si.edu/exhibition/fantastic-worlds/rise-of-the-machines)

Clement was clearly not an easy man to work with but Babbage acted like Clement had no ownership over the work. Tradition had it that the tools a workman designed for a project were his own property and so could be used for other projects. Babbage disagreed, saying "My right to dispose, as I will, of such inventions cannot be contested; it is more sacred in its nature than any hereditary or acquired property, for they are the absolute creations of my own mind." [4] In the end, independent arbiters ruled that Babbage should have the drawings but Clement could keep the tools he had built for the project.

Babbage moved on to work on his Analytical Engine, but he never got close to finishing this or any of his other big engineering projects. These repeated failures left the irascible genius a bitter man [5]. In contrast, Clement's business went from strength to strength—his work on Difference Engine had enhanced his reputation. According to the Victorian industrial biographer Samuel Smiles, at the end of Clement's life he returned to another childhood passion: music. He constructed an organ befitting the quality of all his work: "[it was] pronounced a very excellent instrument" [1].

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How far can neo-behaviourist learning theories be applied to science and technology teaching and learning?

Kevin Fletcher

Introduction

I have already given a brief consideration in a previous article (Fletcher 2016) to the extent to which a more classical model of behaviourism can be applied to science and technology teaching. In this brief discussion I hope to consider a more recent model of learning known as "Neo-Behaviourism" and map the extent to which it can be applied to, and used in, science and technology teaching.

In future articles I intend to discuss Gestaltism, Cognitivism, and Humanism and how far these can be applied to science and technology teaching, with a view to relating theories to practice in the hope of understanding and improving teaching and learning in the classroom.

For now, I turn to neo-behaviourism

The neo-behaviourists

Burrhus Frederic (B.F.) Skinner, Edward Tolman, and Robert Mills Gagne are, perhaps, the best known neo behaviourists. They provided a more human perspective than the original Behaviourists, in that they considered the human mind to be selective in its actions and not simply responsive to stimuli. They considered human subjects in their theories, and did not use only animal subjects and transfer what they learnt from them to Human Learning.

Burrhus Frederic (B.F.) Skinner

Skinner placed great importance on "operant conditioning" where an operant is a series of actions that a learner completes. Through reinforcement of the learning the learning quality becomes greater. Skinner's approach was highly structured. He stated that teachers need to specifically identify what learning they wish to take place and then select "reinforcers" which will help to maintain the desired behaviours (learning). Such a reinforcer may only be a nod of the head in agreement or it may be a more concrete form of reward. Skinner's work showed that it is important to reward the learner frequently in the early stages of learning, then at random or at a fixed interval afterwards. In the early stages of learning, each successive step in the learning process should be as small as possible so that rewards can be given frequently as reinforcement. Skinner's Theory of Learning can therefore be applied to science and technology teaching easily where reinforcers or rewards can be given quickly and easily.

Edward Tolman

Edward Tolman's work additionally suggests that humans use their beliefs and feelings when responding to stimuli and that there is a need to consider the whole learning situation rather than isolated stimulus response incidents. In other words, learners seek a purpose to what they are doing and have a "cognitive map" relating to their actions. So in terms of science and technology teaching, the student has to fit new learning into a pattern, which is "what leads to what". The importance of a logical learning sequence is emphasised and the need for students to be able to apply their new learning in order to test its validity is important. Motivation comes into Tolman's learning theory so it is important that science and technology learners are motivated if effective learning is to take place.

Robert M Gagne

Robert Gagne's Neo-Behaviourist theory suggests that the design of the teaching has to match the type of learning that is taking place. He listed eight learner characteristics which would influence the way in which the "instruction" would take place. His eight types of learning are:

1. Signal Learning: learner associates exact response to stimuli.
2. Stimulus Response Learning: learner associates exact responses to stimuli.
3. Chaining: learner acquires a number of Stimulus Response links as, for example, in titration, when a number of steps must be gone through in a specific sequence to be successful
4. Verbal Association: verbal chains are acquired.
5. Multiple Discriminations: learner discriminates between apparently similar stimuli and makes the correct response i.e. selecting the correct concentration of acid to bring about successful neutralization
6. Concept Learning: concepts seen as classes of stimuli and the learner can recognise these classes.
7. Rule Learning: chains of two or more concepts often called "principles" or "laws".
8. Problem Solving: the discovering of relationships where rule learning is applied.

Gagne suggests that these eight types of learning are in a hierarchy with the lower types such as "signal learning" being needed as pre requisites for the higher ones such as "problem learning". He also suggests that it is valuable to have a sequence to teaching and such a sequence can usefully be based on the learning types.

Neo-behaviourist learning theories applied to science and technology teaching (to create a checklist for effective teaching)

Having now outlined a few of the basic concepts of neo-behaviourist theories I turn to applying these concepts to science and technology teaching with a view to creating a "checklist" to ensure more effective teaching and learning takes place in the subject.

- inform the students what they are expected to do, that is, tell them the objectives at the start;
- question the students to determine their entry behaviour – at the start of the session find out what they already know;
- Use what learners already know as the starting point of a session
- Make learning sequential, and in small steps which are linked and are frequently reinforced
- Learning needs to begin with the simple and be built upon, so that basic first learning ensures that later more complex learning tasks have a solid foundation in which to have roots
- use cues to form the chains of concepts or rules – use mnemonics, pictures, phrases to help them learn & remember;
- question students so that they can demonstrate their learning;
- ask students to make a verbal statements to explain topics and summarize what's been covered (achieved) during a session at the end (recap)

To summarise, in terms of science and technology, the teacher must design the learning programme to ensure that students have lower orders of learning (successful completion of more simple tasks) before they progress to the higher levels (more complex tasks).

Planning for feedback is the key feature of the approach advocated by Gagne and is a characteristic of neo-behaviourism. It is also good practice in the science and technology classroom!

Summary

In this article, I have outlined some of the basic concepts of neo-behaviourism and then attempted to show how they can be applied in science and technology teaching. I have gone on to try to distil these ideas into a "checklist" which might be used in lesson planning and the delivery of science and technology in the classroom.

I hope, in a future article to undertake a similar exercise with Gestaltism; that is, to investigate how this particular learning theory applies to science and technology education

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I also acknowledge the use of images, which I believe are in the public domain, from various web sources which were searched using GOOGLE. I also acknowledge use of images taken in my own classrooms over the years.

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Strawberry Studios

Peter Wadsworth

In 2017, it is fifty years since Stockport's legendary recording studio, Strawberry Studios, was formed and a major exhibition celebrating this milestone is in Stockport Museum.

Strawberry Studios actually began life as Inter-City Studios (a deliberate nod to the British Rail slogan) above a small music store in the centre of Stockport, started by a local man called Peter Tattersall. The music industry in the 1960s was based in London and setting up an independent recording studio outside of the Capital was a risky business. Peter, however, realised that musicians would always need somewhere to record and that many artists were fed-up with having to travel to London to the laboratory-like studios where technicians wore white coats and recording sessions stopped at 5pm prompt. For financial backing Peter turned to those he knew in the music industry – Eric Stewart from The Mindbenders and songwriter Graham Gouldman, who both invested financially in Inter-City. The Manchester-based Kennedy Street management company, in the shape of Ric Dixon, also added financial muscle as well as credibility with the local banks. All the investors involved themselves in the running of the studio which, by 1968 was a small and basic demo studio for local artists, such as Barclay James Harvest.

Peter Tattersall at the Strawberry desk c1970 (Source: Strawbery Archive)

What could have been a fatal blow was dealt to Inter-City in 1968 when the music store decided that the studio could no longer be housed in the building. New premises were found though, and this brought about a change of name to Strawberry. The name was partly as a result of wanting to match the Beatles' creation of their Apple Company, and partly due to Eric Stewart's favourite song of the time being the Beatles' Strawberry Fields Forever. Those in Strawberry Studios were joined by two local musicians, Kevin Godley and Lol Crème, which meant that Stewart, Gouldman, Godley, and Creme became Strawberry's house band, performing and producing for a whole host of people whilst Tattersall ran the studio. In 1970, with Gouldman in New York, the remaining musicians got together and released a single called Neanderthal Man, calling themselves "Hotlegs" (after the Strawberry Studios' secretary of the time!). The single reached number 2 in the charts and included the Studio's name on the record label, an unusual move for the time. This resulted in plenty of publicity for Strawberry Studios.

Eric Stewart's Chery red Gibson Guitar, as strummed on I'm Not in Love (Source: Peter Wadsworth)

It was between 1972 and 1976 however, when Stewart, Gouldman, Godley and Creme joined forces to become 10cc that Strawberry Studios really took off. 10cc's success in those years with numerous hit singles and four hit albums meant that Strawberry Studios became more technically sophisticated, attracting a whole variety of international stars such as Neil Sedaka and Paul McCartney to Stockport. Indeed, Strawberry Studios became so successful that 10cc found that they were unable to book any time in the studio that they co-owned! Their response was to build a new Strawberry Studios in Dorking, Surrey and, although Godley and Creme left 10cc before recording there, Stewart and Gouldman moved south to carry on 10cc's success.

