The Institute of Science & Technology

The Professional Body for Technical, Specialist, and Managerial Staff

The Journal

Spring 2018

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The Journal

The Official Journal of The Institute of Science & Technology

Spring 2018

The Professional Body for Technical, Specialist, and Managerial Staff

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Editor's welcome

Welcome to the 2018 spring edition of the IST Journal.

Ian Moulson
Editor

As always, we feature some really excellent articles, which I hope you enjoy reading. This edition has both historical stories about influential technicians, and also up to the minute stories of today's technicians, as we continue our #TechnicianJourney series. We also continue to feature further discussion articles in our series covering diversity and inclusion, as seen from a technician's perspective. Please let us know if you have an equality and diversity story to share.

Our thanks go to our contributing authors, and also to Technicians Make it Happen for their great photographs and examples of real life technicians.

We would also like to offer a special thanks to Anna Cook of CERN, both for her article and for being a key sponsor of our forthcoming IST Technical Conference in September (see our website for details – don't miss out, book on-line now at istonline.org.uk).

Inside this issue we also have 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. And as part of our push to add to the benefits of being a member of the IST we have now catalogued all the articles published in the IST's Journal going all the way back to 2006. Some 200 (plus this issue's articles) have been featured over that time. The catalogue will be available to members through our brand new website, and offers the opportunity to search topics, dates, or authors, and will enable you to download a pdf copy of the article as it appeared in the journal.

Our membership is on the up, and the number of professional registrations through the IST continues to grow. All of the IST's Executive and its support team are volunteers, are unpaid, and give their valuable time freely. Why, you might ask? Well it's because we all care. We care that technicians, of every discipline and organisation, should be given the recognition that they deserve. And, we believe the way to do that is to organise ourselves, support each other, and beat our own drum. The IST is an organisation for technical people and is run by technical people. So if you care, and want to join the team in running your institute, then do please let us know.

Finally, remember to make sure that you check out the IST's regular e-Newsletter to get up to date news of what is happening in our "technician world". Subscribe free at istonline.org.uk and follow the links to a series of periodic newsletters that we generate quarterly – please feel free to browse our newsletters and see what we have been doing and what we have planned for the near future.

Our e-Newsletter editors are:

Natalie
n.j.kennerley@
istonline.org.uk

Kevin
k.m.oxley@
istonline.org.uk

Please feel free to contact them, or our IST Office **office@istonline.org.uk**

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

Ian

Chairman's view

Terry Croft
Chairman

We are well into 2018 and the team and I are working hard in continuing to represent the technical community across all sectors with our (key) input into many strategic reviews, national initiatives, and expert advice to sector bodies and organisations. The IST continues to fully support the Gatsby Technicians Make It Happen initiative, The Technician Commitment and our involvement with the development of new apprenticeship standards and partnership with the National Technician Development Centre. These are important times for the technical community's voice to be heard with so much uncertainty surrounding the future post-Brexit, and the changes to the environments we all work in. The IST recognises, and will continue to ensure that Government, related organisations, and the public also recognise the valuable work and the contribution that YOU make, as professional technicians, to UK plc. The impact of the technical workforce demonstrates just how important this work is to the future success and prosperity of the UK.

On a lighter side Joan Ward and I represented our members at a recent meeting of the Science Council where members of the IST Executive sit on a number of committees providing valuable advice and expertise as well as contributing to on-going debate as to the future direction of the professional bodies' representative organisation. The meeting took place on 21st March, which was also the World Down Syndrome Day, so we all made sure that we had our odd socks on and made it a fun day for our IST Charity of the Year, the UK Down's Syndrome Association. Our Industry Liaison Advisor, James Trout, has been doing a terrific job both for the charity DSA, and for the IST (you can learn more about his work at this year's IST Conference in September – **istonline.org.uk/news-events**).

Another group of specialist technicians that the IST is working with to improve their visibility, their professional recognition, and their career development, is the Arts and Media technical community. Michelle Jackson and Natalie Kennerley have organised a number of meetings with these highly skilled technicians as they prepare to become a specialist group within the IST.

This will allow the IST to further develop our Registered Practioners Scheme to meet the professional registration needs of this extremely important group of technicians who are a vital technical support for a growing number of sectors within UK plc.

This is a very exciting time for professional technicians and technologists, as well as an uncertain one. However, the IST is busier than ever supporting our community and so I am asking those of you who are passionate about our profession, and want to help us in enhancing the opportunities for professional technicians, to consider becoming a volunteer and joining one of our teams. If your interests are in

media and communications, marketing, professional registration, supporting our outreach activities and workshops, or in being a Champion for the IST in your workplace, then I really would like to hear from you (**t.croft@istonline.org.uk**).

Volunteers have been able to see the benefits from the experienced gained by working with our teams, both locally and nationally, in terms of their exposure and career development. So an exciting opportunity with a key professional body is just a "click" away.

Finally congratulations to our members who have recently attained professional registration and a warm welcome to our new members (see New Members pages). I look forward to representing you, and hopefully meeting you at the IST's conference in Newcastle in September of this year.

Best wishes,

Terry

President's view

Helen Sharman
OBE, FRSC, FIScT

As I write, the snow is melting and life is returning to "business as usual". Many technicians will have been involved in managing unplanned situations due to the effect of the bad weather on people's usual travel plans and deliveries of consumables. The silver lining to any disruption, of course, is to learn from it and you may even be able to build on any new experiences to further develop your skills and career, especially if you have been able to show some skills that others were not aware of before.

In a similar way, the IST executive is using an opportunity that has been presented by changes to the Science Council leadership. Alongside other professional bodies the IST is working with the Science Council to develop it as an umbrella organisation that represents our views and supports our aims; using the knowledge and skills of the IST's members to improve technical career development, opportunities and recognition nationwide.

We expect the Technician Commitment to continue apace, with more organisations signing up as the year goes by. So, if you haven't heard anything about the Technician Commitment from your employer, now is the time to ask.

If you need any support from the IST about this or any other matter concerning the technical profession, please get in touch. If you have a view to share, let us know. The IST prides itself on understanding the needs of technicians and we rely on your input to best represent and support you at all levels.

Best wishes,

Helen

IST Journal Publication

Back copies of our bi-annual journal publication are viewable online, but access is restricted to our current members only. Members can log in using their surname as the username and their date of birth (format: yyyy-mm-dd) as their password.

The Journal Back Issues
istonline.org.uk/ist-journal-publication

If you experience any problems accessing the publications please contact us (office@istonline.org.uk), quoting your surname, membership number, and date of birth.

Article submissions for the IST Journal
We welcome article submissions from all areas of pure and applied science, and all areas of technology, including areas such as IT, media, and the arts. We like to cover existing, historical, and new technological advances, and also unusual aspects of science. We particularly want to encourage submissions from people who want to publish for the first time, and can offer help and assistance in putting a first article together.

Contact
Editor: **i.moulson@istonline.org.uk**
Assistant Editor: **andyconnelly@istonline.org.uk**
Or the IST office: **office@istonline.org.uk**

The guidelines for article submissions to the IST Journal are:

1. Article submission deadlines for 2018/2019
   - Autumn edition is 1st September.
   - Spring edition is 1st March.

2. Articles should be submitted electronically in Microsoft Word .doc format with images supplied separately as JPEG files (in the highest resolution possible please as we may not be able to reproduce low resolution images). Please cross reference to images and captions in your article text

   It is important that all article images have a minimum resolution of 300dpi. Embedded images are not suitable.

3. Short articles: these can be submitted in any length up to roughly 2,000 words.

4. Major articles: these are normally no longer than roughly 6,000 words per edition, but please contact the Editor for longer submissions as they can usually be accommodated across two or more editions.

5. All accepted articles will be edited into the IST Journal's house-style and may be corrected for grammar. Text layout and images may be changed, altered, or omitted.

6. All articles must be written in UK English. Poorly translated articles may be declined by the editors.

7. Article submissions should be submitted via email to **office@istonline.org.uk**. Your email should clearly state "Journal Article Submission" and the article and images sent with it as separate email file attachments.

We can provide subscriptions for hard copies of our Journal – rates for 2018 are as below, for further details please contact (**office@istonline.org.uk**):

UK – £25 per year (2 editions per year)
EU – £40 per year (2 editions per year)
Non EU – £55 per year (2 editions per year)

New members and registrations

New members October 2017 – March 2018

Membership No.	Name	Grade
T15890	Mrs M J Sample	MIScT
T15891	Mr J Guthrie	MIScT
T15892	Mr G Betts	MIScT
T15893	Mr O D Osibodu	MIScT
T15894	Miss L Caldwell	MIScT
T15895	Mr S S Adeleye	MIScT
T15896	Ms S Gillson	AssocIScT
T15897	Mr H Dar	Affilliate
T15898	Mrs C Bresner	MIScT
T15899	Ms C J Barker	MIScT
T15900	Ms T Tanice	AssocIScT
T15901	Mr P Brownhill	MIScT
T15902	Mrs C Sanderson	MIScT
T15903	Mr S Karan	MIScT
T15904	Mr R P Smith	MIScT
T15905	Ms C Maltby	MIScT
T15906	Dr C A Gill	MIScT
T15907	Mr G G Govan	MIScT
T15908	Mrs W Lewis	MIScT
T15909	Dr O O Okedeyi	MIScT
T15910	Dr H Bagshaw	MIScT
T15911	Mrs S M Ahmad	MIScT
T15912	Mrs T P Edwards	MIScT
T15913	Dr R Khushal	MIScT
T15914	Mr C Boothman	MIScT
T15915	Dr J P Waters	MIScT
T15916	Miss A E Cowper	MIScT
T15917	Dr M J Bonner	MIScT
T15918	Dr A Constantinou	MIScT
T15919	Dr P M Taylor-Harris	MIScT
T15920	Dr K Woodruff	MIScT
T15921	Dr J Mallinson	MIScT
T15922	Mr R B Quiambao	MIScT
T15923	Miss L Chessum	AssocIScT
T15924	Miss I van Zwieten	MIScT
T15925	Mrs G Ward	MIScT
T15926	Miss T J Blohm	MIScT
T15927	Miss R Jantschenko	MIScT
T15928	Mr A J Lewis	MIScT
T15929	Miss R Hope	MIScT
T15930	Mr I O Andrew	MIScT
T15931	Mrs T Oughton	MIScT
T15932	Miss B J Grooby	MIScT
T15933	Dr J Lockley	MIScT
T15934	Miss N Barlow	MIScT
T15935	Mrs V J Buckingham-Bostock	MIScT
T15936	Miss R Byrne	MIScT
T15937	Mr S O Ojiemudia	AssocIScT
T15938	Mr K Keating	MIScT
T15939	Mr P R Bentley	MIScT
T15940	Miss SMahroof	AssocIScT
T15941	Ms F F C enton	MIScT
T15942	Mr D Harrison	MIScT
T15943	Mrs C Holland	MIScT
T15944	Mrs A Gopalan	MIScT
T15945	Miss L Mcvittie	MIScT
T15946	Mr T E Wallace	MIScT
T15947	Mr D Howe	MIScT
T15948	Dr J Cowpe	MIScT
T15949	Miss S J Viney	MIScT
T15950	Miss O I Omenai	MIScT
T15951	Miss E Glendenning	MIScT
T15952	Mrs T Garcia Sorribes	MIScT
T15953	Mr J I Aigboje	MIScT
T15954	Mr A Birch	MIScT
T15955	Mr A Pirzada	MIScT
T15956	Mrs K Kroon	MIScT
T15957	Ms A Boxall	MIScT
T15958	Mr Q T Jackson	MIScT
T15959	Mr O V David	MIScT
T15960	Miss O P Ikhimalo	AssocIScT
T15961	Dr L J Fawcett	MIScT
T15962	Dr K J Theis	MIScT
T15963	Mr E F Abhulimen	MIScT
T15964	Dr K Maniam	MIScT
T15965	Mr L M Dean	MIScT
T15966	Dr N Jackson	MIScT
T15967	Dr C Jarrett	MIScT
T15968	Dr A Yee	MIScT
T15969	Miss C L Ord	MIScT
T15970	Ms K Britchford	MIScT
T15971	Mr E O Olori	MIScT
T15972	Mrs G E Riddell	MIScT
T15973	Mr M Mamman	MIScT
T15974	Mr T S Sewell	Affilliate
T15975	Miss R M Lambert-Porter	MIScT
T15976	Dr X Zhu	MIScT
T15977	Dr G Magro	MIScT
T15978	Mr F E Edayi	MIScT

Total: 89

Science Council Registrations

Membership No.	Name	Grade
T15859	Mr L S Dawkins-Hall	CSci
T15918	Dr A Constantinou	CSci
T15920	Dr K Woodruff	CSci
T15938	Mr K Keating	CSci
T15958	Mr O T Jackson	CSci
T15334	Ms L J Soraya	RSci
T15562	Mrs S Marshall	RSci
T15712	Mrs S T Lidstone	RSci
T15719	Dr Y Liu	RSci
T15839	Dr L Ganderton	RSci
T15906	Dr C A Gill	RSci
T15919	Dr P M Taylor-Harris	RSci
T15947	Mr D Howe	RSci

Membership No.	Name	Grade
T12923	Mrs C L Barker	RSciTech
T15630	Mr E Marriott	RSciTech
T15631	Mr N J Bond	RSciTech
T15632	Mr G Reynolds	RSciTech
T15639	Miss J Whitnear	RSciTech
T15646	Mr D Schofield	RSciTech
T15856	Mrs S L Fay	RSciTech
T15904	Mr R P Smith	RSciTech
T15905	Ms C Maltby	RSciTech
T15907	Mr G G Govan	RSciTech
T15908	Mrs W Lewis	RSciTech
T15927	Miss R Jantschenko	RSciTech
T15951	Miss E Glendenning	RSciTech
Total: 26		

IST Organisation

IST Executive Board Members

President: Helen Sharman CMG OBE FRSC FIScT

The main role of the President is to lead and guide the Institute in its strategic and operational development. Helen is ideally suited to this role having become the first British astronaut when she launched into space on board a Soyuz space craft on 18 May 1991. Helen graduated with a degree in chemistry from the University of Sheffield before working in industry. Following which she trained at the Yuri Gagarin Cosmonaut Training Centre in Star City near Moscow. Helen became a science communicator after her space flight, and 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.

E: office@istonline.org.uk

Chairman: Terry Croft MBE FIScT CSci

Terry is the Chairman of the IST. He is passionate about, and is committed to, the technical community. His work involves promoting the professionalisation of the technical workforce. He brings a wealth of experience to the board through his involvement with the wider sector and as Director of the first National Technician Development Centre for Higher Education.

E: t.croft@istonline.org.uk

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 FIScT

As Education Officer, Philippa maintains knowledge of vocational training and qualifications for technical practitioners. She also participates in regional and national development programmes. Philippa 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. He is editor of the IST's biannual publication "The Journal" and 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. Working alongside the Marketing Officer and PR Advisor, Kevin develops the implementation of recruitment and retention campaigns. He also promotes the benefits of membership to Higher Education institutions and industry. Kevin is also the Institute's Diversity Champion and works to ensure that the IST operates in line with the principles of diversity, equality, and inclusion, and to measure progress in that regard.