10cc (source: Strawberry Archive)

Strawberry North, as it became known, continued to be successful though, and provided major recording facilities for a whole new generation of bands who were particularly vocal in proclaiming their Manchester roots. The Buzzcocks, Joy Division,

The Smiths, and numerous Factory Records' bands used Strawberry and Factory's producer, Martin Hannett, was a big fan of the Stockport studio. Joy Division's 1979 album Unknown Pleasures is still regularly voted into the Top 10 albums of all time and has become symbolic of Strawberry Studios' contribution to the post-punk Manchester music scene.

In 1986, Peter Tattersall left Strawberry Studios when the neighbouring Yellow 2 recording studio took over, but the 1980s were tough for the recording studio industry generally as digital sound gradually replaced analogue recording. Faced with the costs of upgrading equipment a number of studios struggled, and Strawberry Studios closed as a recording studio in 1993 and the building was repurposed into office space.

In recent years though, Strawberry Studios' history has become more prominent. The owners of the building put the name back on the outside in the late 1990s; the building was awarded a blue heritage plaque in 2007 (updated in 2016), and Peter Wadsworth completed his PhD research on Strawberry Studios' history at the University of Manchester. The culmination of this historical reawakening is the opening of the Strawberry Studios: I Am in Love exhibition at Stockport Museum which explores some of the key themes of Strawberry's history.

Formula Sound desk with Strawberry memorabilia (Source: Peter Wadsworth)

Of course, technology is a key part of any recording studio and the exhibition does cover some of the technical aspects of the studio's development over the years thanks to loans from Chris Hewitt, who collects old recording studio equipment. Auratone monitors and Music Man amps are displayed along with some of Martin Hannett's iconic pieces of equipment, such as Marshall time-modulators, AMS delay units and an Ursa Major Space Station! The Strawberry Studios building was also home to the Formula Sound Company who custom-built mixing desks, including the desks installed in the Strawberry North and South studios in the late 1970s. An original early 1970s piece of Formula Sound equipment is displayed in the exhibition although plans to borrow Strawberry's iconic early 1970s red Helios desk from the Audities Foundation museum in Canada had to be shelved as it is now a working desk following its restoration.

Strawberry's re Helios desk, now restored and working in Canada (source: Strawberry Archive)

But Strawberry Studios was interesting in that it was also a place where technology was incubated, as seen in the development of a device by Godley and Creme called the Gizmo. This was a device that was attached to a guitar and then small rotating wheels were engaged to rub against the strings in order to produce an array of weird and wonderful sounds.
The device brought to an end the original incarnation of 10cc as Godley and Crème remained in Strawberry North to demonstrate its potential whilst Stewart and Gouldman went to Strawberry South to continue as 10cc. After a prototype was developed with help from the University of Manchester the device was taken on by an American company and renamed the Gizmotron. However, only a couple of hundred were actually made as the device constantly failed and the technology of the time couldn't overcome some of the issues associated with the Gizmo. In 2015 an American company took up the challenge and created a second-generation Gizmotron, which addressed many of

New and old Gizmotrons (Source: Peter Wadsworth)

Kevin Godley and Lol Creme with John McConnell and Martin Jones (University of Manchester) developing the Gizmo (source: Strawberry Archive)

the issues that 1970s technology had been unable to solve. Thanks to the Gizmotron Company, the exhibition has examples of both the new and original Gizmo device, as well as audio examples of how it sounded.

As you might expect, the exhibition has plenty of music playing and there are also audio clips from many of those who were involved in the Studio's development alongside notable memorabilia from Strawberry's history, including record sleeves, tape boxes and other items of interest. The Museum also commissioned celebrated Manchester mosaic artist Mark Kennedy to produce a special piece celebrating Strawberry Studios' history, and this is now a major part of the exhibition. In addition, four prints from Paul Slattery's 1979 Joy Division photoshoot outside Strawberry Studios' building have been acquired for the Museum's collections.

Mark Kennedy mosaic (Source: Peter Wadsworth)

More Strawberry memorabilia (Source: Peter Wadsworth)

Strawberry Studios: I Am in Love runs until January 28th 2018 and is located in Stockport Museum (30-31 Market Place, Stockport) and is generally open every day except Mondays. Full details can be found at **www.strawberry50.com**

Exhibition Flyer (Source: Stockport Metropolitan Borough Council)

Author

Dr Peter Wadsworth works in the University of Manchester Library and completed his PhD on Strawberry's history at the University in 2007. As well as developing the Studio's social media history presence, he has co-curated the "Strawberry Studios: I Am in Love" exhibition which is currently running at Stockport Museum until January 2018.

Vivien Thomas: surgical technician

Andy Connelly

Vivien Thomas did not intend to become a technician. He was a young man from Nashville with dreams of becoming a doctor, but when the stock market crashed on 29th October 1929 he lost his job as a carpenter, his savings, and his chance at medical school.

It took a while but a little luck came his way when a friend found Thomas a job as a technician at Vanderbilt University's Faculty of Medicine. With characteristic hard work and dedication he developed incredible surgical skill. He also gained a surprising level of independence in the laboratory, which was almost unimaginable for a technician at that time, and way beyond the realms of imagination for an African-American technician in the Jim Crow state of Tennessee.

Portrait of Vivien T. Thomas (by Bob Gee)(Source http://www.medicalarchives.jhmi.edu/portlarg/thomasv.jpg)

All this came about due to Thomas's supervisor, and eventual collaborator, Alfred Blalock. Blalock was an ambitious young surgeon who was impressed by this inexperienced technician's hard work. Within a week, to Thomas's surprise, he was assisting Blalock in complex surgical experiments on dogs to investigate the physical effects of shock. Within 5 weeks, conscientious Thomas was carrying out the bulk of the experiments with only occasional visits from the ever-busy Blalock.

The innovative research into shock undertaken by Thomas and Blalock at this time contributed to the saving of many lives on the battlefield during World War II [1]. It also led to Blalock being offered a position as chief of surgery, professor, and director of the Department of Surgery at the world famous Johns Hopkins Medical School in Baltimore in 1941.

Such was Blalock's reliance on Thomas that he insisted on a position for Thomas at Johns Hopkins as part of the package. In spite of this show of loyalty, the pair had a complex relationship. They would, on occasion, share a whiskey in the laboratory late at night. This was a doubly illegal act due to prohibition and the Jim Crow laws. However, outside the laboratory, Blalock did not socialise with Thomas; in fact, the doctor often hired Thomas to serve drinks in his home during social events. Nor did Blalock encourage Thomas's education or any increases in Thomas's wages. Thomas had been classed and paid as a janitor until 1936.

Not that life in Baltimore was much easier. The extreme segregation, two children to support, and a low salary made life hard for Thomas. Even the hospital was segregated, with separate treatment days for African Americans and Whites. The other African Americans who worked at the hospital were all janitors or cleaners and so wore blue coats. Thomas's white coat against his black skin, along with his soon obvious surgical skill and his role teaching young surgeons, made him an object of unwelcome curiosity for all staff members. A reserved and proud man, Thomas found this difficult, in particular the preconceptions and prejudices of visitors who would come to his office and ask to see "Mr. Thomas". Thomas would have to simply reply **"Sure, he's sitting right here".**

Once at Johns Hopkins, an exciting new project presented itself. Paediatric cardiologist Dr Helen Taussig presented Blalock with a seemingly intractable challenge. Blue-baby syndrome was caused by a congenital heart defect that meant there was insufficient flow of oxygenated blood from the lungs. It caused cyanosis and other unpleasant effects, with most affected babies dying shortly after birth. The solution seemed simple: a surgeon needed to connect one of the heart's major arteries to another that fed into the lungs to provide greater blood flow. Until then, no surgeon had thought this possible. Blalock passed the problem on to Thomas.

After two years and more than 200 experiments on dogs, Thomas found a way to carry out the difficult "blue-baby" operation, later known as the "Blalock-Taussig shunt". In November 1944, 15 month old Eileen Saxon was the first child to receive the lifesaving treatment. Thomas prepared the operating room but did not plan on attending the surgery. He was

surprised when Blalock insisted on his presence. The sight must have been extraordinary in 1940s America: a chief surgeon at one of the world's most renowned institutions, engaged in ground breaking surgery while his African-American technician offered advice over his shoulder while standing on a step.

© Karsh

One of the photographic studies done by Yousuf Karsh, to mark the official "1,000th blue baby" procedure performed by Dr. Alfred Blalock.