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

Registrar: Michelle Jackson FIScT CSci

As Registrar, Michelle oversees the registration schemes run through the IST and contributes to the development of associated strategic and operational procedures. She liaises with the Science Council with respect to continuing development of the registration process and monitors all aspects of the IST registration and assessment processes.

E: michellejackson@istonline.org.uk

Fellowship & Overseas Officer: Derek Sayers FIScT FInstLM FRMS

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 our point of contact for overseas inquiries from members and 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

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. She also coordinates and supports training courses (eg. Leading Your Technical Team) and examinations (eg Higher Diploma).

E: office@istonline.org.uk

China Advisor/Representative: Geoffrey Howell MIScT RSci

Geoff is a member of the IST Education Board and one of the assessors for professional registration. His background is in training and he now leads the first International Technical Training Programme in China as part of an ongoing IST Project.

E: g.howell@istonline.org.uk

Partnerships/Champions Coordinator: John Dwyer FIScT

John is co-ordinator for Partnerships/Champions. His role involves actively promoting professional registration for the IST throughout the UK: attending meetings, workshops, and conferences, and seeking champions for this cause at institutions nationally.

E: J.dwyer@istonline.org.uk

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

John-Paul is an IST Executive Support Officer and also the IST's social media advisor. He works closely with the Executive to enhance engagement with the wider technical community helping the Executive to develop its profile/presence across various social media platforms including Twitter, Facebook, and LinkedIn.

E: j.p.ashton@istonline.org.uk

Industry Liaison/Advisor: James Trout FIScT CMgr RSci

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

Assistant Editor: Andy Connelly PhD MIScT

As the Assistant Editor of the IST's biannual publication "The Journal" Andy works with the editor and editorial panel, to oversee the quality of its articles and other content. Andy has been writing and publishing both academic papers and popular science articles since 2007. He also works with the IST's Marketing Team looking at new ways that we can highlight the vital role of technicians and the technical community through our publications.

E: andyconnelly@istonline.org.uk

Education Board:

Philippa Nobbs FIScT (Chair)
David Forster FIScT
Ian Gray MIScT
Geoff Howell MIScT
Michelle Jackson PhD, FIScT
Christoforos Pambou MIScT, RSci

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Natalie Kennerley FIScT, CSci
Kevin Oxley FIScT, CSci
Joan Ward FIScT

Editorial Team:

Ian Moulson FIScT (Editor)
Andrew Connelly PhD, MIScT (Assistant Editor)
Alan Gall FIScT, CSci (IST Archivist)
Stephen Gamble MIScT, FIBMS
Natalie Kennerley FIScT, CSci
Kevin Oxley FIScT, CSci
Joan Ward FIScT

Arts and Media Advisory Board:

Dr Michelle Jackson FIScT CSci
Natalie Kennerley FIScT CSci
Philippa Nobbs FIScT
Joan Ward FIScT
John-Paul Ashton MIScT RSci
Plus a working focus group containing representation from a number of Arts & Media Centres

Vice Presidents:

Maida Davidson FIScT
Terry Evans MIScT
Simon Fairnie FIScT
Ian Gray MIScT
Robert Hardwick FIScT

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Medicine
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IT
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Software
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Textiles Technology
Physics

Application for IST membership

Membership

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.

Kevin Oxley FIScT, CSci IST Membership Development Officer

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.

The IST's UK membership hot-spots

Annual membership fees are:

- Junior: £10
- Affiliate: £22
- Associate: £38
- Member: £49
- Fellow: £63

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

**Please note that IST membership subscriptions of employees are eligible for UK tax relief, under Section 344 of the Income Tax (Earnings and Pensions) Act 2003. Claims needs to be made by members individually directly via HMRC

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 be made online.

Vikki Waring: from cupboard to laboratory

#Technician Journey - as told to Andy Connelly

Vikki is a laboratory technician at the University of Nottingham in the School of Biosciences. She looks after students, bakes, and autoclaves heifer poo. This is her #TechnicianJourney.

I've been a lab tech in Nottingham for a year and I've learnt so much in that time. I learned a lot when I was a school technician, but working in a university laboratory is completely different. In one of the high schools where I was a technician the kids called me 'the lady in the cupboard'. They didn't realise that behind the prep room door there was a whole laboratory, so they'd ask, "Is Miss in her cupboard?" In my new job, we let the kids into the cupboard. In fact, we encourage it!

When my children were little I worked nights in a nursing home as a care worker and then on the bank at the hospital. I'd always wanted to be a midwife and I got offered a permanent job as a Health Care Support Worker on the delivery ward. Then, when my youngest was five, my home life changed completely, and I ended up on my own with three small children. I wondered if I should I just get myself a little job and just be happy, but I decided to go to university as a mature student. I realised that being a midwife wouldn't work so I applied to the University of Worcester to do a human biology degree - it was the only subject I was good at in school. Worcester was really supportive - if my children were ever poorly, there was someone at the end of the phone to send me notes for the lectures I'd missed.

When I was at university I realised I loved working in labs - I absolutely loved it. In the third year there was a module where you could work in the labs, and that was it; as soon as I did that I got the bug. I started off helping other students out and I ended up doing longer there, most of my third year. One of the technicians suggested that I could work as a technician in a school as they have more family-friendly hours than working in a university and was possibly not as stressful, so that's what I did. In the sense that it was more family-friendly hours, it was perfect for me.

I graduated in 2006 and over the next ten years I worked in about five or six different schools around

Vikki Waring next to the brand-new autoclave she helped set up

Kidderminster. I don't know what it is about being in a school, but people don't seem to stay very long. Regardless of where you work in a school, it can become stagnant quite quickly. It was hard work as well - you are normally the only technician in the school covering three subjects: physics, chemistry and biology. There was also an idea that support staff only need paying in term time. When are you supposed to PAT test everything? When do you try out new experiments?

As a technician, I learnt to beg, borrow, and steal very quickly. When students asked what I did I would say that I'm a magician - I make practicals appear. There were times when three members of staff wanted the same piece of equipment, at the same time, in three different rooms. These were the things I'd have

to deal with every day - a real lack of resources. It is completely swapped now; in university, it is our time that is lacking, especially when you are in the teaching lab and there are three or four project students all asking you questions.

The University of Nottingham laboratories I work in now are food microbiology laboratories; we look at all sorts of yeasts and bacteria. I love working here. I feel appreciated, people say "thank you". It is as simple as that.

We currently have lots of final year undergraduates doing their projects in the laboratory. They ask so many questions. Sometimes they'll ask me something I can look up and other times I assess whether there are any post-docs or PhD students who might be able to help. I am quite open with them - I have only been here 12 months and I am learning too. When I am not helping students I am running autoclaves, doing the washing up, and doing maintenance stuff. One project is looking at antibiotic resistance in heifer poo. Autoclaving poo is not at the top of my list, although I've only had to run out of the lab once! If you ask my kids what my job is they say, "Mum cooks poo".

There is also progression here. My line manager knows that I don't want to stay at my current level, but management is not for me. I'd miss being in a lab, but I want to progress.

I wanted to be a technician, and now I am a technician. We need to be recognised as an actual proper profession - I sent my RSciTech application off a few weeks ago. I get a bit annoyed when people gloss over the whole technician thing; I think that is what I didn't like when I was a school technician.

Being a school technician was also much more isolated and stressful. I used to bake a lot of bread to unwind - I'd do a lot of kneading! I love baking and my kids knew that it was my little den. They'd know that "Mum's had a stressful day, so we'll leave her in the kitchen". I met Paul Hollywood once and said, "Hello Paul Hollywood, my future husband, how are you?" Everyone around just stood there open mouthed!

My life was: left school, had babies, got married. So, now I am doing what I should have done when I was 18-30. I think you appreciate it way more when you're older. I turned 40 and my friends took me on a plane. I'd never been on a plane before in my life and I can't wait to do it again! Two years ago, I decided that I was going to start dating again. I met someone who captains a local cricket team. I've never really watched sport but I kind of get cricket; I kind of understand what is going on. It is a lovely, friendly atmosphere and I get to bake cake for the cricket teas.

I have applied to go on the Great British Bake Off for the last few years and am trying again this year. I put 'laboratory technician' down as my job on the application form - after all, baking is a science. I love being in the kitchen and I love working in a laboratory. I love watching an experiment get the results you want. I also love when you don't get what you want and then you've got to work it out. I love all of that - it is just so interesting. I love introducing the students to it, I love working here and I don't want to go back into the cupboard.

Personal views of equality and diversity

Denise McLean & Liaque Latif

As part of a series of articles about technician's experience of equality and diversity – Denise tells us about her personal experiences.

I am a Senior Research Technician at the University of Nottingham specialising in microscopy. I was born in the UK but moved to live in Jamaica from age seven to seventeen, after which time I moved back to England.

When I returned to the UK, I was shocked to discover the low self-esteem some of the black and minority ethnic individuals I came across exhibited. They had reservations about applying for certain jobs as they didn't believe they had a cat in hell's chance of being shortlisted…I found this really disturbing.

I believe that both my schooling and living in Jamaica taught me self-confidence and the importance of hard work. Our school motto was, *Preces et Opera Omnia Vincunt* which translates, "Prayer and Work Conquer All" and Jamaica's motto is 'Out of Many, One People', which is based on the population's multiracial roots. This would most certainly have helped to underpin my confidence in applying for jobs which most of my peers felt they would not be considered for.

I remember the first job I was successfully appointed to, was working as a Saturday girl in the Radio and Television department at John Lewis. This was in the late 80s and friends tried to discourage me from applying by telling me that John Lewis's Store would not hire a black person. My response was, why wouldn't they? we'll see. I applied, went for an interview, and they offered me the job. In that section, it was assumed that women worked on the tills and the men worked on the shop floor selling electronics. I expressed my desire to work on the shop floor, as I have always been interested in electronics and although initially they seemed to have reservations and seemed a little surprised, they eventually agreed. The men on the shop floor would sometimes jokingly called me Dennis.

Also on my first day at John Lewis, one of the management team invited me into her office for a short induction talk. While I was there, she asked me if I could tone down my accent. I had not long returned to the UK, so I still had my Jamaican accent, but I was very comprehensible. I asked her if she would say the same thing to a Scottish, Irish or Welsh person and whether she could understand me. I think at that point she realised what she had asked, apologised, and never mentioned it again. More to the point, none of the customers had an issue understanding me.

I have held technical roles in various institutes over the years including the NHS and Department of Health, but I've never had another experience quite like that.

I remember when I went for my second job in the NHS, I phoned the department to request a visit before applying for the advertised position. When I knocked on the laboratory door and introduced myself, the team seemed taken aback. A few months, after I settled into the job, one of the team told me that based on the conversation we had on the phone, he was expecting a wee Scottish lass to turn up and in I bounced with a big smile looking like Rustie Lee.

I have been at the University of Nottingham for 20 years now. Initially I was working in flow cytology and tissue culture. However, within a few months of working with the group, they moved to Edinburgh. I decided not to go with them. Instead, I worked as a floating technician, mainly helping academics to set up new laboratories. Unfortunately, I went through some very difficult personal issues and had to take a lot of time off. The technical manager at the time was very supportive and when I came back to work, I requested to work in the electron microscopy and histology labs. At first, management were reluctant, but as I had spent my spare time supporting and bonding with the team in the histology lab, coupled with the fact that they enjoyed working with me, they finally agreed.

I have been promoted over the years and currently, I am contented. I have a good job working in the School of Life Sciences, Advanced Microscopy Unit and I am also on secondment two days a week in the Nanoscale and Microscale Research Centre. This affords me the opportunity of working autonomously, as well as in a team. As a part of my role, I take part in outreach programmes, along with my team members in primary and Secondary schools to encourage children, particularly those from black and ethnic minority background, into science. Here at the university, I am on the committee for the Technical Working Group, a member of the Black and Minority Ethnic group and recently registered on the Disability group, so as you can see, I am fully embracing Equality and Diversity. Earlier this year, I was asked to join the committee for Equality and Diversity at the Institute of Science and Technology, which I am very pleased about. I hope to use my position on these committees to challenge and bring about positive change which will benefit many. I feel supported and respected in my role and I believe that my life experiences have been instrumental in shaping my positive attitude about life. I can't speak for everyone else, but I must confess that I feel honoured to wake up daily knowing I am going to a job I thoroughly enjoy.

Author
Denise is a Senior Research Technician specialising in electron microscopy and histology at the University of Nottingham.

As part of a series of articles about technician's experience of equality and diversity – Liaque tells us about his personal experiences.

As a second generation British Pakistani from West Yorkshire I have experienced my fair share of type-casting; although yes, cricket is in my blood. From my early days as a school boy and being told by my careers teacher to find a local factory job, to standing in a queue with the family and being told, "Brexit will see to the likes of them", it has been dispiriting at times. At the same time, there are those that support—and see the benefits of supporting—every employee equally. It is thanks to those people I have had the opportunity to manage two laboratories and support and train countless students, locally and from all over the world, in a range of techniques. On top of this I have been co-author on more than twenty publications; supported several successful grant applications; invented a novel device for measuring migrations of cells in culture and won East Midlands funds to develop the device; and have a patent pending on a novel device for helping reduce spread of infections. Had I allowed the views of the few to influence my career decisions I would have never contributed so much.

I started as a volunteer junior technician 1994. I had left college with a Science BTEC National Diploma - equivalent to A levels but involving more practical work, which I enjoyed. After months of unemployment and back and forth from job centre I was offered a work experience post at the University of Nottingham. I felt so privileged to get the post and was really excited that I was going to have the opportunity to do scientific research! I worked with the nicest man I have met in my science career, Prof. David Kendall. I made every effort to impress everyone and enjoy what I did, which seemed to pay off.

I completed my bachelors part-time while working as a technician and had started a PhD but had to give that up for the possibility of a permanent technician position. I was then given the responsibility of managing the School of Biomedical Science Cell Culture Facility and Protein detection. This role has lasted for over 15 years and during that time I have met tremendous people from all over the world and had the opportunity to do research ranging from isolating cells and proteins from osteoarthritic patients to developing devices that measure the microscopic movement of cells.

I would be lying if I said it does not disturb me sometimes that I have not made it to a senior post and have remained at the top of my current pay grade. However, I just think about how much I have enjoyed finding answers to so many scientific curiosities – it really makes it all worthwhile.

While my story has ended up positively I have seen from friends and family that it is not the case for everyone. We live in a world of the internet and easy communication where, to anyone who looks, is it is very apparent that we all need one another equally to survive as humans. Yet, we still have to monitor and regulate the fair treatment of staff across gender, age, ethnicity, religious belief, sexual orientation, and myriad other human characteristics. We have made progress towards a more equal society but not yet in some of these basic concepts and this often concerns me.

There are many influences on this slow progress such as media portrayal, upbringing, and our social circles. I think we are all, to different degrees, affected by these and I think everyone has the right to draw opinions from all these sources. However, we have to choose between right and wrong. This can be a blurry line and hence I believe it is essential that the different treatment of people is carefully monitored. In most circumstances, the person with the power is probably unaware of their actions and the impact they are having. These are the circumstances that can be most influenced and improved upon with proper training and monitoring of decisions. Regular monitoring, highlighting of irregularities within institutions, and making impacting and lasting changes, can change the balance to the better.