Unfortunately, Eileen Saxon developed complications and died during an attempt to repeat the operation. However, hundreds of subsequent operations were successful; Blalock saved many lives and reaped prestigious awards, even being nominated for the Nobel Prize. Thomas was not acknowledged in the paper by Blalock and Taussig that described the technique to the surgical community, or in the subsequent papers written by Blalock that expanded on the experimental work.

It took until seven years after Blalock's death for Thomas to receive some of the acknowledgment he deserved. Many of the young surgeons that Thomas had trained went on to become influential surgeons, becoming a part of the prestigious "Old Hands" club. Such was their respect for their former teacher that in 1971, the club insisted on commissioning Thomas's portrait, which was then hung next to Blalock's at Johns Hopkins. At the unveiling ceremony, one of Thomas's former students explained:

"From him I learned the valuable surgical lesson that experimental procedures which seemed nearly impossible to execute when first tried might ultimately be performed... after the separate steps had been mastered" [2].

In 1976, Thomas was proud to be awarded an honorary degree from Johns Hopkins, even if the attention made this habitually private man somewhat uncomfortable. Presenting him for the award, the eminent surgeon Dr. Norman Anderson addressed Thomas, saying:

"There are people around here with all kinds of degrees that never have, and never will, accomplish anything. You've already made a contribution." [3]

Author

Dr Andy Connelly is a former research scientist. He also worked as a physics teacher. He now works as a technician at the University of Leeds in the School of Earth and Environment. He is involved in the Technicians' Network at the University and edits the technicians' newsletter "Technically Speaking" **http://www.leeds.ac.uk/forstaff/news/125152/technicians_network**. He enjoys writing about science in his spare time h**ttps://andyjconnelly.wordpress.com/**.

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From the archives: some explosive stories

Alan Gall, IST Archivist

1. Philip Harris investigates

On Saturday, 7 December 1861, George Barnett and his assistant spent the late evening looking through the business accounts at a chemists shop on Jamaica Row, Birmingham when the floor beneath them ripped apart. Both men survived, although Barnett suffered extensive burns. The premises and property next door were severely damaged. Early newspaper coverage supposed the incident to be caused by a gas explosion.[1] Several papers published a syndicated report describing the destruction:

The whole of the plate-glass in the windows were blown across the road; show globes, drug bottles, chemical apparatus, and glass of every description were smashed to atoms; and many of the shelves in the grocery department were cleared and ripped from the walls. With the exception of a few drawers and canisters, the shop is gutted; and the stock, which was very valuable, utterly destroyed. Such as was blown into the street, and that was not a little, was stolen by the mob.[2]

The *Birmingham Daily Post* observed, **"The cause of the explosion is a mystery which does not seem likely to be satisfactorily cleared up."**[3] Enter pharmacist and amateur sleuth Philip Harris.

Philip Harris had been invited by "some friends of Mr Barnett" to investigate and so he examined the cellar in the company of two others, one a builder called Samuel Briggs. Previous speculation in the papers centred on an escape of gas or the ignition of inflammable vapour. Harris started with the expectation that "the explosion had originated from some of the pent-up gases of the hydro-carbons which are now in general use", possibly ignited by the gaslight which permanently illuminated the cellar.[4] However, the containers of naphtha and paraffin were found to be untouched, causing Harris to comment, "... it was evident that combustion by gas was not the cause; and we were therefore quite unable to offer any explanation ..." The investigators were just about to leave the cellar when the assistant suggested it might be worth checking on the stock of gunpowder!

Operating variously as Harris & Margetts and Harris & Pierce, Philip Harris's chemists shop developed into the well-known laboratory supplier specialising in educational products, Philip Harris Ltd

A letterhead from the 1960s

2. On the beach

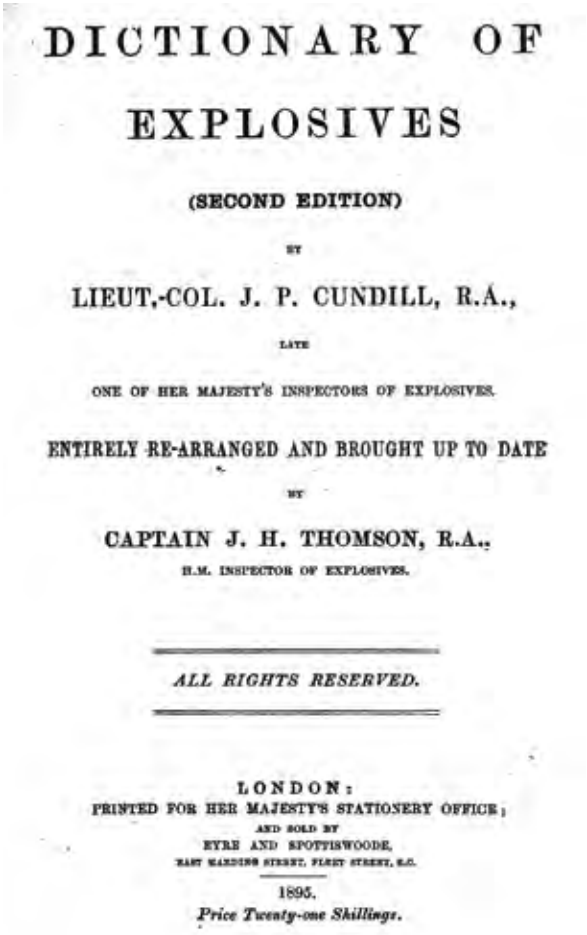
A sledgehammer, a handgun and a "torpedo" were brought to Southport beach in 1877, all to provide a demonstration not seen before or since at the seaside town. The elaborate publicity stunt introduced a new company, formed to acquire manufacturing rights to a recently patented explosive.

The *Liverpool Mercury* reported on the display and that a licence to manufacture "cotton powder", invented by S. J. Mackie, had been granted to the Liverpool Cotton Powder and Ammunition Company Ltd at factory premises close to Cunscough Bridge, Melling, near Liverpool. Mr Mackie himself subjected the material to hammer blows and the impact of a bullet, without causing detonation. The spectacle included an improvised torpedo made from a cask, and a display of rockets. Afterwards, a number of invited guests made off to the Victoria Hotel for lunch.

Originally established as the Improvised Sawdust Powder Co Ltd around 1873, the business went through various transformations. It existed briefly as the Liverpool Cotton Powder and Ammunition Co Ltd before changing to the Potentite Cotton Powder Co Ltd in 1882.

Her Majesty's Inspector of Explosives had cause to visit the factory on a number of occasions. Lieutenant-Colonel Ford investigated an incident that injured one

man on 15 July 1882. A more serious accident occurred the following year in which three operatives died and another three received injuries of varying severity.[5]



DICTIONARY OF EXPLOSIVES

(SECOND EDITION)

BY

LIEUT.-COL. J. P. CUNDILL, R.A.,

LATE

ONE OF HER MAJESTY'S INSPECTORS OF EXPLOSIVES.

ENTIRELY RE-ARRANGED AND BROUGHT UP TO DATE

BY

CAPTAIN J. H. THOMSON, R.A.,

H.M. INSPECTOR OF EXPLOSIVES.

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LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE;
AND SOLD BY
EYRE AND SPOTTISWOODE,
EAST HARDING STREET, FLEET STREET, E.C.

1895.

Price Twenty-one Shillings.

In his role as HM Inspector of Explosives, John Ponsonby Cundill investigated an explosion at the Potentite company in 1883

A German merchant in Gateshead called William Hartig became bankrupt in 1882. He moved south to take up employment as manager of the Melling factory. His presence there attracted attention in 1900 after he confronted two trespassers on factory land with a shotgun. Not one to stand any nonsense, Hartig discharged the weapon claiming to have done so only in an attempt to frighten the pair as they beat a hasty retreat. Unfortunately for Hartig, this resulted in a charge of shooting with intent to cause grievous bodily harm.

At some point, the Melling Powder works came under the control of Nobel's Explosives Co Ltd who sold it in 1922. Powderworks Lane still exists to pinpoint the site.

3. A lack of oxygen can be fatal in more ways than one

The eminent chemist Henry Roscoe[7] while perusing a copy of The *Manchester Guardian* read an account of a serious local explosion at a workshop in Peter Street, which had occurred on 17 December 1864. Being a public-spirited citizen, and to satisfy a professional interest, he wrote to the chief constable offering his services.

Described by Tilden (1917)[6] as part of a "Cotton Powder Works" it shows the safety features used in explosives manufacturing: a small, lightly constructed building surrounded by earth mounds to deflect any blast upwards

A worker emptying a box of TNT. Note the overshoes to prevent any nails in his boots from causing a spark (source: IST archive)

A drawing of Henry Enfield Roscoe (1833 – 1915) from Popular Science Monthly, January 1885

Oxygen, discovered as a constituent of air in the 1770s, became an item of entertainment and education. In Victorian times it was not uncommon to obtain, from a chemists shop, manganese dioxide[8] and potassium chlorate to produce oxygen, or alternatively, buy the gas already made by the reaction of these compounds. Heating potassium chlorate on its own will yield pure oxygen but the temperature of decomposition is much reduced by the addition of the manganese dioxide.

Roscoe had come across cases where manganese dioxide mixed with carbon caused explosions during oxygen preparation. As it happened, analysis of manganese dioxide residue found at Peter Street subsequently showed this adulteration. The coroner's inquest and the reports of the following manslaughter case outlined the events leading up the accident.

An optician called Morgan wanted a supply of oxygen for a demonstration to be held at Pendleton Mechanics' Institute. At first he attempted to manufacture his own using materials bought from Evan Griffiths Hughes, a druggist of Cateaton Street, Manchester. An explosion resulted when Morgan heated the ingredients, although not of a life-threatening nature – the blast only knocked him down. Assuming that the

apparatus had merely blocked up, he sent the unused manganese dioxide to Samuel Crowther with an order for oxygen. Crowther responded by saying that his equipment resided in Leeds but if Morgan could supply a suitable retort then he would go ahead. A mercury retort from Mottershead & Co[9] duly arrived for what would turn out to be a fatal event.

A cast-iron mercury retort, possibly of the type used by Samuel Crowther (A. Gallenkamp & Co Ltd, 1911)

Watched by his two-year-old son, Samuel Crowther mixed together the ingredients, the usual proportions for the preparation said to be three parts by weight of manganese dioxide to seven of potassium chlorate.[10] At some point during the heating process the retort exploded. The resulting structural damage to the house and the gruesome details of injuries to Crowther's body gave ample testimony to the power unleashed. Both father and son died.

Professor Rocoe's chemical analysis found carbon in a bag of manganese dioxide recovered from the accident site and originating from Evan Hughes's shop. A sample of the substance taken from the stock in a drawer was cleared, but a more meticulous examination of the drawer found particles in the bottom with a high concentration of carbon. This suggested that Hughes had swapped the original material with uncontaminated stock before the police arrived.

Despite other incriminating evidence, the jury returned a verdict of not guilty to manslaughter. Evidently, many of Mr Hughes's supporters attended court and were in boisterous mood: **"The learned Judge lectured the spectators upon the impropriety of their demonstration, which he said he strongly condemned, because, although the friends of the prisoner had a right to rejoice out of court, there ought never to be any cheering in a court of justice before the judge and jury."**[11]

In an ironic twist, the following newspaper advertisements appeared during 1924:
The powers of oxygen as an antiseptic and life-giver are well known, and we state without fear of successful contradiction that Radox Bath Salts liberate more oxygen than any other Bath Salts on the market.

Who manufactured this product? It was E. Griffiths Hughes Ltd, introduced by them well after the death of Evan Griffiths Hughes himself. Radox is now a Unilever brand name for toiletries.

4. The flying bedstead

Chemical compounds are not a necessary prerequisite for a powerful explosion. Proof of this came on a Saturday morning at the factory of Mr George Williamson in Rochdale. *The Preston Chronicle* of 22 July 1854 reported on **"an amount of personal injury and destruction of property almost unparalleled."**

In a weaving shed stood a boiler, small in size but capable of terrific damage. Workers had been uneasy about its rumbling and shaking for many weeks before the boiler finally burst apart. When it did so, the force demolished not only the shed but also a substantial section of the factory and part of the owner's house. The safety valve, obviously not very effective, reportedly ended up about three hundred yards away. The newspaper went on to describe what happened to three lucky survivors.

A cottage adjoining the north end of the factory was turned over, and three of the inmates, two of them children, were thrown, with the bed in which they were sleeping at the time, into the river Roche, and floated on its surface until assistance could be rendered, and they were saved.

The episode had a less comical aspect as nine fatalities resulted.

Notes & references

1. For example - "Terrific Gas Explosion", *The Era*, 15 December 1861.

2."Fearful Explosion at Birmingham", *Lancaster Gazetteer*, 14 December 1861.

3."Fearful Explosion in Jamaica Row", *Birmingham Daily Post*, 9 December 1861.

4.Philip Harris, "The Late Explosion in Smithfield", letter to the editor in the *Birmingham Daily Post*, 26 December 1861.

5. Very detailed accounts are to be found in the House of Commons Parliamentary Papers Online – Lieutenant-Colonel A. Ford, "No. XLV. Report to the Right Hon, the Secretary of State for the Home Department on the Circumstances Attending an Accident which Occurred in the Factory of the Potentite Company (Limited), at Melling, Near Liverpool, on 15th July 1882", 28 November 1882. Captain J. P. Cundill, "No. XLIX. Report to the Right Hon, the Secretary of State for the Home Department on the Circumstances Attending an Accident which Occurred in the Factory of the Potentite Company (Limited), at Conscough Bridge, near Melling, in Lancashire, on 26th January 1883",10 March 1883.

6. Sir William Tilden, *Chemical Discovery and Invention in the Twentieth Century* (London: George Routledge & Sons, 1917), 379 - 380.

7. Henry Enfield Roscoe (1833-1915), professor at Owens College, Manchester 1857-1887. He was at various times President of the British Association for the Advancement of Science, President of the Chemical Society and President of the Society of Chemical Industry. He received honorary degrees from universities at Manchester, Liverpool, Aberdeen, Montreal, Dublin, Cambridge and Oxford.His PhD from Heidelberg University was completed under the supervision of Robert Bunsen. In 1869 he managed to obtain metallic vanadium by reacting vanadium dichloride with hydrogen for over 40 hours. Elected FRS 1863, knighted 1884 and MP 1885-1895.

8. Manganese dioxide was often referred to as just "manganese".

9. Mottershead & Co, of 1 Market Place, manufacturing and dispensing chemists and dealers in chemical and photographic apparatus. It became Frederick Jackson & Co and later, after a takeover by J. W. Towers & Co Ltd, part of A. Gallenkamp & Co Ltd.

10. Other sources give different proportions.

11. "The Fatal Explosion at a Photographer's", *The Manchester Weekly Times*, 25 March 1865.

The Technical Managers in Universities Conference 2017

Geoff Howell & Ian Lyne

The Technical Managers in Universities 2017 Conference was hosted by the University of Bristol, on the 5th to the 7th April and held in the Faculty of Arts. The conference theme was "Leading Technical Services - Making it fit for the future."

After registration of well over 60 delegates on the first day about 40 then met up and enjoyed an afternoon guided tour of Clifton, which culminated with outstanding views of the suspension bridge.

On the Second day, Geoffrey Howell, TMU Chair-person, and the 2017 event organiser Dave Hooper (Technical Manager, Materials group, Faculty of Engineering) welcomed everyone and set the scene.

Geoff Howell and Dave Hooper setting the scene for the conference

Opening the Conference was Professor Nishan Canagarajah, Pro Vice-Chancellor for Research and Enterprise, whose presentation was "The Technical Strategy at the University of Bristol."

This was then followed by,
Kelly Vere, Technical Skills Development Manager, University of Nottingham and Fred Hale, Science Strategic Support Manager, University of Bristol, whose presentation was, "Do you need a technical strategy."

Steve Gaze, Technical Manager, Biomedical Science, University of Bristol and Dave Hooper Technical Manager, Material Group presented work they were working on "Career Frame Works."

Allison McRitchie, Staff Development in Human Resources and Dr Caroline Jarrett, Deputy Technical Manager at the School of Physics, presented, "Technical apprenticeships and trainees."

Chris Turgoose and Ian Tidmarsh, from the Technical Development and Modernisation Team, finished off with a presentation of the "HEFCE Project and toolkit."

After lunch there was lively debates on the above subjects.

The Conference Dinner was at Goldney Hall (The Orangery), a superb venue and members networked well into the night.

On the third day was the AGM and offers from several Institutions to hold future Conferences.

We would also like to thank All the Suppliers who attended, for their continued support of our Event.

More information is available on the TMU website: http://www.tmu.uk.net/

A new antibiotic, produced by bacteria found on a species of African ant, is very potent against antibiotic-resistant "superbugs" like MRSA

Crematogaster nigriceps ants in a defensive demeanour on Acacia drepanolobium; picture taken in Ngorongoro Conservation Area, NW of the caldera (Credit: Pharaoh han, via Wikimedia Commons)

Researchers at the University of East Anglia (UEA) and the John Innes Centre (JIC), which is strategically funded by the Biotechnology and Biological Sciences Research Council (BBSRC), have discovered a new member of the Streptomyces bacteria family, isolated from the African fungus-growing plant-ant Tetraponera penzigi. They have named the new species Streptomyces formicae and the antibiotics formicamycins, after the Latin formica, meaning ant.