I think one way we can encourage change is by setting up local committees within organisations, such as universities, and then allow those smaller committees to monitor equality and diversity. I, myself, am a member of the Equality, Diversity and Inclusion (EDI) committee for life sciences and we have just received the silver Athena SWAN award for life sciences. Awards like Athena SWAN provide regular reminders of the obvious disadvantages to institutes when they select or promote staff for reasons other than their abilities. Overall, having more active advertisement and promotion of equal opportunities throughout institutions will make people more aware of their actions and the consequences of those actions.

Author
Liaque manages the School of Biomedical Science Cell Culture Facility and Protein detection in the Faculty of Medicine & Health Sciences at the University of Nottingham.

Roger Dainty remembered

Ken Bromfield MBE, Chartered FCIPD, FIScT

Roger Dainty MBE, FIScT, 1946-2017

The citation for Roger's MBE (in the New Year Honours 2012) reads: "Roger James Dainty. Chief Technician, Biochemistry Department, University of Nottingham. For services to Scientific Research and Training". The recommendation leading up to the award states, "We are looking for people with exemplary service, which may be paid or unpaid, who have changed things, with an emphasis on practical achievement; have demonstrated innovation and entrepreneurship; are examples of the best sustained and selfless voluntary service or have delivered in a way that has brought distinction to UK life." This is the backdrop to this valedictory.

At first glance, his rise from Junior Technician, in Toxicology at the University of Birmingham (1962-1964) to Business & Technical Resources Manager at the University Nottingham Medical School (1997-2006) seems a fairly typical progress for someone reaching the peak of the "technician" profession. So what was it about Roger that made him an outstanding (exemplary) man both professionally and personally?

There as an adage flying around social media and national science publications; "Technicians make it happen". By 2006 Roger had accumulated a huge portfolio of technical skills and knowledge derived from his practical and organisational experience throughout four decades of CPD. A Stem Cell Bank company, Future Health Technologies was in the process of setting up its operation a stone's throw away from Nottingham University. So Roger was head-hunted to make this science and technology company "Happen". He became its UK Managing Director. This was a huge technical and logistical assignment that exploited to the full his technical prowess. Roger led Future Health in achieving the Queens Award for Enterprise in 2010. It is in this respect, that Roger is a national role model. By relentless attention to his own training and skills development, he not only made it happen in the lab world, he also made it happen for himself and his family. This must serve as a powerful motivational source for technicians everywhere. What is more, this sort of application of skills is exactly what our country needs-an issue close to Roger's heart-and thus he was a worthy recipient of the IST Fellowship.

Roger's commitment went way beyond "paid" employment. He was lead applicant for the European Social Fund Technician Training Fund for the University of Nottingham, a Justice of the Peace (JP) on the East Derbyshire Bench, Chairman of Ways and Means and Community Service for the Beeston & District Round Table, Chairman of the Gotham Branch of Save The Children Charity Fund; I could go on.

I particularly remember his pivotal role in setting up and sustaining the National Association of resource managers from university Biochemistry and Biology departments (NABBS). He was its long term chair, providing the momentum that sustained it for 35 years until it merged with UBMA.

It is in the context of NABBS that I best recall Roger as a personality, his wonderful talent as a communicator, the life and soul of everyone around him, wise, kind and very witty. Our meeting were a joy thanks to him. Whilst we shall grieve over his passing my enduring memory will be Roger, nigh on asphyxiated with laughter, reading out an MBE progress report to the NABBS conference at Cambridge University; in so doing overwhelming the rest of us in helpless hilarity. This indeed is an abiding precious gift.

So, as his MBE recommendation demanded, we have Roger Dainty, "A man with exemplary professional and voluntary service, who changed things, with an emphasis on practical achievement; having demonstrated innovation and entrepreneurship; and delivered them in a way that brought distinction to UK life." Throughout all of this he brought us fun and laughter and for which we shall ever remember him.

Technicians: the oracles of the laboratory?

Andy Connelly

Lab Technicians lead the way

"What's your record for consecutive questions asked?" – John Candy, Uncle Buck

As a technician, I often feel like I am being bombarded with questions: questions about the location of things, questions of safety, and questions of cost. Some questions test my knowledge of the laboratory and of science, others test my patience. Working in a university means that this time of year is particularly full of questions as we welcome a lot of new laboratory users. This can make me feel like an ancient Greek oracle, constantly being consulted for my opinion. An oracle who sits in an office, not in a cave, and who wears a lab coat instead of flowing robes. Shame really.

"Dude, where's my car?" – Dude, where's my car?

The question I am most frequently asked is, "Andy, where is X?" To which the answer is usually, "Right in front of you." As a technician, I generally get to choose where things get placed, even if it is generally not me paying for them. In some ways this is ideal: academic colleagues generate the income and give me the opportunity to make the best use of the available space. However, it does also mean that I'm responsible for answering that constant flow of 'where' questions.

Costello: Well, all I'm trying to find out is what's the guy's name on first base?
Abbott: Oh, no, no. What is on second base.
Costello: I'm not asking you who's on second.
Abbott: Who's on first! – Abbott and Costello

While "where" questions can be oddly satisfying, as they help users get on with their work, other questions can be trickier. These come in a range of forms: "When will it be finished?", "How much will it cost", and "Can you fix it?" Apart from the last question, to which the answer is obviously "Yes, we can!"*, I do not always have the answers straight away. The great thing about my role is that I get the freedom to find the answers.

I really enjoy this process, especially when the answer is not immediately obvious, or if it relies on information that cannot easily be Googled. Questions like: "What type of filter paper should I use for this?"[1], "Which pH probe should I be using", or "How do I clean this?" Sometimes these can be answered through experience, "Well, we usually use X." but this is not always good enough. At this point it is my relationship with suppliers, manufacturers, and other technicians that comes to my rescue. A quiet phone call to the right person and I can be the perfect oracle, mysteriously all knowing.

"What is the airspeed velocity of an unladen swallow?" – Bridgekeeper (Terry Gilliam), Monty Python and the Holy Grail

When finding an answer requires more than a simple phone call then some more formal professional development might be needed. As a member of the Institute of Science & Technology (IST) I have started down the road of professional registration and am current applying for RSci. This process has already identified a few areas where some extra training would be useful for me. In this way, I'm hoping to get the training in before the questions arrive. I've also found that the IST's annual conference has helped me find lots of great contacts.

Unfortunately, even with all these resources, there are still questions I cannot answer. This might be because I lack the time, training, or contacts to search out the answers. In these circumstances, it is tempting to answer like a true oracle: impenetrably. One story from ancient Greece goes that when King Croesus of Lydia asked an oracle whether he should go to war on his neighbouring kingdom, the oracle replied that if he went to war, a great kingdom would fall. He thought she meant the other kingdom, but unfortunately for him, it turned out to be his own. Of course, in ancient Greece any inconsistencies between prophecies and events were dismissed as failure to correctly interpret the responses, not an error of the oracle. If only this was true in my laboratory…

"What's in the box?" – Mills (Brad Pitt), Se7en

There are also questions I shouldn't answer. These are often questions that should really have been asked

of a laboratory user's academic supervisor, not a technician. Some of these questions seem to come my way because users are too embarrassed to ask their academic supervisors in case they look stupid. Other questions come to me because the user doesn't quite appreciate the complexity of what they are asking.

Two questions that fit into the last category are: "Which method should I use for my samples?" and "What PPE do I need?" These types of questions have a limited set of answers, for example, "Which (of the two methods) should I use?" The obvious answer to such questions can easily be wrong, as the best answer might actually require deep background knowledge of the project which the laboratory user may, or may not, have.

Apparently, these are known as "argument why-questions" and they are exactly the kind of questions true oracles were asked, and even they sometimes found it better to deflect or avoid such questions. The oracles of ancient Greece would avoid answering such questions by being 'indisposed', so leaving it to the priests to respond by tossing coloured bones. I avoid answering questions by sending the laboratory user back to their academic supervisor; who can then choose to throw them a bone... or not.

"Why so serious?" – The Joker (Heath Ledger), The Dark Knight

The other great thing about being a true oracle was that you never had to explain your wisdom - you never had to answer the "why" question. Unlike other types of questions, "why" questions can be uniquely tricky. Why questions have an almost infinite set of possible answers, not only that but, as any parent of a young child will know, "why" questions can be stacked: Why? Why? Why? Once you start answering "why" questions, especially in research, you can end up down a very deep rabbit hole of knowledge and obscurity: a dangerous place to be.

"Why" questions can also express different levels of meaning. At the lowest level, "why" questions look for the purpose behind an action, for example, "Why am I pipetting this solution?" This type of "why" question doesn't feature so much in my life as a technician as the purpose of most actions is clear – to prepare the sample for analysis, and so on. The next level up and "why" questions are looking for a *reason*: "Why am I using this method?" or "Why is there more iron in sample A than sample B?" I often find that these questions require more background knowledge about the project. Sometimes I have this information; other times I try to avoid answering this type of "why" question, usually by becoming mysteriously indisposed.

The highest level of "why" question is a motivation question, for example, "Why am I here!?" It is a question I rarely feel qualified to answer, scientifically or psychologically. Luckily for me, it is generally academic supervisors have command of the motivation "why" question, having usually originated the "why" question in the first place. I suggest to the questioner that they are the best person to talk to.

"You expect me to talk?"
"No, Mr. Bond, I expect you to die." – James Bond and Auric Goldfinger, Goldfinger

Of course, in research there is rarely a "true" answer to any question but hopefully we can find the 'best' answer through teamwork: technicians, laboratory users, academics, manufacturers, and suppliers working together. It certainly seems a better approach than the Delphic oracle took. Archaeological evidence suggests that her visions came from the influence of the gas ethylene. I'm not sure health and safety would allow this anymore.

Teamwork may be important in general terms but, within my laboratory, I am definitely the oracle—or at least the first port of call for the anxious—no ethylene required. That said, if you come knocking on my door with questions at lunchtime, the only answer you are likely to receive is:

"You talkin' to me?" – Travis Bickle (Robert De Niro), Taxi Driver

Acknowledgements

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**Disclaimer (to any of my lab users), this statement does not guarantee that I can actually "fix it". At least not straight away. Sorry.*

This article first appeared in the GE Healthcare Life Sciences web pages in their section -*Lab Filtration Blogs, Knowledge and practical advice to advance your laboratory filtration*
www.gelifesciences.com/solutions/lab-filtration/blogs/Technicians-the-oracles-of-the-laboratory
www.gelifesciences.com/solutions/lab-filtration

Author

Andy Connelly is a technician and laboratory manager in the School of Earth and Environment at the University of Leeds. Alongside his day jobs, Andy has been writing and publishing both academic papers and popular science articles since 2007. His articles have appeared in *Physics World, Physics and Chemistry Review*, and on Guardian.co.uk. More recently, he has focused on practical science for his blog (andyjconnelly.wordpress.com) and writing about technicians, recent, historical, and fictitious.

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Working in a place like nowhere else on earth: CERN, where technicians and engineers work side by side for the advancement of fundamental physics research

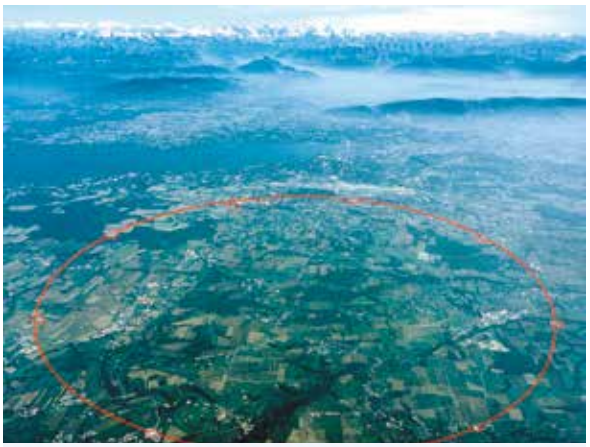
Anna Cook

Photo credit: © 2014-2018 CERN

When you think of CERN, what comes to mind? Is it the Large Hadron Collider or the Higgs Boson's discovery in 2012? Is it the amazing scientific endeavour bringing together physicists and engineers from all over the world to work towards the common goal or probing the fundamental structure of the universe? Or is it just how important technicians are for this incredible scientific endeavour?

CERN, the European Organisation for Nuclear Research, is one of the largest scientific experiments in the world. Unravelling the mysteries of the universe is a big task and requires many experts: talented individuals who come to CERN to test themselves, to push their abilities, and help create history with ground-breaking discoveries. But this is not just about physics. The engineering and technical skills needed to make the experiments succeed are as world-class as the science behind them. If you want to help answer the world's toughest questions, this is the place to do it.

Sitting astride the Franco-Swiss border and funded by 22 Member States, it is where the world's largest and most complex scientific instruments are used to study the basic constituents of matter – the fundamental particles. These particles are made to collide together at close to the speed of light and the results give physicists clues about how the particles interact as well as providing insight into the fundamental laws of nature.



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Technicians at CERN

And where do technicians fit into this picture? The answer is in every corner of the organisation as engineers and technicians are vital to CERN's activities. They're building some of the most advanced machines in the world to push the boundaries of experimental physics.

Photo credit: © 2014-2018 CERN

The instruments used at CERN are purpose-built particle accelerators and detectors. Accelerators boost beams of particles to high energies before the beams are made to collide with each other or with stationary targets. Detectors observe and record the results of these collisions. The physics programme at CERN presents engineers and technicians with varied challenges at the forefront of technology, from the atomic scale to the colossal. Engineers build and test the machines and systems that physicists rely on and technicians keep these systems running smoothly, performing repairs and upgrades where necessary.

David Francis, who is responsible for the trigger and data acquisition systems of the ATLAS experiment at CERN, sums it up in a short sentence, "I have great respect for the contribution of technicians to experimental physics. You could say they are the unsung heroes of our field."

Building a particle accelerator requires digging tunnels and installing large infrastructure projects so civil engineering is vital. Other engineers and technicians assemble components such as: radiofrequency cavities which must be crafted to just the right shape and size to boost particles along accelerators; thousands of huge, custom-built electromagnets focus particle beams and guide them around bends in circular accelerators; and the world's largest cryogenic system cools magnets on the Large Hadron Collider (LHC) to close to absolute zero so that the wires supplying their electricity can work in a superconducting state without losing energy to resistance.

Detectors present other engineering challenges. Their components and subsystems are designed, built, and tested separately before they are joined together to work in harmony. Kilometres of wiring and thousands of electrical components make particle detectors a complex feat of engineering.

CERN hires technicians to work in all domains ranging from electronics to computing, electricity, mechanics, IT, vacuum, cooling and ventilation, safety, radioprotection, survey engineering, process operation, and many more. The organisation relies on this expertise so the Technician Training Experience programme (TTE) is aimed at technicians who are looking to get a first great professional experience to further their career. Alternatively, some take it before they embark on advanced study programmes.