Laboratory tests have shown that these new antibiotics are effective against methicillin resistant Staphylococcus aureus (MRSA) and Vancomycin-Resistant Enterococci (VRE) bacteria, which are resistant to a number of common antibiotics, and can cause life-threatening infections.

"Our findings highlight the importance of searching as-yet under-explored environments, which, when combined with recent advances in genome sequencing and editing, enables the discovery of new species making natural product antibiotics which could prove invaluable in the fight against AMR." - Professor Barrie Wilkinson from JIC

Almost all of the antibiotics currently in clinical use come from a group of bacteria called actinomycetes that were isolated from soil between 40-80 years ago, the "golden age" of antibiotic discovery. Inappropriate use of these antibiotics since then has led to widespread antimicrobial resistance (AMR), where disease-causing bacteria and fungi have become resistant to one or more antibiotics.

"We have been exploring the chemical ecology of protective symbioses formed between antibiotic-producing bacteria and fungus-growing insects to better understand how these associations are formed and explore them as a new source of anti-infective drugs." - Professor Matt Hutchings from UEA

The Kenyan plant-ants live in symbiosis with thorny acacia trees. They live and breed in domatia – which are hollowed out structures which the plant evolved to house them – and grow fungus in them for food. In return, they protect the plants from large herbivores including elephants, which won't eat plants covered in ants.

Stars are regularly ripped apart by black holes in colliding galaxies

Depiction of the tidal disruption event in F01004-2237. The release of gravitational energy as the debris of the star is accreted by the black hole leads to a flare in the optical light of the galaxy. (Credit: Mark Garlick)

UK astronomers have found that stars are ripped apart by supermassive black holes 100 times more often than was previously thought.

Up to now astronomers had thought that this stellar cannibalism – known as Tidal Disruption Events (TDEs) – was exceptionally rare, only occurring between every 10,000 to 100,000 years per galaxy. However new research by an astronomy team based at the University of Sheffield and funded by STFC, recorded a star being destroyed by a supermassive black hole in a survey of just 15 galaxies – an extremely small sample size by astronomy standards.

"Each of these 15 galaxies is undergoing a 'cosmic collision' with a neighbouring galaxy. Our surprising findings show that the rate of TDEs dramatically increases when galaxies collide. This is likely due to the fact that the collisions lead to large numbers of stars being formed close to the central supermassive black holes in the two galaxies as they merge together." - Dr James Mullaney, Lecturer in Astronomy at the University of Sheffield and co-author of the study.

Supermassive black holes can be difficult to spot because they are so dark due to their gravity being so strong that nothing can escape, not even light. However, the release of energy when stars are ripped apart as they move close to the black holes leads to dramatic flares which shine very brightly. In this way, TDEs can be used to locate and study otherwise dim black holes.

The Sheffield team first studied these 15 galaxies in 2005, but when they looked at the sample again in 2015 they noticed that one galaxy looked completely different. Looking at data from 2010 it showed the brightness of this galaxy, which is 1.7 billion lightyears away, flared dramatically in a manner which was characteristic of TDEs.

"Based on our results, we expect that TDE events will become common in our own Milky Way galaxy when it eventually merges with the neighbouring Andromeda galaxy in about 5 billion years." – Professor Clive Tadhunter, Professor of Astrophysics at Sheffield and leader of the study

The findings were based on observations made with the William Herschel Telescope, which is operated by STFC on the island of La Palma. The study also used data taken with NASA/ESA Hubble Space Telescope, and the Catalina Sky Survey.

Optimising the performance of Brassica crops

January 2017 saw the launch of a new 5-year project BBSRC Brassica, Rapeseed and Vegetable Optimisation (BRAVO), funded by the Biotechnology and Biological Sciences Research Council (BBSRC).

Oilseed rape and Brassica vegetable crops have a combined UK market value in excess of £1Bn, but suffer yearly losses of up to £230M, primarily due to increasingly unfavourable and unpredictable weather patterns. BBSRC BRAVO aims to combat these crop losses by unravelling the processes that control key aspects of plant development. This knowledge will then be applied to help develop new, more resilient varieties of Brassica crops that can achieve superior field performance whilst reducing yield loss and industry wastage.

The project, led by Professor Lars Østergaard of the John Innes Centre (JIC), brings together the expertise of leading UK plant scientists from three research institutes (JIC, Rothamsted Research and the Institute of Biological, Environmental and Rural Sciences) and four universities (Bath, Nottingham, Warwick, York) together with representatives from the oilseed and horticultural industries.

Environmental conditions influence a number of key stages of plant development including inflorescence growth, flowering, fertilisation and seed production. In the face of climate change it is more important than ever that our crops are capable of tolerating rapidly changing environmental conditions while still maintaining good vigour and achieving consistently high yields.

Discussions between BBSRC BRAVO consortium members and industrial stakeholders identified a number of strategic targets sensitive to such changing weather patterns. These include more concise flowering, consistently high fertility under fluctuating environments, reduced yield loss and more uniform seed performance.

As well as improving the fundamental understanding of how Brassica crops grow and respond to the environment, the £4.4M BBSRC BRAVO project will support the training of young scientists and raise industry stakeholder awareness of new developments through workshops in Brassica genetics, genomics, phenotyping and modelling.

"As our climate changes and the global human population is predicted to exceed 9 billion people by 2050, it is more important than ever that our crops are able to grow and produce as much food as possible in varying weather conditions and season lengths. By unravelling and exploring the processes behind important genetic traits in crops, we will provide a basis for the development of improved Brassica crops that reduce losses and withstand changes in climate and environmental conditions." - Professor Lars Østergaard

BBSRC's Strategic Longer and Larger (sLoLa) grants support integrated research projects requiring long timescales, extensive resources and multidisciplinary approaches. Supported projects must be scientifically excellent, demonstrate exceptional relevance to one or more of our strategic priorities, an understanding of the potential for impact and be conducted by an internationally leading research team.

"This proposal addresses a number of key BBSRC research priorities. Making UK crops more resilient to our changing climate is key to maintaining future productivity and reducing food waste. This group is building on past investments in basic plant science and translating this knowledge to key UK crops, working with the relevant industry to deliver real potential long term benefits for UK farmers." - BBSRC's Head of Agriculture and Food Security, Dr Adam Staines

Dr Rachel Wells, Senior Scientist, JIC Crop Genetics

Scientists at the JIC are developing a new line of fast-growing sprouting broccoli that goes from seed to harvest in 8-10 weeks. It has the potential to deliver two full crops a season in-field or it can be grown all year round in protected conditions, which could help with continuity of supply, as growers would no longer be reliant on seasonal weather conditions.

The part of the broccoli plant that we eat is the flower buds. This innovation in crop production builds on the wealth of fundamental research carried out by Professor Dame Caroline Dean and her lab on vernalisation – the need for some plants to experience a period of cold weather before they can flower. The timing of the switch to flowering is critical for a plant's adaptation to the environment and its resulting yield. Dr Judith Irwin and her team, working collaboratively with Professor Dean, have focused on translating this knowledge to Brassica crop species.

Dr Judith Irwin, Senior Scientist, JIC Crop Genetics

Many crops rely on this period of cold before they can flower and so are very susceptible to fluctuating winter temperatures. Recent adverse weather in Murcia, Spain led to a shortage of courgettes, iceberg lettuce and broccoli. The team at the John Innes Centre have been working on way to increase crop productivity and reduce our vulnerability to fluctuations in climate.

"We harnessed our knowledge of how plants regulate the flowering process to remove the requirement for a period of cold temperature and bring this new broccoli line to harvest faster. This means growers could turn around two field-based crops in one season, or if the broccoli is grown in protected conditions, 4-5 crops in a year." - Dr Irwin

The John Innes Centre aims to provide pre-breeding material to plant breeders and growers for year-round scheduling of Brassica vegetables.

The consequences of our changing climate are one of the main issues facing crop production. The British Food report, published in February 2017, has shown how vulnerable our vegetable supply is to adverse weather conditions, both at home and abroad. The UK's reliance on imported vegetables is particularly acute with only 23% of our fruit and vegetables grown in the UK (British Food report 2017).

In addition to having a short growing period, there is the opportunity to move production into urban farms enabling reductions in the carbon footprint of food production and supply.

"The continuity of food production is being challenged by changes in our climate. Here at the John Innes Centre we have been challenging the way people think about how we produce food. As part of this approach we are considering the potential of moving some forms of food production into contained horticultural production systems – these could range from simple glasshouse or growth rooms to more complex vertical farms. This new line of broccoli could be grown in such systems under LED lights that would overcome the problem of seasonality and our dependence on imported crops." - Dr Jonathan Clarke, Head of Business Development at JIC

The new broccoli line developed at the John Innes Centre is one of a number that have been selected to address this issue and as a step toward climate-proofing our crops.