Jamie is one of the technicians who took advantage of this scheme to come to CERN and gain invaluable experience. "I didn't think there was any chance that at 22 I'd be moving to Geneva to work on the very experiment I'd had hung on my wall for four years," he said. "I always wanted to work on big machines for science, but I didn't think I would be working on the largest machine on the planet so soon!"

Jamie, technician at CERN in front of the ATLAS detector

Zoe works at CERN as a junior fellow, assigned to the project of the FCC (Future Circular collider). The FCC is a new 100km, 16 Tesla collider which would be a worldwide collaboration project. "My role is the research into the feasibility of fitting the new dipole magnets into the original LHC tunnel; an intermediate solution," she said. "The idea is similar to the game played by babies of fitting the correct block into the correct hole, where the dipole is a square and the tunnel is the circular hole. It's a project of many

iterations and a balancing act of magnets, structures and cryostats."

Zoe, engineer at CERN in front of the ATLAS detector

Ashley, mechanical technician at CERN

Ashley, a mechanical technician also from the UK, came to CERN following an apprenticeship with STFC during which time he gained experience in France at the Institut Laue Langevin (ILL) and European Synchrotron Radiation Facility (ESRF). "These were great opportunities for me because I was able to work with people from all over the world and compare work methods and cultures," he said. "At the end of my apprenticeship I knew that I wanted to continue pushing myself and gain valuable work experience. I was thrilled to hear about the Technician Training Experience (TTE) scheme and the opportunity to work in an environment that challenges me and tests my existing knowledge and skills."

These are but three shining examples of technicians and engineers who took the step to experience a unique workplace, a unique work setting, context and culture. Over 100 nationalities work side by side at CERN, providing for an incredible environment in which to grow, learn, and challenge oneself. It can be summarised in these few words: challenge, integrity, purpose, imagination, collaboration, and quality of life.

And the motto is?
Take part!

Author
Anna Cook is the Deputy Head of Talent Acquisition, CERN HR Department.

For more information, see **http://home.cern** and **http://careers.cern**.

Management of errors in a clinical laboratory

Raffaele Conte

Abstract

Clinical laboratories focus their attention on quality control methods. However, such quality control cannot be assured by merely focusing on analytical aspects as both pre-analytical and post-analytical phases must be considered as well. This article analyses the causes of errors occurring in clinical laboratories by evaluating literature data and statistics from the "AMES" poly-diagnostic centre in Naples.

Keywords: Pre-analytical errors; Analytical errors; Post-analytical errors; clinical laboratory

Introduction

Clinical laboratory practice has a leading role in the field of healthcare quality management and is one of the first areas to use quantitative statistical control methods. In particular, there are three phases of laboratory testing: pre-analytical, analytical and post-analytical. The pre-analytical phase is concerned with specimen collection, transport, and processing. The analytical phase relates to the testing of specimens while the post-analytical phase deals with the transmission, interpretation, follow-up, and retesting of the results.[1,2] However, most errors affecting laboratory tests occur in the pre-analytical phase.

Pre-analytical Error

Pre-analytical errors are inaccuracies that occur during the time of patient assessment, test order entry, request completion, patient identification, specimen collection, specimen transport, or specimen receipt in the laboratory. In fact, examples of common sources of pre-analytical error are ordering tests on the wrong patient or ordering the wrong test, misidentification of the patient, the choice of the inappropriate collection container, or the improper labelling of the containers. In literature, pre-analytical errors are estimated to be 31.6% to 75% of total errors.[3]

Many guidelines have been developed to assess these contributions to the total error. All these guidelines are based on the development of clear written procedures, the enhancing of health care professional training, the automatizing of function, the monitoring of quality indicators, and the improving of communication among health care professionals.[4,5,6]

Analytical Error

The analytical phase comprises all of the period from the preparation of patient's specimen for testing in the laboratory through to the interpretation and verification of the result from the laboratory operator. Test results in the analytical phase are affected by failure in properly processing a specimen prior to analysis or by the presence of substances interfering with assay performance. Other circumstances where errors can occur are in the analytical phase of laboratory testing and are due to faulty techniques, instrument breakdown, reagent contamination, and calibration drifts.[7] Methods to counteract analytical errors aim to verify the performance of the method and check the accuracy, precision, sensitivity, specificity, and linearity of the method.[8]

Post-analytical Error

Post-analytical errors are the inaccuracies that occur after the generation of the reports until the release to the patients. Usually, these are due to transcription errors, delivery to wrong patients, or misplacing of reports. This phase is very important in that the results are released to the clinicians who use them to make diagnostic and therapeutic decisions. These errors in the post-analytical phase affect the reputation of the whole laboratory testing process.[9]

Methodology

This study was carried out in the toxicology laboratory of AMES poly-diagnostic centre in Casalnuovo, Naples. This laboratory is well equipped with an automated liquid chromatography-mass analyser, a gas chromatography-mass analyser, high performance liquid chromatography, an inductively coupled plasma mass spectrometer, and an atomic absorption spectroscope with graphite furnace and flame modes. These instruments are operated by a team of three chemists. Data have been recorded from November 2016 to December 2017 studying the errors that occurred during pre-analytical, analytical and post-analytical phases of the testing process of 15,000 specimens. Patient blood samples were collected by trained nursing staff and transported by paramedical staff. The instrumentation was regularly calibrated and maintained on a daily and weekly schedule. All samples were stored at 4°C.

Results generated in the laboratory are manually entered into the report form, verified by faculty, and dispatched by the para-medical staff. This work analyses the errors occurred in this laboratory over a year and categorizes them in to pre-analytical, analytical and post-analytical errors. In this study we have classed:

- Pre-analytical errors as sample collection to entry of the sample in to the analyser
- Analytical error as error due to the defective instrument/ reagent
- Post-analytical errors as errors occurring between the generating of reports to the dispatch to the patients.

A log book of errors was maintained. Statistical analysis was done by using descriptive statistics.[10]

Results

The study highlighted the fact that the chances of errors occurring is less than 1% overall. The tables below breakdown the overall errors and expresses them as the percentage of errors in the pre-analytical phase (Table 1), the analytical phase (Table 2), the post-analytical phase (Table 3), and the summary (Table 4) of the errors found during the recorded period.

Cause of error	Percentage
Hemolyzed sample	50
Clotted sample	16
Insufficient sample	21
Lipemic sample	2
Incorrect identification	5
Illegible handwriting	4
Freezing of reagents	2

Table 1. Percentage of pre-analytical errors

Cause of error	Percentage
Reagent contamination	5
Probe error	5
Calibration drift	10
Blocked tubing	40
Machine shutdown because of voltage flux	20
Systemic error (e.g. lamp)	20

Table 2. Percentage of analytical errors

Cause of error	Percentage
Transcription error	5
Prolonged turnaround time	5

Table 3. Percentage of post-analytical errors

Cause of error	Percentage
Pre-analytical	55
Analytical	35
Post-analytical	5

Table 4. Total percentage distribution of errors

Discussion

As shown in Table 4, the AMES poly-diagnostic centre confirms the trend discussed previously in that most errors derive from the pre-analytical phase. In particular, pre-analytical errors accounted for 55% of total errors, analytical errors accounted for the 35% and post-analytical contributed to 5% to the total errors. Specifically, below are singularly analysed the main causes of errors:

- Hemolysis of the specimen: This was a major pre-analytical error in the AMES laboratory. Hemolysis occurred due to vigorous withdrawal of blood through a needle, or because of the forcing of blood in the tube. Corrective actions regarded the use of proper phlebotomy techniques and the training of the nurses in phlebotomy. Moreover, it is important that laboratory personnel ask for new samples when hemolysis is detected.[11]
- Clotting of the sample: this was another common pre-analytical error. This occurred mainly due to improper mixing of blood with the anticoagulant. Such error was corrected with effective training of personnel.[12]
- Insufficient sample: this was the second cause of pre-analytical error in the AMES poly-diagnostic centre. Such error was provoked by the fact that some tests needed repetition to confirm certain disease conditions or because of wastage of specimen. Moreover, the same samples might be analysed in different departments of the centre (e.g. clinical chemistry or genetics) and technicians of other specialties might be unaware of the volume required. Such problems were simply resolved by improving communication among health care professionals.[6,13,14]
- Identification: problems in sample identification were due to negligence of the sample handlers. Computerization and bar-coding solved this issue.[12]

The analytical errors were mainly due to problems in maintenance of instruments. For example, blocked tubing in the automated liquid chromatography-mass analyser and in the high performance liquid chromatography instrument represented almost half of the whole analytical errors and systemic problems (e.g. lamp error) were another important factor. Other analytical errors were provoked by an electrical supply problem that, unfortunately, affected all instruments in the laboratory. In fact, voltage fluctuation led to the

shutdown of the instruments with a consequent loss of the set sequence of analysis. This problem has since been addressed by providing an uninterrupted power supply.

Post-analytical errors were mainly due to transcription errors because of manual entry of report forms. The installation of management software for the automatic acquisition of data from the analytical instrument has solved this problem.

Conclusion

This study assessed the main errors in the results obtained by the AMES poly-diagnostic centre over the period of one year. The aim was to minimize inaccuracies in the results produced by the laboratory. From the results we believe that the errors can be reduced by training the laboratory personnel phlebotomy techniques, storage, transport of specimen, and instrument handling. Moreover, computerization of the entire process should minimize post-analytical errors in particular. The centre plans to implement the recommendation of these findings and will continue to monitor the laboratory's output to see if improvement is made.

Author

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Dicon Nance: a technician in form

Andy Connelly

The image of the genius artist working alone in their studio is as pervasive as that of the solo scientist, and as improbable in reality. Artists, especially those who create on a huge scale, employ assistants—technical people with skills vital to the production of their art. Technical people like the craftsman Dicon Nance. Dicon worked as an assistant to Barbara Hepworth at her Cornish Trewyn studio from 1959-1971. The world-renowned sculptor Hepworth had set-up her St. Ives studio in 1949 and soon found that her ambition and the scale of her artistic vision required her to employ assistants. These assistants, Dicon included, have largely been written out of the history books, despite playing a vital part in the production of key Hepworth pieces.

Richard William "Dicon" Nance was born in Nancledra, midway between Penzance and St Ives, in 1909. He was exposed to art and crafts from an early age by his father, the painter and Cornish language revivalist Robert Morton Nance. Dicon and his young sister were home-schooled by Arthur Raleigh-Radford, a flamboyant bohemian, after Dicon's parents were horrified by the effect of boarding school on Dicon's older brother, Richard (Robin). His parents reportedly regarded Dicon as "not an intellectual"[1]. Such dismissive attitudes, and the isolation of home-schooling, may have been responsible for Dicon's reportedly painfully shy and self-effacing nature.

Dicon seems to have taken naturally to working with his hands; as teenagers, Dicon and a friend built a working scale model of a traction engine called The Cripplesease (see below). In his early twenties, he worked as a general maintenance man for Bernard Leach, who is often regarded as the "father of British studio pottery".[2] This was Dicon's first taste of the inter-war 'artist craftsman'. These upper-middle class, financially secure enthusiasts often had little practical knowledge and relied on low-waged traditional craftsmen for (often unacknowledged) technical support.

Dicon became frustrated with what he saw as Leach's sloppiness, the unnecessarily ruined pots, and inefficiency which bore little in common with the true local craftsmen of his youth. Such inefficiencies drove Dicon to invent various machines, including an innovative take on the traditional potter's wheel. Even the arch-traditionalist Leach abandoned his traditional Japanese wheel in favour of Dicon's improved version, and the "Leach wheel" became world famous. Dicon received little or no recognition for this and certainly no financial reward. His time working in Leach's studio left him with the feeling that "Leach was an artist and I was not."[1]

The grown-up Dicon (right) looking at this childhood creation with Michael Leach (left). (http://www.artcornwall.org/features/nance_belgraveweb214.jpg)

At the outbreak of the Second World War, Dicon declared himself a conscientious objector and spent the first part of the war collecting seaweed from inaccessible Cornish coves for use as agricultural fertiliser. He invented elaborate aerial ropeways and hoists to access the coves, despite no formal training in engineering. In 1942, he was invited to travel to Ghana to join one of Leach's former apprentices, the artist craftsman Michael Cardew, in setting up a pottery to supply the needs of British West Africa. Unfortunately Cardew, like Leach, was not a practical man. His high-minded ambivalence towards machines and mechanisation meant that Dicon found him a "very difficult man to help"[1]. The combination of Cardew's romantic ideals, paternalistic attitude, and a lack of local resources resulted in the failure of the pottery and in Dicon returning to the UK in 1945.

In 1946 his brother Robin returned from his time in the Army. Together they reopened Robin's pre-war cabinet-making workshop on the quayside at St Ives with the aim of producing affordable handmade furniture. From this workshop sprang elegant modernist furniture, along with pottery wheels for the Leach pottery, picture frames, and bases for the newly-arrived Hepworth's sculptures. Dicon designed and built a morticing machine which could produce large quantities of identical and accurate components for their popular ladder-back chairs.

In his spare time, Dicon attended evening classes in carving held by Barbara Hepworth's assistant, Denis Mitchell, and started producing small wooden sculptures. In 1959 Dicon joined Hepworth at her Trewyn studio. Dicon was 50 years old and Hepworth 56, with a large scale artistic vision and more work than she could complete alone. He joined Mitchell and Terry Frost, both of whom later became famous artists in their own right, in helping her realise that vision.

Barbara Hepworth and two assistants (Dicon Nance above, Norman Stocker below) working on "Winged Figure" 1962. (https://barbarahepworth.org.uk/commissions/list/winged-figure.html)

Hepworth drove herself and her assistants hard, expecting them to work the same long hours she did. Despite this she was keen to keep the illusion of the solo artist. Anthony Frost, Terry Frost's son, tells an anecdote of the time: "When journalists or photographers came round, she didn't want them to see that she had these people working away on her sculptures. So, she would shut the workers in the greenhouse, where they had their morning breaks. Then Barbara would start polishing the sculpture, as if she'd been at it all day. One time my father was bursting for a pee, but she wouldn't let them out, and the only thing he could find was a pot with a geranium with very dry earth in it – but the pee went straight through and trickled across the greenhouse floor, and out under the door, between the legs of the visitors. Barbara banned him from having biscuits for the rest of the week."[3]

The assistant's role was a highly technical one. Dicon used his skills as a craftsman to produce sculptures under Hepworth's supervision. He describes working on the piece Forms of Movement: "Like all Barbara's versions ... there was no attempt at making a replica with all the attendant measurements. Each form, though basically as the original, was judged on its own, especially if there was a change in scale."[4] These working conditions must have been inspirational but difficult for Dicon. He was a perfectionist who kept himself, and others, to high technical standards. This meant that the apparent sloppiness or inefficiencies of sculptors and potters were difficult for him to accept.

Dicon's position as craftsman created boundaries between himself and the artists with whom he so often worked. These boundaries where partly class-based but there were also pervasive status boundaries.

This is seen in the actions of the Penwith Society of Arts. When the Society was founded in 1949 it was initially a progressive, forward looking society for artists and craftsmen - Dicon was a founder member. However, the artist Ben Nicholson, with Hepworth's support, insisted the membership be split into three groups. Group 1 comprised "advanced artists", Group 2 "traditional painters"', and Group 3 the "craftsmen". This hierarchy put craftsmen at the bottom and branded them as somehow less than the artists. This created bad feeling in both directions. Dicon's brother, the cabinet-maker, wrote at the time, "Craftsmanship should be put on an equal footing with Art. [...] I do not mean by this that I would like to see our workshops invaded by long-bearded and woolly-minded aesthetes"[5].

After a difficult time working with Leach and Cardew, Dicon's years with Hepworth led to his final disillusionment with the art world. Dicon questioned the validity of the artist's role, particularly when the physical execution of Hepworth's designs fell exclusively on the shoulders of craftsmen such as himself. Some pieces were even completed from only the simplest sketches, and were despatched in Hepworth's absence.

Little has been written about Dicon's life after leaving Trewyn. We know that he died in 2002 having, without formal training, mastered a huge range of disciplines: engineering, carving, throwing, wood turning, and chair-making. He was almost invisible to those who did not know him and received virtually no credit for his many achievements. He was a perfectionist, a true master craftsman. According to Dicon's son, Johnny, he displayed a naive quality of honouring originality above all else: "you wouldn't find him anywhere near a bandwagon, let alone jumping on one. He taught me that there is virtue in being a perfectionist."[5]

Author

Andy Connelly is a technician and laboratory manager in the School of Earth and Environment at the University of Leeds. Alongside his day jobs, Andy has been writing and publishing both academic papers and popular science articles since 2007. His articles have appeared in Physics World, *Physics and Chemistry Review*, and on Guardian.co.uk. More recently, he has focused on practical science for his blog (andyjconnelly.wordpress.com) and writing about technicians, recent, historical, and fictitious.

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We are working hard to ensure that we provide our members with the best service that we can, and one of the areas that we have updated is our communications. There are now a number of ways in which we can stay in contact and provide information for our members.

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John-Paul Ashton MIScT, RSci IST Social Media Engagement Advisor

Making and using monoclonal antibody probes to elucidate the structure of plant cell walls

Sue Marcus

Antibodies, also known as immunoglobulins are Y shaped proteins that are produced by the immune system and combine chemically with substances that the body recognises as alien such as bacteria, viruses and foreign substances in the blood. This immune response is made use of when you receive vaccinations against certain diseases. The immune response can be used in research to produce antibodies that are specific for a particular protein or polysaccharide. For an antibody to be useful for treating diseases or for use in diagnostic kits, they need to be specific and we need to be able to grow large amounts of them. That is why we make monoclonal antibodies.

My role as a research laboratory technician, apart from being responsible for the day to day smooth running of the laboratory, is to produce monoclonal antibodies that are useful for our research. I help to characterise the antibodies and maintain stocks of antibodies and cell lines that produce the antibodies. I also maintain my own tissue culture facility where the antibodies are made and grown.

The technology to make monoclonal antibodies has been around for more than 40 years but monoclonal antibodies are still a very important tool for both research and treatment of diseases. One of the first important discoveries was the development of lymphocyte fusion for the production of monoclonal antibodies by Kohler and Milstein in 1975[1]. Previously, anti-sera or polyclonal antibodies had been produced in the serum of animals but a good antibody could only be produced during the lifespan of the animal. The serum from the animal also contained other antibodies some of which may have similar but not identical specificities to the antibody of choice. By combining B-lymphocyte cells from the spleen and myeloma cells-a cancer cell line which can divide continuously, it is possible to produce hybridomas-a hybrid cell of the two cell types which secretes a specific antibody and can divide continuously.

In the Paul Knox Cell Wall Laboratory at the Centre for Plant Sciences at the University of Leeds, we have been producing monoclonal antibodies since 1993 in order to study the structure and function of plant cell walls in different species of plants.

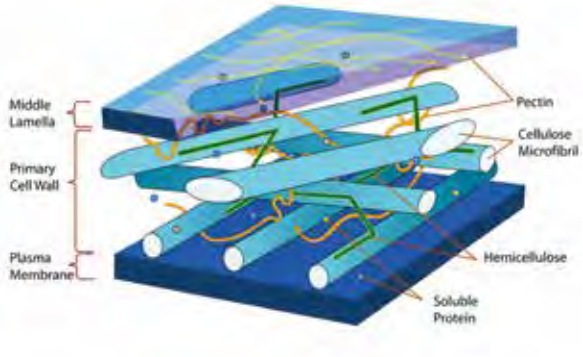
Plant cells are different from animal cells in many ways but one of the main differences is that they possess cell walls. Land animals can only grow larger by possessing a skeleton. The cell walls surrounding every cell in the plant gives the plants the strength to grow very tall and be able to stay upright. Giant Redwood trees that grow in California can reach heights of over 100 metres and this is only possible because they have strong cell walls.

Cellulose and pectins from cell walls have great commercial importance. Cellulose is used to make clothing, biofuels, paper and packaging amongst other things. Pectins are extensively used in the food industry as a gelling agent for jams and jellies. This is one of the reasons that there is a lot of research on the structure of cell walls. For instance, during the ripening of a fruit, the cell walls of the fruit will change their composition to become softer and juicier and nicer to eat. The firmness of the texture is due to the composition of the cell walls. Using monoclonal antibodies is one of the methods that we can use to study these changes either by looking at sections of these fruits under the microscope or by quantifying the amounts of different polysaccharides present in cell wall preparations.

Structure of cell walls

Plant cell walls are complex structures made up of cellulose microfibrils linked together via hemicellulosic tethers to form a network that is embedded in the pectin matrix. Hemicelluloses include xylans, glucuronoxylan, arabinoxylan, glucomannan and xyloglucan. Pectins include rhamnogalacturonan, galactan, arabinan and homogalacturonan. The many polysaccharides-large molecules made up of chains of single sugar molecules – have very different functions

in the cell wall and by studying their distribution, we can learn more about their functions. There has been much work by research groups all around the world to try and find out more about plant cell walls and their composition which varies between different species and even in different parts of the plant



Courtesy of Wikipedia

Why monoclonal antibodies?

Monoclonal antibodies specifically target a particular part of a molecule be it a protein or, in our case this will be an oligosaccharide- a small chain of sugar molecules, and are very sensitive. They are highly versatile and can be used in a range of applications. They can detect very small amounts of antigen. Once you have made and characterised a monoclonal antibody cell line you can prepare a lot of antibody and then keep the cell line frozen until it is required to grow more.

Making a monoclonal antibody

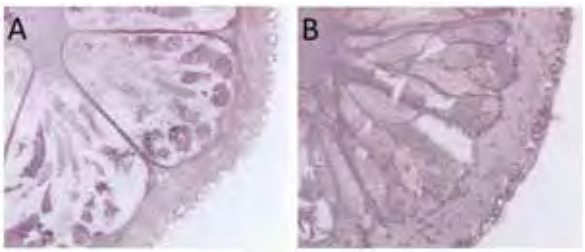
Monoclonal antibodies are mostly made in rodents particularly in mice. In our group we use rats which are very efficient in terms of hybridoma production. The animals, usually two or three, are immunised at intervals with the antigen of choice. In our case it could be a small linked chain of sugar residues coupled to protein, an isolated polysaccharide, or a crude extract from a plant cell wall preparation. The animals are tested for signs of antibody production in their serum and when a good response is observed, the spleen is removed from the animal. The spleen is then gently homogenised and mixed with myeloma cells from the same species that are deficient in an enzyme hypoxanthine-guanine phosphoribosyl transferase (HGRPT) and do not secrete antibodies. This is important for selection purposes. The cells are mixed together in the presence of polyethylene glycol to fuse the cell membranes together to make hybridomas. This procedure is explained in more detail elsewhere.[2]

After the cells have been fused, they are plated out on feeder cells; these are usually epithelial cells in tissue culture treated 96-well plates. The next day they are put into selective medium which will kill all myeloma cells and any myeloma cells fused with each other. Unfused spleen cells, and those fused with each other, will also die after a couple of weeks. Only spleen-myeloma fused cells will survive the selective medium and continue to divide-the spleen providing the HGRPT enzyme and the myeloma cell the capacity to divide indefinitely. The supernatants from the cells can be tested using ELISA (Enzyme Linked ImmunoSorbent Assay) to see if they contain any specific antibodies to the antigen. The principle of an ELISA assay is that antigens from the sample are attached to a surface. Then, a specific antibody is applied over the surface so it can bind to the antigen. This antibody is linked to an enzyme, and, in the final step, a substance containing the enzyme's substrate is added. The subsequent reaction produces a detectable signal, most commonly a colour change in the substrate. The intensity of the colour reaction is read in a 96-well plate reader at the appropriate wavelength of light giving a quantitative result. Any useful cell lines are cultured further at low dilution and selected again to ensure that they are derived from a single cell and hence monoclonal. Throughout these procedures, supernatants are collected and the monoclonal antibody hybridoma cells frozen down until they are required again.

Using Monoclonal Antibodies

Monoclonal antibodies can be used in a variety of ways:

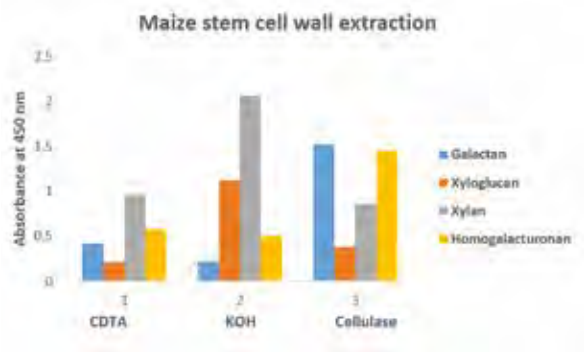
1. Citrus growers can use monoclonal antibodies to examine cell wall changes in their crop. For example they can compare tissue prints of lemons during development and ripening of the fruit and observe changes in what polysaccharides are present. The lemon is sliced and pressed onto nitrocellulose paper which will absorb both proteins and polysaccharides. The antibodies are added in a protein-phosphate buffered saline solution. A colour reaction is created by the use of a specific stain which reacts to the antibody.[3]



Tissue prints on nitrocellulose of cut surfaces of a lemon fruit. A: Galactan B: Arabinan

2. Cell wall polysaccharides in plant cell walls can be extracted and sequentially solubilised in different buffers. The dried plant material is finely ground

and extracted with solvents to remove all material apart from the cell wall residue. To this cell wall residue is added a cation chelator-this binds to calcium, (50mM CDTA) which will solubilise pectins, 4 M KOH which can solubilise hemicelluloses and an enzyme cellulase can be used to solubilise polysaccharides tightly bound to the cellulose backbone. These extracts can then be used to coat ELISA plates and quantitative results of the amounts and types of polysaccharides present in each fraction can be determined. This will vary greatly between plants species or even different plant organs.



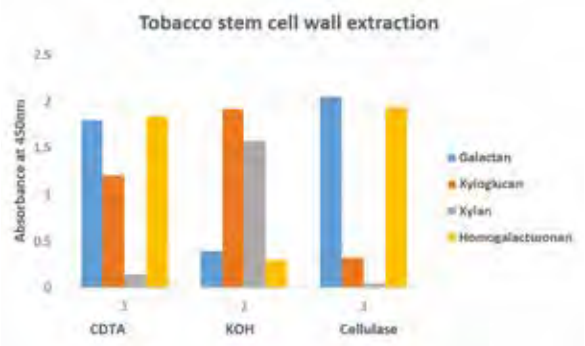
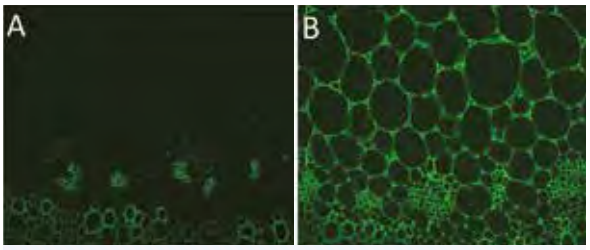


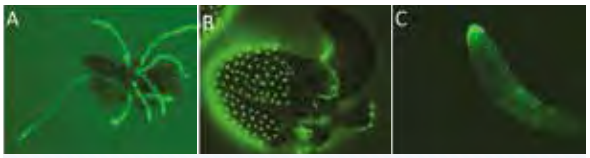
Fig.3. Cell wall extraction of maize and tobacco stem cell wall preparations and analysis with monoclonal antibodies to show quantitative differences between cell wall components

3. We can use the monoclonal antibodies on sections of plant material to look at the anatomical patterns of plants and how cell walls vary between different cell types. Sometimes binding of antibodies to certain polysaccharides can be masked by other polysaccharides and these need to be removed first by either enzyme digestion or chemical treatment Here fixed plant material has been embedded in wax and 10 micron sections cut which have been placed onto slides. A fluorescent dye which binds to the antibody has been added to visualise the antibody binding.[4]



Xyloglucan antibody labelling on tobacco stem sections
A: before pectin removal B: after pectin removal

4. We can also immunolabel small plants or parts of plants directly without sectioning to see what polysaccharides are found on the surface of the plants including seed coats, stems and roots. To carry this out, the plant material is fixed in formaldehyde solution to preserve the tissue. The tissues are incubated in the antibody solution and then washed and a second antibody that is coupled to a fluorescent dye is now added and the samples observed under a fluorescence microscope.



A: Liverwort gemma B: Arabidopsis seed C: Arabidopsis root tip

5. We also make our antibodies available to plant cell wall researchers around the world. We have a portfolio of around 50 cell lines secreting monoclonal antibodies that mostly are targeted to land plants but also some specifically targeted to cell wall polysaccharides of brown algae.[5]

Author

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Acknowledgements

I would firstly like to thank my academic supervisor Professor Paul Knox for directing the research of the group and all my fellow researchers who I have worked with over many years who have contributed to this research, the University of Leeds where the work has taken place and the UK Biotechnology and Biological Sciences Research Council for funding.

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Flow of electro-deoxidized titanium powder

Charles Osarinmwian

The scale-up of solid state electro-deoxidation in molten salts introduces a number of challenges including continuous operation, effective agitation, pumping, and maintaining salt in the molten state. Here, the flow of Ti-molten $CaCl_2$ suspensions and Ti powder is investigated. Spherical Ti particles in $CaCl_2$ melt migrate until the region of lowest shear rate in an annular space between two coaxial inert cylinders (i.e. wide-gap Couette) contains nearly the maximum volume fraction of a random packing for spheres. The boundary-layer transition mechanism at 1000 rpm and 0.55 average volume fractions of Ti particles in von Kármán flow is dominated by inviscid crossflow instability. In addition, the magnitude of the Hausner ratio indicates that the flow property of electro-deoxidised Ti powder is fair-to-excellent with a 25–40° angle of repose.