"This is a very exciting development as it has the potential to remove our exposure to seasonal weather fluctuations from crop production. This could mean broccoli – and in future other vegetables where the flower is eaten, for example, cauliflowers – can be grown anywhere at any time enabling continuous production and supply of fresh local produce." - Dr Irwin

Judith and her team identified the new line as part of JIC's GRO Institute Strategic Programme. They were surprised to see how rapidly it grew from seed to harvestable sprouting broccoli spears. Detailed analysis identified the gene responsible for this trait. They are now testing further generations under conventional glasshouse and controlled environment conditions. This line has been developed using conventional breeding techniques.

In order for this experimental line to move towards commercialisation the next steps involve flavour and nutritional analysis and performance testing under true protected and field commercial growing conditions.

First evidence of rocky planet formation in Tatooine system

A disc of rocky debris from a disrupted planet surrounds a white dwarf plus a brown dwarf binary star. The white dwarf is the burn-out core of a star that was probably similar to the Sun, the brown dwarf is only ~60 times heavier than Jupiter, and the two stars go around each other in only a bit over two hours. (Credit: Mark Garlick, UCL, University of Warwick and University of Sheffield)

Evidence of planetary debris surrounding a double sun, 'Tatooine-like' system has been found for the first time by a UCL-led team of researchers.

Published in Nature Astronomy and funded by the Science and Technology Facilities Council and the European Research Council, the study reports on the remains of shattered asteroids orbiting a double sun consisting of a white dwarf and a brown dwarf roughly 1000 light-years away in a system called SDSS 1557.

The discovery is remarkable because the debris appears to be rocky and suggests that terrestrial planets like Tatooine – Luke Skywalker's home world in Star Wars – might exist in the system. To date, all exoplanets discovered in orbit around double stars are gas giants, similar to Jupiter, and are thought to form in the icy regions of their systems.

In contrast to the carbon-rich icy material found in other double star systems, the planetary material identified in the SDSS 1557 system has a high metal content, including silicon and magnesium. These elements were identified as the debris flowed from its orbit onto the surface of the star, polluting it temporarily with at least 1017 g (or 1.1 trillion US tons) of matter, equating it to an asteroid at least 4 km in size.

"Building rocky planets around two suns is a challenge because the gravity of both stars can push and pull tremendously, preventing bits of rock and dust from sticking together and growing into full-fledged planets. With the discovery of asteroid debris in the SDSS 1557 system, we see clear signatures of rocky planet assembly via large asteroids that formed, helping us understand how rocky exoplanets are made in double star systems." - Lead author, Dr Jay Farihi (UCL Physics & Astronomy)

In the Solar System, the asteroid belt contains the leftover building blocks for the terrestrial planets Mercury, Venus, Earth, and Mars, so planetary scientists study the asteroids to gain a better understanding of how rocky, and potentially habitable planets are formed. The same approach was used by the team to study the SDSS 1557 system as any planets within it cannot yet be detected directly but the debris is spread in a large belt around the double stars, which is a much larger target for analysis.

The discovery came as a complete surprise as the team assumed the dusty white dwarf was a single star but co-author Dr Steven Parsons (University of Valparaíso and University of Sheffield), an expert in double star (or binary) systems noticed the tell-tale signs.

"We know of thousands of binaries similar to SDSS 1557 but this is the first time we've seen asteroid debris and pollution. The brown dwarf was effectively hidden by the dust until we looked with the right instrument but when we observed SDSS 1557 in detail we recognised the brown dwarf's subtle gravitational pull on the white dwarf." - Dr Steven Parsons

The team studied the binary system and the chemical composition of the debris by measuring the absorption of different wavelengths of light or "spectra", using the Gemini Observatory South telescope and the European Southern Observatory Very Large Telescope, both located in Chile.

Co-author Professor Boris Gänsicke (University of Warwick) analysed these data and found they all told a consistent and compelling story.

"Any metals we see in the white dwarf will disappear within a few weeks, and sink down into the interior, unless the debris is continuously flowing onto the star. We'll be looking at SDSS 1557 next with Hubble, to conclusively show the dust is made of rock rather than ice." - Professor Boris Gänsicke

Revealing the UK's hidden depths

Since 1958, it has been mandatory for records of cores deeper than 30 metres to be archived at BGS, but they aren't always detailed; older records might have noted which layers held coal but not collected any data on the layers above it.

Underneath the Earth's surface lies a wealth of resources. But will the way we currently use them give us problems in the future? Dr Ciaran Beggan, Dr Andrew Barkwith and Dr Caroline Graham at the British Geological Survey (BGS) explain why we need a clearer picture.

People have been using the subsurface for millennia. We have quarried stone to build homes, dug cellars to store goods, drilled for oil, mined for minerals, buried rubbish... the list goes on. And often we don't know how it was used by people before us or what it's actually made of.

Our reliance on groundwater supplies in the UK is up by 50 per cent compared with 60 years ago.

Four stories of lab space in London's brand new Francis Crick Institute extend underground to house highly sensitive equipment.

These buried secrets can cause nightmares for planners. Builders working on the Edinburgh tram route were slowed down by forgotten, unmapped Victorian water pipes and sewers, the remains of a leper colony and hundreds of 15th century skeletons. In fact, it's been estimated that half of the overruns on civil engineering projects are caused by unforeseen ground conditions.

Mapping it

We need to know more about previous human activity underground as well as the ground's physical, mechanical and chemical properties. More than that, we need all that information to be in one place. That's not just to aid construction projects but also so that we don't compromise our future. For example, cities dealing with increasing populations are digging down to create space while our reliance on groundwater supplies in the UK is up by 50 per cent compared with 60 years ago. These needs are in competition, as our underground infrastructure blocks our access to groundwater.

Because each use of the subsurface has a knock-on effect for the future, to manage it properly we need to think about what pressures we might face next. In the Futures Team at BGS they are trying to understand and avoid problems different buried infrastructure might cause and emphasise how it can best work in harmony.

Until recently, we have only had pockets of information about certain areas of the country, gathered from various projects and held in different places. So at BGS they are bringing it all together. Using that data collected over many decades NGR are building a 3D map called UK3D - external link, showing 5km of the UK's underground layers.

UK3D shows a network of cross sections through the Earth's crust. You can download it for free from BGS and open it in Google Earth to rotate, tilt and zoom into the UK's geological layers.

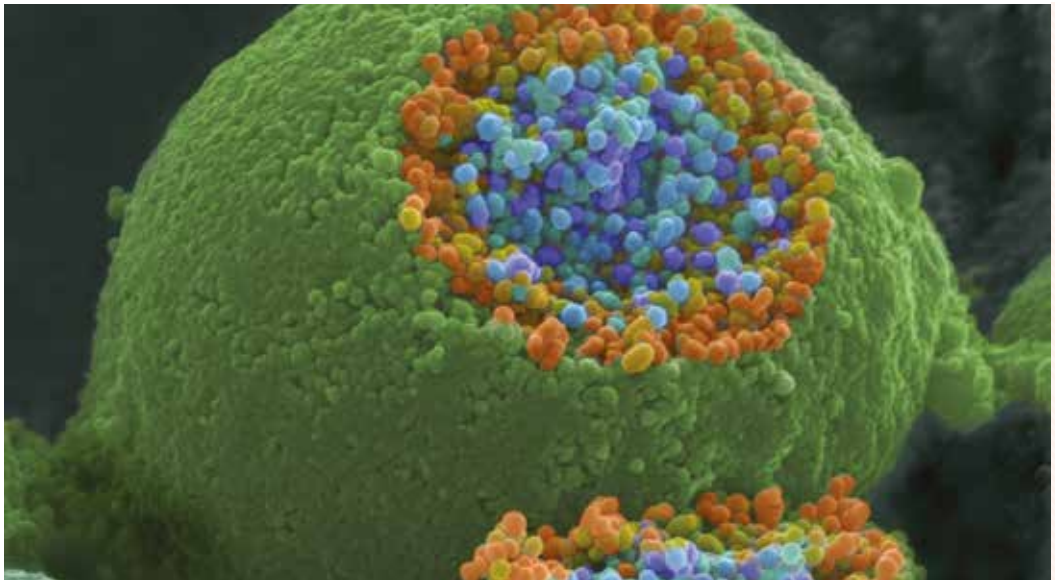
UK3D will help us get better at forecasting the effects of events like groundwater movement during floods and of the wider implications of future projects. For example, we'll be able to ask questions like: "If I build a tunnel at X, will I affect the water table at Y?" We're also working to make it easy to use for non-geologists, like policymakers.