Introduction

The ability to tailor Ti products towards targeted powder metallurgy techniques, by controlling average particle size and its associated size distribution, could help industry to simultaneously traverse two current global revolutions: shaping the economics and complexity of Ti production by collapsing steps in conventional metallurgy and delivering low cost consumables to 3D printing[13]. Similar to the CSIR-Ti process[4,5], the requirement of continuous operation in the electrochemical FFC process includes effective agitation, pumping, and maintaining salt in the molten state. In this work, the dependence of the ratio between the tap density and apparent density (or Hausner ratio) and Hall flow on particle size distributions of Ti powder was derived from the physical properties of Metalysis Ti powder[2]. Also, constitutive equations based on a continuum diffusive-flux model and Navier-Stokes equations were used to describe Ti-molten $CaCl_2$ suspension flow. Similar to other suspensions[6], the successful use of Ti-melt suspensions may need the supply of the suspension at a specified location with a prescribed volume fraction of Ti particles.

Model development

Assuming negligible Ti-melt suspension anisotropy, the dynamics of the incompressible suspension was modelled by a momentum transport equation for the suspension, a continuity equation, and a transport equation for the Ti particle volume fraction[7]:

3.

$$\rho\frac{\partial \mathbf{u}}{\partial t} + \rho(\mathbf{u}\cdot\nabla)\mathbf{u} = -\nabla P - \nabla\cdot\left[\rho c_s(1-c_s)\mathbf{u_{slip}}\mathbf{u_{slip}}\right] + \nabla\cdot\left[\eta\left(\nabla\mathbf{u} + \nabla\mathbf{u}^{\mathrm{T}}\right)\right] + \rho\mathbf{g}$$

where $\mathbf{u}$ is the mass-averaged suspension velocity vector, P is the pressure, $\mathbf{g}$ is the gravity vector, c_s is the dimensionless particle mass fraction, and $\mathbf{u}_{slip}$ is the relative velocity between the particle and melt. The density of the suspension $\boldsymbol{\rho}$ is given by

4.

$$\rho = (1-\varphi_s)\rho_f + \varphi_s\rho_s$$

where $\boldsymbol{\rho_f}$ = 2009 kg m^{-3} is the density of $CaCl_2$ melt at 1223 K[8], ρs ~ ρab = 4.78 g cm^{-3} is the density of Ti (Fig. 1c), and $\boldsymbol{\varphi}_s$ is the particle volume fraction. The viscosity

of the suspension η is described using a Krieger-type expression:

5.

$$\eta = \eta_f \left(1 - \frac{\varphi_s}{\varphi_m}\right)^{-2.5\varphi_m}$$

where η_f = 0.157 Pa.s is the viscosity of $CaCl_2$ melt at 1223 K[8]. Eq. 5 describes behaviour ranging from highly viscous solid-like behaviour at the limit of maximum packing φ_m to the lower viscosity of the melt. The continuity equation for the suspension model and the transport equation for the particle volume fraction is

6.

$$(\rho_f - \rho_s)\left[\nabla \cdot \left(\varphi_s(1 - c_s)\mathbf{u_{slip}}\right)\right] + \rho_f(\nabla \cdot \mathbf{u}) = 0$$

7.

$$\frac{\partial \varphi_s}{\partial t} + \nabla \cdot \left(\varphi_s \mathbf{u} + \varphi_s(1 - c_s)\mathbf{u_{slip}}\right) = 0$$

Eqs 6 and 7 are equivalent to those formulated by Rao et al.[7] provided that uslip = $J_s/\varphi s \rho s(1\text{-}c_s)$ where J_s is the particle flux. Thus, the particle migration from high to low shear regions in Couette flow is

8.

$$\frac{\mathbf{J_s}}{\rho_s} = -\left[\varphi_s D_\varphi \nabla(\gamma \varphi_s) + \varphi_s^2 \gamma D_\eta \nabla(In\ \eta)\right] + f_h \mathbf{u_{st}} \varphi_s$$

where $D\varphi = 0.41a^2$ and $D\eta = 0.62a^2$ are data fits to the Phillips diffusive-flux model[9] where a = 140 µm is the particle radius[2] and γ is the magnitude of the shear-rate tensor. Eq. 8 couples a Newtonian stress/shear-rate relationship with a shear-induced migration model of suspended particles in which the local η is dependent on the local φ_s. The Stokes settling velocity $\mathbf{u}_{st}$ of a spherical particle in the melt is given by

9.

$$\mathbf{u_{st}} = \frac{2a^2(\rho_s - \rho_f)}{9\eta_f}\mathbf{g}$$

To account for surrounding particles, the $\mathbf{u}_{st}$ is multiplied by the hindered settling function $f_h = \eta_f(1\text{-}\varphi_{ave})/\eta$ where the average volume fraction φ_{ave} is the initial volume fraction for closed Couette flow. The velocity field for the suspension is given by Navier-Stokes equation and the continuity equation:

10.

$$\rho \frac{\partial \mathbf{u}}{\partial t} + \rho(\mathbf{u} \cdot \nabla)\mathbf{u} = \nabla \cdot \left[-P\mathbf{I} + \eta\left(\nabla \mathbf{u} + \nabla \mathbf{u}^{\mathrm{T}}\right)\right] + \mathbf{F}$$

11.

$$\nabla \cdot \mathbf{u} = 0$$

where **I** is the identity matrix and **F** is the volumetric force vector. Gresho[10] describes Eqs 10 and 11 for stationary, axisymmetric flow. The boundary conditions for the disk and walls are Sliding wall **u**·**n** = 0 and No-slip **u** = 0, respectively. The rotation speed was set low enough to avoid turbulence and sufficiently high so that forced convection dominates over free convection (i.e. 600-1000 rpm) while avoiding excessive vortex formation at > 2000 rpm[11].

Results and discussion

For a given particle sphericity ψ, the decrease in Hausner ratio H_r for Ti powder with increasing average particle size d_{50} (Fig. 1a) indicates a decrease in both the powder cohesiveness and coefficient of internal friction.

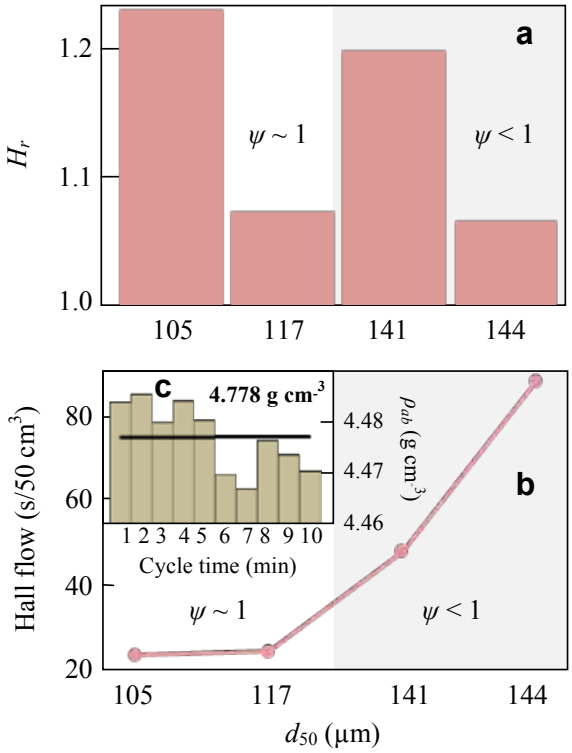

Fig. 1 Ti powder flow: (a) Dependence of H_r on d50 and ψ for electro-deoxidized Ti powder. (b) Increase in Hall flow (i.e. flow rate of Ti powder in seconds per 50 cm³) is more noticeable at lower ψ. (c) Each ρ_{ab} was measured after a single purge cycle per minute in He gas pycnometry.

The flow property for this powder (1.00 < H_r < 1.25) can be considered fair-to-excellent with a 25-40° angle of repose[12], which agrees well with the angle of repose for Ti powders[13]. However, knowledge of the H_r does not lead to a definitive determination of particle shape despite $H_r = 1.478 \times 10^{-0.136\psi}$ and the correlation of H_r with Fourier particle shape descriptors[14]. Although fractal analysis predicts that spherical powder flows faster than irregular powder, the increase in d_{50} leads to a greater increase in Hall flows for irregular-shaped

particles (Fig. 1b) due to possible agglomeration effects[15]. Thus, the angle of repose may gradually decrease as d_{50} increases because the increase in Hall flow indicates a gradual change from cohesive flow to free flow.

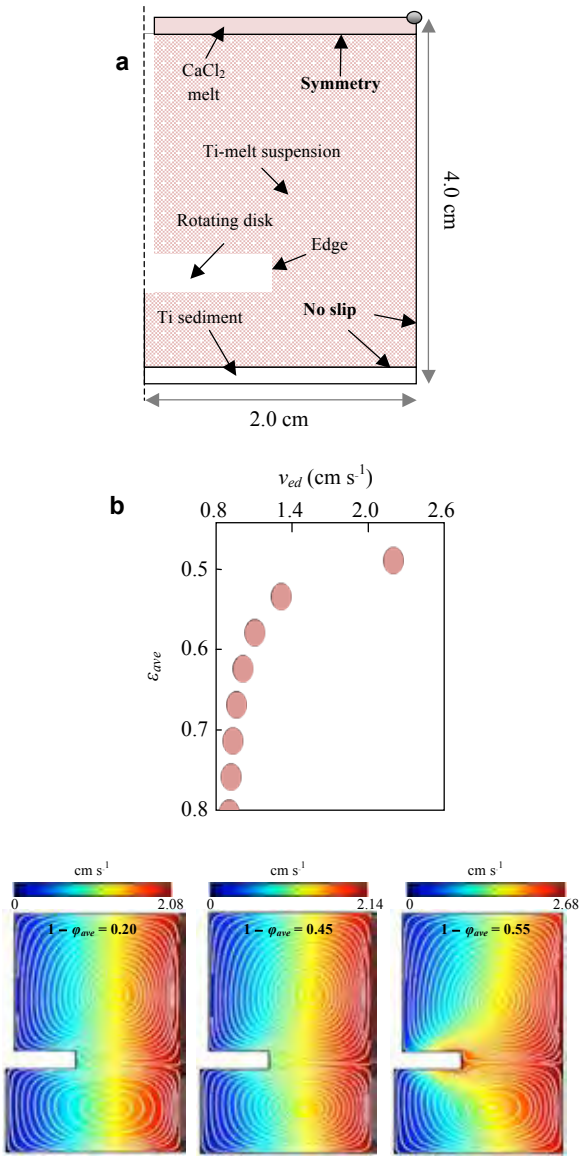

Fig. 2 von Kármán rotating disk. (a) Ti-melt suspension where Symmetry allows flow in the axial and rotational direction, and zero pressure (top right corner) accounts for a non-outflow boundary. (b) At 1000 rpm, according to field-scalar stream functions[17], each flow line corresponds to a space surface inside which a constant quantity of well-mixed suspension flows; this induces two contra-rotative laminar vortices. Centreline velocity at the disk edge v_{ed} increases with increasing 1 - φave as rotating-disk boundary layers become destabilised.

Suspension flow close to the rotating-disk edge (Fig. 2a) experiences a centrifugal force proportional to its tangential velocity, which ejects the suspension radially outward; this is accompanied by axial inflow towards the disk to satisfy continuity (Fig. 2b). The intrinsic instability in the cross flow (radial) profile of the laminar-to-turbulent transition is highlighted by the sharp increase in centreline (peak) velocity along the edge from 1-φ_{ave} = 0.45 to 0.55. This indicates that irrotational (inviscid) motions dominate the rotating-disk boundary layer consistent with boundary layer destabilization by inviscid cross flow instability[16].
In Couette flow, particle migration is from high shear-rate regions near the inner cylinder toward the low shear-rate regions near the stationary outer cylinder wall (Fig. 3). However, φ_s decreases with increases in *r* at 600 rpm because particles near the inner cylinder experience both a higher shear rate and shear-rate gradient than the particles further away. This localized behavior is smoothed by φ_s gradients leading to φ_s becoming strictly increasing with *r* at 1000 rpm.

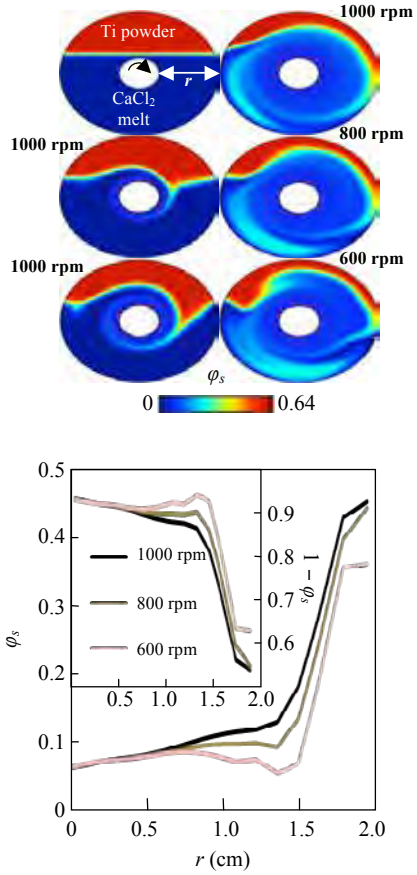

Fig. 3 Ti-melt suspension flow: From a sedimented initial condition (1 - φave = 0.59) in the wide-gap Couette, the suspension velocity satisfies No-slip boundary conditions at each cylinder at the onset of inner cylinder rotation. The Ti particle volume fraction is dependent on rotation rate. Peak 1 - φs near the outer cylinder at 600 rpm occurs due to the influence of geometrically hindered packing.

Outlook

One of the primary influences of particle shape on flow is the change to apparent friction which increases the angle of repose and prevents rough particles from flowing on shallower slopes. Given that a particle size distribution cannot fully describe a particle population,

particle shape factors are used to estimate particle surface area, the number of particles within a size range, and the variation of particle shape with size[17]. Sphericity (compactness), roundness, and smoothness characterize different scales associated with particle shape. Computed X-ray tomography could be used to acquire 3D Ti particle shapes based on volume, surface area, aspect ratio of three principal axes, and sphericity[18]. The roundness and smoothness could also be calculated using the Form factor and SEM images, respectively.

Multi manufacturing a large range of periodic-table metal powders and alloys at Metalysis Ltd could continually be adapted to meet a given specification while offering 'just-in-time' options to create conventional and unconventional metals, master alloys, high entropy alloys and more.

Mr Dion Vaughan, CEO at Metalysis Ltd, said[19]:

"Metalysis' rutile-derived titanium powder is produced at lower cost and is suitable for 3D printing so that manufacturing metal components becomes more economical. The Metalysis process could reduce the price of titanium by as much as 75 %, making titanium almost as cheap as specialty steels. We believe that titanium made by the Metalysis process could replace the current use of aluminium and steel in many products. This world-first for a titanium 3D printed component brings us a step closer to making this a reality."

Professor Sir Keith Burnett FRS, Vice-Chancellor at The University of Sheffield, added[19]:

"We are delighted that this innovative work is being undertaken in the University of Sheffield's world-leading Faculty of Engineering. Most people associate 3D printing with plastic parts, but, with Metalysis' titanium powder, we have for the first time demonstrated its potential in the manufacturing of metal parts. This is potentially a significant breakthrough for the many sectors which can benefit from its low-cost production. We look forward to continue working with Metalysis as they develop this ground-breaking technology."

Author

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How far can Gestalt 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 classical model of Behaviourism can be applied to science and technology teaching. This was then followed by a similar consideration of Neo-Behaviourist models (Fletcher 2017).

In this brief discussion I hope to consider Gestalt theories of learning and map the extent to which they can be applied to, and used in, science and technology teaching.

In future articles I intend to discuss cognitivism and humanism and how far these learning theories 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 science and technology classroom.

For now, I turn to Gestalt theories of learning

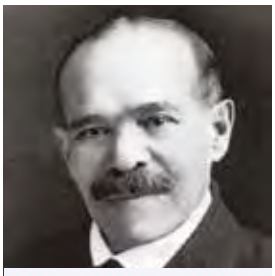
Gestalt theories

"Gestalt" comes from the German word for pattern or structure. This indicates that the Gestalt learning theories are concerned with overall perspectives, patterns, trends, and making sense of "parts" so they make a "whole".

Wolfgang Kohler

The basis of Gestalt theory is the **"Law of simplicity"** which means that we perceive every stimulus in its simplest form. The main focus of the theory is "grouping" which means emphasis is placed on grouping together these "parts" to make a coherent and meaningful whole.

It was Wolfgang Kohler (one of the early contributors to Gestalt theory) who coined the phrase, "the whole is different than the sum of the individual parts". This is often misquoted as the whole is greater than the sum of the individual parts. In this simple statement, Kohler sums up a basic notion of Gestalt theories of learning and perception: that the human brain is inclined toward organization and making sense of bits of information. When we are presented with incomplete information, we have a natural tendency to "fill in" the gaps to create a complete and coherent picture.



Max Wertheimer

Another early contributor to Gestalt theories was Max Wertheimer who is also credited with being one of the first psychologists to recognize the importance, in learning, of perceiving "the whole", rather than the parts. Again emphasising basis of Gestalt psychology: that perception (and understanding) comes from patterns, and whole objects, or trends that arise from "grouping" together bits of information to create a whole that we can understand.

Four laws of Gestalt theories

The factors that determine the principle of "grouping" are the following:

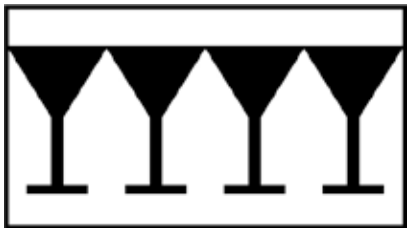
1. **Proximity**
   Parts are typically grouped together based on their closeness to one another (these circles appear as one group of six in "A" but are perceived as two groups of three in "B" and "C")

2. **Similarity**
   Parts similar to one another tend to be grouped together.

   Law of Similarity:
   Items that are similar tend to be grouped together. In the image above, most people see vertical columns of circels and squares.

3. **Closure**
   Parts are typically grouped together if there are bits missing so that a whole can be seen. This arrangement of shapes allows us to perceive the image of a giant panda, even though there are no connecting lines or continuous outline.

4. **Simplicity**
   Parts are organized into pictures, images, or figures, based on their regularity and symmetry. These shapes appear as a row of identical wine glasses.



In terms of teaching and learning in science and technology, the goal of Gestalt theory is to encourage the brain to view not just the parts, **but how these parts come together to make a coherent whole**.

For example, when a learner is looking at a side arm, round bottom flask, a Leibig condenser, Bunsen burner, stand, clamp, and collecting tubes, is that all she/he sees or is it that these parts, when assembled in a particular way, are a distillation apparatus set-up? The whole and the sum of its parts are two different things, and learning can be achieved if learners are able to cognitively process how parts can make up this whole.

Gestalt theory and learning

The above outline of Gestalt theories leads us toward a few very basic ideas for using Gestalt theories in learning:

1. **Encourage your learners to discover the relationship of the parts that make up a problem and how these parts fit together to make a whole.** This might be choosing and correctly assembling bits of apparatus to make a certain set-up. For example, choosing all the right bits of apparatus to be able for fractional distillation.

2. **Missing bits and gaps in information can be used as important stimuli in the learning process.** This might be a "fill-in-the-blanks" worksheets.

3. **Creating learning tools, tasks or worksheets that make use proximity, similarity, closure and simplicity.** This might be being able to group together apparatus that is suitable for boiling liquids over a Bunsen burner as opposed to those not suited to this task.

4. **Group similar things together so that the `pattern' can be seen more easily.** The Periodic Table of Elements is a good examples of this.

5. **Use diagrams where possible as this shows the whole at one glance.** While teaching, we may display an image on an interactive whiteboard while we go on to discuss particular parts of this image or diagram.

6. **Allow time for students to apply information to their own situations so they can relate new experiences to their previous experiences and see similarities.** Tasks or learning opportunities should allow time for learners to discover things for themselves, share them and discuss them in groups.

7. **Allow learners to solve problems in their own way.** Apart from keeping oversight of a group undertaking practical work, it is best not to be too specific or controlling over methodologies, to allow learners to develop their own strategies for problem-solving rather than just "one-way" being correct.

In a learning environment, therefore, Gestalt theory can be used in problem solving and perception. It can also be used to frame what is known as "consequential

learning". This is one of the most important forms of learning according to Kurt Koffka, another early contributor to Gestalt theories.

According to Koffka, consequential learning is when for example, a student burns themselves on a Bunsen burner flame, and they will quickly learn not to make the same mistake again. They have learnt the dangers of Bunsen burners as a consequence of their actions. Unfortunately, very often consequential learning arises from a negative and sometimes harmful action, for example an exploding glass flask when the operator is not wearing safety goggles.

This is a good opportunity for emphasising laboratory rules at the start of a new academic year, as the consequences of ignoring them can be life-changing.

Koffka also believed in the importance of learning by imitation, which he believed was a naturally occurring way to learn. Again, this strategy is often used in science and technology teaching; when we perform a demonstration to a group who then go on to copy these actions themselves. Of course, there is a down-side to imitation learning in that our students can also pick up our bad habits.

Conclusion

As with all the schools of psychology, there is evidence that to some degree Gestalt theories can be mapped onto science and technology teaching and learning situations.

Unfortunately, as with other schools of psychology, Gestalt theories have their critics. The "laws" and ideas that make the theories have never been `proven' as there appears to be a lack of factual or empirical evidence for them.

However, Gestalt theories can be seen in operation in our science and technology classrooms.

Summary

In this article, I have outlined some of the basic concepts of Gestaltism and then attempted to show how they can be applied in science and technology. I have gone onto try to distill 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 cognitivism. That is, to investigate how this particular learning theory applies to science and technology education.

Acknowledgement

Much of the material for this article was taken from worksheets and hand-outs developed and used by the Teacher Training Team at Hull and Goole Colleges over many years. I freely acknowledge these documents, images and my colleagues as the source material for this article.

Author

Kevin Fletcher, BA, BSc(Hons), AdvDipEd, MA, MEd, MEd, Cert. IT & Comp, FSET, CBiol, MRSB, MIScT, QTLS, is the retired Head of an East Yorkshire Further Education College. Having spent the first ten years of his career as a Laboratory Technician & Manager in various secondary schools, Kevin's first degree took him into secondary school teaching for a further ten years, ending up as a Head of Science and Deputy Head teacher. Finally, he moved into Further and Adult Education for a further ten years as Head of School in Hull before becoming Head of Goole College. Throughout his career, Kevin maintained a teaching commitment in his areas of interest which are Science, Education/ Psychology and Management. He still keeps abreast of developments in these areas despite having retired.

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WEB Sources

I acknowledge the use of certain images (now in the public domain) and information taken from various web sources such as Wikipedia which were found using search terms entered into search engines such as Google

Drosophila facility at The University of Sheffield

Katherine Whitley

Introduction

Here at The University of Sheffield fly facility we use the fruit fly, *Drosophila melanogaster*, as a model organism to study a wide variety of biological processes. Many of these processes are conserved in other animals, including mammals, so the fruit fly provides a powerful tool to understand the molecular and cellular mechanisms underlying development, physiology, and aging of organisms. Over 100 years of research devoted to the study of the fruit fly means that a remarkable amount is already known about how its genes contribute to its biological function. More importantly, genetic tools developed in the *Drosophila* community over the past decades allow the very precise study of physiological process.

Drosophila melanogaster By Database Center for Life Science (DBCLS)

These tools include: visualising transcription of specific genes in real time; manipulating gene expression in specific tissues and at specific times; and a range of human disease models. In fact, nearly 75% of human disease genes have an equivalent in flies.[1]

In addition, the complete genome sequence of *Drosophila melanogaster* was published in 2000.[2] Following this, many different *Drosophila* species and lines have had their whole genome and transcriptome sequenced adding to the wealth of information available.

The small size of flies means we can store and care for millions at any one time in a fairly small amount of lab space. We can also observe a fly's entire lifespan within a few weeks and generations of flies in a few months. To carry out this work on rodents would require many more labs, years of time, and much more expense. Using *Drosophila* as a genetic model makes it possible for us to learn about healthy biological processes and disease much faster and in more detail.

So what do the fly technicians contribute to this?

Flies do not readily survive freezing so fly stocks are maintained by live culturing. Our team of technicians maintain over 6000 stocks. These are housed at 18˚C in a humidity controlled culture room.

Drosophila melanogaster stocks in 18˚C, humidity controlled culture room

At this temperature, the life cycle of the fly from initial egg laying to the emergence of adults from the pupal case is completed in 19 days. The true breeding adult flies in the stock are transferred to fresh fly food without anaethestisation. The technicians tap the flies down to the bottom of the vial, quickly remove the plugs and tip the flies into the new vial. Each fly stock is kept in vials in triplicate at different timescales so that adult flies are always available.

We put the flies onto fresh culture media every two weeks. Too few flies can mean that stocks are unhealthy and become outcompeted by bacteria or fungi. Too many flies and the stocks contain a large amount of fly waste leading to the food becoming too wet. This makes it difficult to tip the flies onto fresh culture

media and their wings can also stick together. Labelling stock vials accurately is also very important, and the fly technicians ensure this is done vigilantly. We label each vial with a stock number and the full fly genotype, keeping databases of all stocks on the lab computer.

The technical team also produce the fly food required for stock maintenance and experimental work, making forty litre batches of fly culture media in the vessel shown.

Food processing vessel for the large-scale production of fly culture media

The media contains all the nutrients the flies need for optimal growth. We also add a fungal inhibitor and acid to reduce bacterial contamination. Each batch of fly food is dispensed into vials and bottles whist molten. They are then left to dry so the agar solidifies. The vials and bottles are plugged and stored at 4˚C until needed.

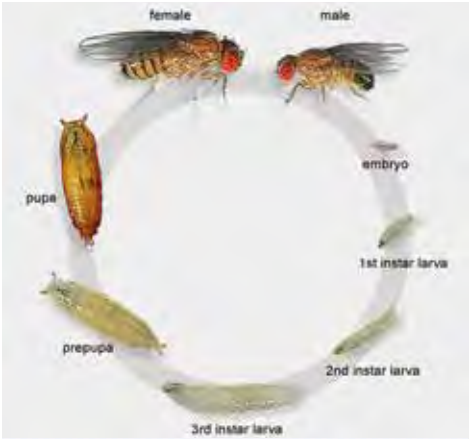
Handling the flies

The facility includes a temperature controlled laboratory maintained at 19˚C which houses twenty two fly stations with stereomicroscopes, each equipped with fly pads and piped CO_2 to temporary anethetise flies.

The CO_2 enters the bottom of the fly pad via a tube and the flies are placed onto the top porous surface. The CO_2 paralyses the flies so they can be viewed down the microscope. This enables researchers to identify and sort the correct sex, phenotype, and the virgin flies needed for genetic crosses. When correctly identified, the flies needed are placed in vials using a paintbrush. Once removed from the CO_2 they return to seemingly normal behaviour within minutes.

Fly pad showing Drosophila melanogaster on the porous surface

The male and virgin females are placed into vials and are cultured in a 25˚C, humidity controlled room. After mating the female will lay hundreds of eggs. At this temperature the eggs hatch within 24 hours and the larvae then feed and grow for the next 4-5 days. During this time, as shown in the diagram, the larvae moult twice from the initial 1st instar larvae to 2nd and then 3rd instar larvae. The 3rd instar larvae crawl up the side of the vial where they pupate. They stay at the pupal stage for a further 4 days during which time the tissues undergo morphogenic changes to form the adult structures. Then eclosion takes place and the adult flies emerge.



The life cycle of Drosophila melanogaster

Drosophila embryos are used in many areas of research, for example to study immune cells, cell to cell adhesion, normal cell development and tumour progression. To study the flies the technicians make apple juice plates which are petri dishes containing apple juice agar.

These apple juice plates are used by technicians and researchers to set up laying cages as shown below. A small amount of yeast paste is placed on the centre of each apple juice plate. This yeast provides a protein

source and scent so the female flies lay more eggs. Adult flies are then put into a beaker with holes in the top to allow air circulation. Next the agar plate is put on top and secured with an elastic band. The laying cages are inverted and incubated at the required temperature for the desired time. The female flies lay eggs on the apple juice agar (see below fly embryos on apple juice plate). The plate is then removed and replaced with a fresh apple juice plate when required. Once at the desired stage of development the fly embryos are collected using a paintbrush and placed into a small sieve. *Drosophila* embryos are covered by an outer layer called a chorion. This is non-transparent so needs to be removed before imaging can take place. This is done by soaking the embryos in bleach for a short period of time. Embryos are then washed and observed under a stereomicroscope to ensure the chorion is removed. These dechorionated embryos are used for experiments.

Fly laying cages

Fly embryos on apple juice plate with yeast paste in centre

Research using *Drosophila melanogaster* as a model organism at The University of Sheffield

(adapted from https://www.sheffield.ac.uk/bateson/fly-facility)

The fly research community at The University of Sheffield consists of over 30 researchers across eight research groups. The research covers a variety of fields using different developmental stages of *Drosophila melanogaster* as a model organism. Here are some examples of fly projects going on at The University of Sheffield.

1. *Drosophila* are considerably simpler than vertebrates such as ourselves, yet the key genes important in macrophage function are also present. This makes it much easier for us to study and identify new genes involved in macrophage functions such as migration, phagocytosis and degradation of ingested material. Importantly, fruit flies contain a population of cells called hemocytes that are very similar in their function and behaviour to our own macrophages. The image of a *Drosophila* embryo below shows the hemocytes fluorescently labelled in green.

Drosophila embryo showing green fluorescently labelled hemocytes

Proteins in flies can be genetically labelled with different coloured fluorescent markers. By tracking fluorescently labelled hemocytes in the fly embryo by live imaging we can understand how these cells respond to wounds and infection.

Dr Iwan Evans' lab study these fly macrophages to understand new mechanisms by which our own immune cells may be controlled. Contact with cells undergoing a programmed form of death (apoptosis), which often occurs at sites of injury or pathology, is thought to alter the behaviour of macrophages. This can be helpful in some circumstances but on other occasions it may cause macrophages to contribute to disease progression. *Drosophila* hemocytes display altered responses when challenged in the presence of increased levels of cell death. One key area is to use fruit flies as a model system to understand how apoptotic cells regulate macrophage function. We are also interested in understanding how engulfment of other cargoes is controlled and regulates macrophage behaviour (e.g. pathogens).