Earth observatories: Real-time data

A new Natural Environment Research Council (NERC) project with BGS will help us get highly-detailed, real-time data on the immediate effects of human activity underground by using a range of monitoring devices in more than one hundred boreholes. By independently monitoring and observing drilling, extraction and underground storage, the project will tell us about using subsurface resources safely and sustainably.

Dr Ciaran Beggan, Dr Andrew Barkwith and Dr Caroline Graham are part of the BGS Futures Team.

Discovery sheds light on how nerve cells self-repair



A colourised scanning electron microscope picture of a nerve ending that has been broken open to reveal the synaptic vesicles (orange and blue) beneath the cell membrane. (image credit: Tina Carvalho)

Medical Research Council (MRC)-funded researchers have discovered how a protein in the body enables nerves to repair themselves after injury. The finding could ultimately lead to treatments for those whose peripheral nerves (those outside the brain and spinal cord) have been damaged, for example through traumatic injuries or diabetes.

Scientists, from Plymouth University Peninsula Schools of Medicine and Dentistry, discovered that a protein called Merlin, which was known to play a part in suppressing the growth of nerve tumours, is also vital to the process by which nerves repair themselves.

Merlin protein is found in Schwann cells, which wrap around the nerve cell projections that carry information in and out of the spinal cord and brain, helping nerves to signal to one another. Schwann cells have the rare ability to regenerate themselves after injury, and the researchers found that Merlin was crucial in directing this repair.

In mice which had been genetically altered to remove Merlin, Schwann cells were unable to repair damage to the peripheral nerves. Further experiments suggested that failure of nerve repair in Merlin-free Schwann cells was down to another protein, YAP, shedding more light on the complex pathway of signalling within these cells that controls nerve regeneration.

Peripheral nerve damage has limited treatment options and has a detrimental effect on the lives of those who have sustained it. The findings identify, for the first time, the mechanisms by which nerve damage repair happens. Understanding the mechanism can help develop effective therapies to produce nerve repair in situations where that might not have been an option before.

The research has uncovered another piece of the jigsaw puzzle in discovering how nerves regenerate, with potential impact in the future for trauma and diabetes patients and even elderly people whose nerves have lost the ability to repair themselves.

The original research paper “Merlin controls the repair capacity of Schwann cells after injury by regulating Hippo/YAP activity” was published in the Journal of Cell Biology, 30 January 2017.

Chartered Scientist
Registered Scientist
Registered Practitioner
Registered Science Technician
IST CPD Award

Technical Professionals

The Institute of Science and Technology has been supporting specialists with the technical skills that the world's economy needs for more than 60 years. Our membership is diverse, consisting of all sorts of technical experts, and managers wherever they work: from science labs and engineering facilities to recording studios and IT departments.

Central to IST's aims is the belief that people who work in technical roles deserve formal recognition for the work that they do, the experience they've racked up and the expertise they have to share. We encourage our members to further their careers by pursuing professional and personal development, and by attaining a professional status that recognises the value of their experience and expertise.

We know that our members are skilled professionals, and as one of the Science Council's Licenced Bodies we can give experienced technicians official accreditation through awarding Chartered Scientist (CSci), Registered Scientist (RSci), or Registered Science Technician (RSciTech) status. For those technical people working outside of science we are able to award Registered Practicioner (MIScT(Reg) or FIScT(Reg).

To register, you simply need to show that you have, and use, the skills that qualify for professional status, while always continuing with your professional development. A full explanation of what you need to do to get registered status can be found on the IST website: **istonline.org.uk/professional-registration**

In addition, the IST is running workshops in different organisations to explain the application process in more detail. If you are interested in one of these workshops, and there is enough interest where you work, email **office@istonline.org.uk**

You can also meet some of the people who have registered so far by visiting our website: **istonline.org.uk/professional-registration/case-studies**

Our work with organisations such as HEaTED and unionlearn, promotes the professional development of technical staff in all areas. Together, we are ensuring people working in technical roles get the support and opportunities they need to achieve their potential. There is advice and guidance available for IST members (particularly new or young ones) through the IST's Mentoring Support Network.

We know how important it is for people who work in technical roles to be able to develop their skills and have their expertise recognised. We know too, as we look to the future, that many more highly skilled technical people are needed. That's why the IST has dedicated itself to continuing to raise the status of specialist, technical, and managerial staff and to continue to support their progression.

The number of skilled technical people joining the IST's registration scheme is growing fast. That's because more and more of our members are discovering the great benefits and opportunities that professional recognition can bring.

The IST is an organisation run by technical people for technical people.

Leading Your Technical Team

"Delivering the fundamental and key elements for leading and managing people"

Leading Your Technical Team & Building on Your Leadership Skills

The Leading Your Technical Team programme set of **Leading Your Technical Team** and **Building on Your Leadership Skills** is geared toward delivering the fundamental and key skill elements for leading and managing people, particularly in a technical team.

The nature of technical support in many universities and higher education colleges is changing. People who work in a technical role have become both increasingly specialised and also high impact in terms of directly supporting teaching, research or infrastructure. Recent surveys have shown that high quality technical support is now seen as essential in delivering a high value student experience and quality research.

For many organisations one of the key challenges is how to effectively channel, develop and manage their highly valuable technical resource. Increasingly, what has been highlighted when realigning and grouping together technical support is the need to prepare and train people to manage, and above all, lead technical teams. We have designed the Leading Your Technical Team programme set to meet this need.

Both LYTT and BYLS are delivered in the context of a higher education technical environment, but they are not aimed at any specific job role or discipline. Our participants come from a very broad range of higher education institutions, and from a very diverse range of academic disciplines and departments or service sections. For example our recent courses have included people from institutions such as Robert Gordon University, University of Manchester, University of Oxford, University of Birmingham, University of Bristol, University College Cork, and the Open University to name but a few. Similarly our participants also have a wide variety of job roles. These ranging for example from Technician, Senior Technician, Laboratory Manager, IT Network Team Leader, Workshop Manager, Geological Facilities Manager, Textile Workshop Manager and Bio-repository Manager.

Leading Your Technical Team has a long and well respected history. It has been running for over 30 years with more than 1,500 people having been through the programme over this time. The programme content has continued to adapt and develop in line with changes in HE and it continues to be held in very high regard by HE senior managers and staff developers. Its high reputation is maintained through delivering a very high standard of technical management training via experienced HE managers, in a practical context with the reality of managing in a university technical environment.

How the programme works: Both programme follow a similar format, in that the learning is enhanced through informal participative sessions that include active discussion, exchange of ideas and delegate group work. There is no role playing.

Leading Your Technical Team

Specific programme goals

The programme introduces the fundamental building blocks of management and leadership specifically in the context of technical support in universities and higher education colleges. It provides an opportunity to look at the practical challenges of managing and supervising technical staff from both academic and service areas, as well as examining a range of essential management and leadership skills and techniques. The programme links practical leadership theories to dynamic team leading in context with the reality of managing in a technical university environment.

By the end of the programme participants will have:

- Identified the main management/leadership/ supervisory skills required of them within their own working environment.
- Reflected upon the practices and processes affecting management and leadership in technical units, sections and departments.
- Practised a number of leadership and management skills and identified ways to develop these skills further.
- Had an opportunity to share with presenters and fellow participants from a wide number of universities and higher education colleges, their views, experiences, expertise etc.

Content

The programme will cover topics including:

- Key issues - roles and responsibilities.
- Management v leadership.
- Motivation and delegation - individuals and team.
- Communication skills & team briefing.
- Influencing skills and analysing your network.
- Managing and leading your team through change.
- People management issues & case studies.
- Positive team leadership

Who should attend

This programme is intended for people who now or in the future have managerial or supervisory responsibilities and are interested in developing their fundamental management and leadership skills . The programme content is delivered within the context of working in an HE environment and will be applicable to support staff from academic, research, and service areas. It is most important that participants are, wherever possible, residential and therefore available to attend the programme throughout.

There are a strictly limited number of places and applicants are advised to apply early in order to secure a place.

Additional dates, bespoke courses:

We would be happy to discuss running these courses at your host institution or at a suitable venue, if a number of attendees from a single institution wish to undertake the courses. Please contact Wendy Mason.

Building on Your Leadership Skills

Specific programme goals

The programme builds on the fundamentals learned in Leading Your Technical Team and provides a further opportunity to look at the practical challenges of managing or supervising technical staff from both academic and service areas, as well as examining a range of essential management and leadership skills and techniques. The programme again links practical leadership theories to dynamic team leading in context with the reality of managing in a technical environment. The programme content incorporates a range of topics that were suggested by attendees on LYTT as areas that they would most like to explore further, e.g. Managing Staff Performance, Dealing with Difficult People, and Influencing Skills. Toward the end of the programme we begin to explore the topic of Leadership Intelligences, which introduces you to themes covered in greater depth in more advanced leadership programmes.

By the end of the programme participants will have explored how to:

- Lead and motivate by identifying the key skills and characteristics of successful leaders and to develop the key people management skills you need to ensure success.
- Improve performance through developing personal strategies for enhancing the effectiveness of your team by using flexibility across the leadership styles.
- Manage performance through developing your team's strengths by setting and reaching both personal and team objectives using delegation and leadership skills.
- Lead a team made up of different personalities and encourage mutual respect and cooperation from all team members and understand how to overcome barriers to communication.
- Work with difficult people through resolving conflict and dealing with difficult people and situations confidently and positively.
- Understand yourself, your influencing environment and your impact and to develop multidirectional influencing skills and an influencing strategy.

Content

The programme will cover topics including:

- Leadership & motivation - The differences of motivation, influence and manipulation.
- Managing performance – Where and when to improve team and/or individuals performance.
- Working with difficult people - How to take control & case studies.
- Influencing - Influencing teams & influencing individuals.
- Leadership intelligences - Personality based leadership, leadership and team performance.

Who should attend

This programme is particularly suited to people who have completed Leading Your Technical Team or those who have previously attended similar programmes and

have a few years' experience in a technical managerial or supervisory role and want to further develop their management and leadership skills. The programme content will be delivered within the context of working in a university environment and will be applicable to support staff from academic and service areas.
It is most important that participants are, wherever possible, residential and therefore available to attend the programme throughout.

There are a strictly limited number of places and applicants are advised to apply early in order to secure a place.

Additional dates, bespoke courses:

We would be happy to discuss running these courses at your host institution or at a suitable venue, if a number of attendees from a single institution wish to undertake the courses. Please contact Wendy Mason.

Deligate feedback

Leading Your Technical Team

'I have learned more about the supervisory skills that I require in my job, how to develop these skills and especially in the way I communicate to other members of staff. I really enjoyed sharing views and experiences with fellow participants from other universities.'

'I was able to learn the skills to solve some of the problems which I am facing myself in my leadership role.'

'This course is well structured and presented. It thought me to look at my management technique and to focus my efforts on areas where I can succeed'

'Good course that hits a lot of the main areas and interesting areas regarding management and team leadership. It's motivational to the point that you return to work with more ideas and your own motivation to tackle day to day leadership.'

'For me the course was a positive experience and directly related to my day to day working life.'

'It was useful to find that many people are in the same position with the same worries and the programme provided useful information on dealing with many of our issues.

Building on Your Leadership Skills

'A Different way of looking at the way I respond to my team to improve all our performances. A way of understanding the individual members of my team. A chance to discuss with people from different institutions and areas of work how they deal with difficult members of their teams.'

'Felt I came away from the course feeling better about being a team leader and focusing on management issues.'

'A fun and informative way of helping me explore my leadership skills and how they affect my team.'

'The course was very informative and inspirational with lots of ideas and discussions throughout the sessions. A very useful programme delivered in a fun relaxed environment.'

'A very relaxed and informative course with like-minded delegates; the course was inclusive and challenged delegate with thought provoking ideas and concepts.'

'Interaction and problems experienced between people across the HE spectrum away from your place of work is of great value and should not be forgotten. In-house training is not necessarily the way forward.'

Presenter profiles

Kevin is the Programme Director for the LYTT & BYLS courses, which are now run through the Institute of Science & Technology (IST). He is the Resources & Operations manager of the Department of Infection, Immunity & Cardiovascular Disease within the Medical School at the University of Sheffield. He began his career at Sheffield as a trainee Medical Laboratory Scientific Officer over 35 years ago and has subsequently experienced a series of diverse technical roles within the School. Over the last 10 years he has undertaken a range of senior managerial positions, leading technical and support staff teams, under various administrations and has been involved with small and large project teams across the University. Kevin is also actively involved in both promoting and delivering staff development and training at Sheffield.

Lisa has significant experience managing large teams in both private and public sector organisations. After graduating from Loughborough University she worked for airport operator BAAplc in a variety of operational, change management and training roles across all the London airports. Whilst with BAA she also gained her MBA from the University of Surrey. In 2000 Lisa moved with her family to the USA where she undertook volunteer work which included the American Red Cross and the Small Business Administration in Texas. Lisa joined the University of Sheffield in 2005 and currently manages a team of 400+ staff in her role as Head of Campus Services.

For dates, venues, and to book a place on either of these programmes please contact:

Wendy Mason,
LYTT & BYLS Programme Administrator
T: 0114 276 3197 e: office@istonline.org.uk

The IST One-day Technical Conference 2017

Date: 14th September 2017
Venue: Mercure Grand Hotel
Granby Street Leicester
LE1 6ES

This exciting one-day conference and its talks/ workshops offer you an opportunity to update technical knowledge, skills, and further your career development. It will also provide valuable networking opportunities to engage and learn from other technical staff and technical supervisors/ managers.

Target participants

The conference will be of specific interest to a wide group of specialist, technical, and managerial colleagues who work in a broad range of environments such as science, engineering, arts, industry, local authorities, schools, FE, HE, research/analytical/ health facilities, and government departments.

The conference also provides opportunities for you to actively participate through poster presentations, and visits to supplier/manufacturer stands.

For professionally registered delegates (RSciTech, RSci, CSci, and also those delegates considering applying for professional registration) the conference and its talks/ workshops will contribute significantly to your professional and personal development (PPD).

A few comments from last year's conference

"I enjoyed meeting like-minded people from other institutions and exchanging ideas and current thinking"

"The talks were very good, suitable length and the presenters clearly had in depth knowledge of their subjects. Held the interest very well"

"It enabled me to gain better understanding of the diversity of our roles"

Conference Programme

Keynote speakers

Keynote 1 – Professor Anu Ojha, Director of the Space Academy, Leicester

Keynote 2 - Dr Turi King, Geneticist, University of Leicester

Plus 15 talks/workshops, organised in three sessions throughout the day, where you can choose from 5 exciting topics in each session.

The full programme of workshops is on our web page, some examples are:

- Champions for Professional Registration
- Registration and how to complete your application
- Health and Safety
- Developing Design Consultants of the Future": Embedding Virtual & Augmented Reality into the Urban Design Curriculum
- Design an enzyme
- CPD is a good thing!

Plus presentation of IST Awards

Including the prize for the best IST Conference Poster Award

You have the opportunity to contribute to this conference through our Poster Competition. It's your chance to share your work experiences with others in an informal way, to tell a story in pictures and/or words. Contact the IST Office.
Details of other Prizes/Awards will be posted on our conference web page

Delegate costs - 'Early Bird' discounted rates

(discounted rates finish on 21st July, so book early)

£40 - IST members
£45 - non-members
£40 - Groups of 6 or more (members and/or non-members)

The full programme and booking form is available soon on our web site **http://istonline.org.uk**

To book your place please contact Wendy:
E: wendymason@istonline.org.uk
T: 0114 276 3197
Wendy Mason, Administrator
Institute of Science and Technology
90 Rockingham Street
Sheffield
S1 4EB

The Institute of Science and Technology one-day Technical Conference 2017

Sponsorship Opportunities

The IST one day Technical Conference is scheduled for September 2017

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

The 2017 one-day conference and its workshops will focus on updating technical knowledge, skills, career development, and will provide valuable networking opportunities to support technicians and technical supervisors/managers, the majority of whom who either use or purchase your company's product/ services.

This conference will be significantly larger than previous individual events with the scientific supplier exhibition being an integral part of it.

We really hope that you will be able to support this initiative; we already have quite a number of suppliers wishing to take part.

The Institute of Science & Technology will formally acknowledge each sponsor's support through its publications, web site, and its bi-annual Journal. The conference papers will also include company logos.

The Conference offers an ideal opportunity for **suppliers of services** to develop new influential contacts, promote their products through sponsorship, and to also reinforce existing relationships. Conference suppliers will be engaging with technical staff who are directly using their types of services and products, and staff who are likely to be recommending or receiving feedback from their own clients.

We expect over 250–300 delegates from across the UK.

Sponsorship Opportunities 2017

£300
Inclusion of promotional material (up to A4) in delegate packs

£750
Display/promotional stand in circulation area for duration of the Conference

£1,000
Key Sponsor – Key location of display/promotional stand in circulation area for duration of the Conference plus a 45 minute Workshop plus Company's logos in IST's Journal publication

The sponsorship form is available on our web site: istonline.org.uk

The Institute of Science & Technology

If you are interested in any of the sponsorship opportunities, or want to discuss any of the above opportunities contact Wendy:
Email: **wendymason@istonline.org.uk**
Tel: **0114 276 3197**

Production: touchpointdesign.co.uk

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