2. Dr Andrew Lin's lab study how the brain represents sensory information to allow it to store unique memories, using the olfactory system of *Drosophila melanogaster* as a model system. Flies have a much simpler nervous system than humans but are still capable of complex behaviours such as associative memory. This simplicity, combined with the power of fly genetics, makes *Drosophila* an excellent model system for tackling basic questions about neural circuit function. Some methods used for this research include fly behaviour experiments using adult flies in custom built apparatus, imaging of fly brains and patch clamp electrophysiology.

Flies can form distinct associative memories for different odours, even very similar ones, and this stimulus-specificity depends on 'sparse coding',

in which Kenyon cells, the neurons that encode olfactory associative memories, respond sparsely to odours, i.e. only a few neurons in the population respond to each odour. This sparse coding in turn depends on a delicate balance of excitation and inhibition onto Kenyon cells. We are studying how this balance is created and maintained. By improving our understanding of how the brain balances excitation and inhibition, this work may shed light on neurological disorders, like epilepsy, where this balance goes wrong.

3. Professor David Strutt's group use the developing fly wing to research the genetic control of animal development and how cells interact to build complex tissues and organs. We focus on the particular problem of how cells coordinate their polarity within developing tissues, and as a model study the phenomenon of planar polarity in the epithelia of *Drosophila*. In this case, planar polarity is the co-ordinated polarisation of cells within the horizontal plane of a sheet of epithelial cells.

   The developing wings of the fly are dissected and used to study the orientation of cells relative to each other. The regular array of planar polarised hairs on the surface of the wing can be seen in the image below. These hairs can be used as a read out because changes in planar polarity lead to the irregular arrangement of hairs. The manipulation of the function of fly genes has allowed the identification of a large number of genes involved in the coordination of cell orientation.

Adult Drosophila wing showing the regular array of planar polarised hairs

Author

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Glossary

Analyte: a substance that is the subject of chemical analysis (e.g.)
Agar: A gelatinous substance obtained from algae used as a solidifying agent in culture media
Conserved: Remains essentially unchanged throughout evolution.
Eclosion: The emergence of an adult insect from its pupal case
Gene expression: The processes by which instructions in an organism's DNA (deoxyribonucleic acid) are used to synthesise functional products such as proteins
Genotype: The genetic constitution of an organism
Phenotype: How the organism looks or how it behaves resulting from the interaction of its genotype with the environment
Transcription: The process of making a copy of genetic information stored in a DNA strand into a complementary strand of mRNA (messenger ribonucleic acid)
Transcriptome: The sum of all the messenger RNA molecules expressed from the genes of an organism
True breeding: The parents will pass down a specific phenotype to their offspring. True bred flies have a pure genotype and will only produce a certain phenotype.

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Drosophila melanogaster image: https://commons.wikimedia.org/wiki/File%3ADrosophila_melanogaster_-_side_(aka).jpg

By André Karwath aka Aka (Own work) [CC BY-SA 2.5 (https://creativecommons.org/licenses/by-sa/2.5)], via Wikimedia Commons from Wikimedia Commons

Alternative *Drosophila melanogaster* image: https://commons.wikimedia.org/wiki/File:Fruitfly_(Drosophila_melanogaster).png

By Database Center for Life Science (DBCLS)

Life cycle image: https://goo.gl/images/QNxLt7

Altenative Life cycle image: https://www.flickr.com/photos/11304375@N07/2993342324 by Image Editor

https://commons.wikimedia.org/wiki/File:Fruitfly_(Drosophila_melanogaster).png

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From the archives: Harris Bigg-Wither and the early years of the Roburite Explosives Company

Alan Gall, IST Archivist

Introduction

Readers of the Spring 2017 issue of this journal[1] may have noticed a picture of the title page from John Ponsonby Cundill's A Dictionary of Explosives (1895). This book found its way into a room full of junk at Nobel's Explosives Co Ltd, Gathurst, near Wigan (formerly the Roburite Explosives Co Ltd) and was saved from likely oblivion by myself. On the flyleaf is a signature that remained undecipherable for nearly forty years (figure 1). Recently, research for an article on Haldane Gwilt Cotsworth[2] revealed the identity of the general manager at Gathurst in 1911 as a certain Mr Harris Bigg-Wither. The signature in the book suddenly came into focus and comparison with that on the 1911 census confirmed that it did indeed once belong to the same Harris Bigg-Wither, whose grandfather (of the same name) once proposed marriage to Jane Austen.

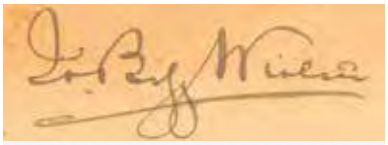

Figure 1. The signature of Harris Bigg-Wither on the flyleaf of A Dictionary of Explosives)

The manufacture and sale of roburite explosive under Bigg-Wither faced many obstacles: his own lack of experience in the industry, a miner's strike over toxic fumes, a price-war with dynamite makers, a shareholder's revolt and litigation over claimed patent infringement. At one point he faced prison on a possible charge of contempt of court, for breaching an injunction.

After the death of Harris Bigg-Wither, the job of general manager passed to his right-hand man, Volta Moseley. With an unusual first name like Volta there had to be someone in the family with more than a passing interest in the history of electricity. That someone was his father, an electrical engineer and inventor whose patents spanned half a century.

Dynamite inventor Alfred Nobel had already established himself in Scotland with a works at Ardeer, in Ayrshire. Most of the British explosives industry, including Roburite, would become merged under the Nobel name and in 1926 form part of one of Britain's largest firms in its day – Imperial Chemical Industries.

(In what follows, to distinguish between the two, Roburite refers to the Roburite Explosives Co Ltd and roburite refers to the product).

The Bigg-Withers

The short-lived romance between Jane Austen and Harris Bigg-Wither (1781-1833) has been the subject of various discussions such as "Jane Austen's Lovers"[3] and "A New Light Thrown on JA's Refusal of Harris Bigg-Wither."[4]

The Christian name Harris came from his grandmother Jane Harris, and when his father Lovelace Bigg inherited property called Manydown from cousins with the surname Wither, so the family name became Bigg-Wither (although the daughters kept the surname Bigg).

Figure 2. Harris Bigg-Wither, manager of the Roburite Explosives Company Ltd. A composite image processed by Robin Marshall from obituary notices

Whether or not Harris Bigg-Wither is the only person to have proposed marriage to Jane Austen is still unclear, although a number of sources favour him as the one and only suitor. A letter written by Caroline Austen to her daughter Amy in 1870 gives the date of proposal and acceptance as Thursday 2 December 1802, followed by rejection on the following day. Although the letter says, "Mr Wither was very plain in person – awkward & even uncouth in manor" it does concede that, "I believe the wife he did get was very fond of him, & that they were a happy couple."[5] The wife in question, Anne Howe Frith, gave birth to Harris Jervoise who, with wife Elizabeth Maria Hunt, were the parents of "our" Harris Bigg-Wither.

John Stokes

An easily identifiable event that led to Harris's eventual appointment as Roburite's manager occurred while he was still in his mid-teens. This happened when the Bishop of Oxford joined Isabella Stokes and the Reverend St John Blunt in holy matrimony.

The marriage on 13 April 1863 united the two separate families and in the process brought Harris, whose grandmother was a Blunt, into contact with Isabella's brother John (later lieutenant-colonel and later still, Sir John Stokes).

John Stokes held the post of British commissioner on the European Commission of the Danube while still a serving army officer. This body had been set up as an international collaboration to exercise control over part of the river Danube after the Crimean War. Harris accompanied Stokes on one of the trips to the Danube and through this connection found employment with the Commission later on. This employment also led to a romance with John Stokes' Romanian-born daughter Constance.

1887 turned out to be quite a memorable year for Sir John Stokes. He retired with the honorary rank of lieutenant-general, became a vice-president of the Suez Canal Company, approved the prospective marriage of Constance to Harris Bigg-Wither and received an invitation to join the board of the embryonic Roburite Explosives Company.

The impending marriage of Harris to Constance Stokes created a worrying situation because his future son-in-law still worked for the Danube Commission in Sulina, Romania. As Sir John wrote in his autobiography, "I did not like the idea of my daughter going to live on the shores of the Black Sea, so far away ..."

The Gathurst site

By 1867 there were about a hundred collieries in the western district of the Lancashire coalfield, the majority around Wigan. To a producer of mining explosives in the 1880s, it made good sense to base operations as close as possible to the epicentre. The man entrusted to find a suitable location, Richard Hammersley Heenan of engineers Heenan & Froude, discovered a disused chemical factory at Gathurst, near the village of Shevington.[6] In August of 1887 Sir John paid a visit.

"I went down to see it, and found it admirably adapted for our purpose. The old factory had a chimney and various good buildings, and across the River Douglas and the Canal (running from Wigan to Southport) was a partly wooded hillside where the factory for the explosive, the magazines etc. could well be built. It is necessary in dealing with an explosive, for such buildings to be some distance from the rest of the works. I saw at once, that by running a bridge across, at a high level from the works on the one side to the magazines etc on the other, we should be able to keep the two branches of the factory distinctly apart; and, by means of a tramway on this bridge, have very easy and rapid communication between them. Acting on my report the Board purchased the factory and obtained the lease of land on the other side on sufficiently good terms. We now set to work to put up the necessary buildings; for which we employed Mr Heenan for the construction of iron sheds etc."

A photograph of the chemical works is shown in figure 3. To the far right can be seen the high level bridge connecting the two parts of the site, as envisaged by John Stokes. The Navigation Arms (the local for Roburite staff) is in the top left corner and Gathurst Station behind the train carriages.

Figure 3. The "chemical section" of the Roburite explosives works, to the south of the Liverpool & Leeds Canal and the River Douglas, demolished c. 1930 (Courtesy of wiganworld)

Figure 4. Demolished c.1982, the viaduct supporting a narrow gauge railway line, connecting north and south sections of the site (Courtesy of Ian Santus and John Collier)

Some trials on the effectiveness of roburite had already been made at the ironworks of Heenan & Froude in Newton Heath. *The Manchester Times* reported that a charge of 12 ounces was capable of splitting a cast iron plate six inches thick and weighing three tons.[7] With the public's attention drawn

to the arrival in this country of a new explosive, and construction of the plant well underway, it remained to appoint a manager.

The marriage of Constance Stokes loomed (it took place on 29 December 1887) and the solution that satisfied Sir John's desire to keep his daughter close to home also solved the problem of finding a trustworthy man to look after roburite production.

The board duly approved the appointment of Harris Bigg-Wither as general manager. He assumed his duties in the same month as his marriage. Harris and Constance moved to Wigan and by the mid-1890s were ensconced in the Mount, a house within the confines of the factory grounds.

Roburite, the explosive

German chemist Carl Roth originated the formulation of roburite and developed it for commercial exploitation. According to *A Dictionary of Explosives*, in its simplest form it is a mixture of ammonium nitrate and dinitrochlorobenze (expressed in more modern nomenclature). Its novelty came from the inclusion of chlorine on the benzene ring, said to confer stability, and enhanced power. Sanford (1906) explains, "... chlorine exerts a loosening effect upon the NO_2 groups, and enables the compound to burn more rapidly than when the nitro groups alone are present." A later analysis showed little evidence of any chlorine bonded in this way.

To exploit the invention in this country (it had already been produced in Germany) a group of mainly ex-military men formed the Roburite Explosives Company Ltd in 1887. In addition to Lieutenant-General Sir John Stokes, the directors of the new company were: Vice-Admiral P. H. Colomb, Colonel Gerard Smith, Colonel J. Copley Wrey and Major-General W. H. Wardell. Others were J. D. Alexander, director of the Imperial Fire Insurance Company, S. Loewe[8] of London, and H. W. Maynard, director of the Employers' Liability Insurance Corporation Ltd.

Philip Howard Colomb and Copley Wrey were old friends of Sir John and Maynard was his wife's cousin.

J. P. Cundill (1895) comments that roburite "much resembles Bellite". This similarity did not escape the notice of the Lancashire Explosives Company Ltd, manufacturer of the said Bellite. The company was determined to put a stop to the competition and the start of a vigorous legal challenge commenced with a hearing in July 1895 by Mr Justice (Arthur) Kekewich in the Chancery Division. Lancashire Explosives (hereafter to be called LEC) brought in the big guns: a high-powered Queen's Council for the defence, John Moulton (later Lord Moulton), and Sir Frederick Abel, a leading explosives expert. Council for the Roburite Explosives Company contended that the inventor of LEC's product didn't come up with the original mixture of components and prior "common" knowledge invalidated the patent. This, to some extent, called into question the value of Roth's patent on roburite, but provided an effective defence. The judge held that the plaintiffs (LEC) had failed to make their case. Undaunted, LEC carried the action to the next level, this time with success. The Court of Appeal reversed the decision and granted an injunction to prevent the manufacture and sale of roburite. Harris Bigg-Wither sprang into action to avert the disaster.

In a statement to shareholders on 10 December 1895 Harris reported that the company had devised, prepared, tested and licensed a new explosive called roburite number 3, said to have taken 6 days "without overtime" to produce nine tons.[9] Unfortunately, LEC considered number 3 to be just a slight variation on the previous formulation, and still subject to the injunction.

Tension ramped up when LEC applied for an order to commit Bigg-Wither and Sir John Stokes to prison for contempt of court. The case came before Justice Kekewich who, as before, found for the Roburite Explosives Company and dismissed the case. A further appeal resulted in three Justices, Lindley, Lopes and Rigby, deciding that the new product did not infringe the Bellite patent. However, LEC doggedly continued to pursue the Roburite men with an appeal to the highest possible authority, the House of Lords.

Lancashire Explosives Company Ltd, Withnell

In the early 1970s, Albert Gillham carried out an investigation into the Withnell Explosives Works following an examination of some unusual iron gateposts he found on the Belmont to Abbey Village road. After rejecting an initial idea that a gunpowder factory once occupied the site, discovery of, and visits to, surviving ex-employees gave much more of the story.

A Mr Rowell, then over 90 years old, furnished the following information for Albert Gillham's report.

"A Swiss gentleman by the name of Mr. Lamn [sic] owned the works and he resided at Blackburn. He travelled by train to Withnell Station and it was Mr. Rowell's job to meet him off the train with a horse and trap to bring him to the works. Later on a horse drawn cab was used."

The person in question was Carl Lamm (actually Swedish) director of the Rötebro Explosive Company,

of Stockholm. He did indeed live for a time in Blackburn to keep an eye on Bellite production. The Bellite patent was the result of his development work, communicated to the patent agent Harry Lake in 1885, and eventually assigned to the Lancashire Explosives Company Ltd. It managed to precede the roburite patent, just.

What turned the patent infringement case in Roburite's favour was not a question of the ingredients. In fact, the argument that "number 3" differed only cosmetically from the first version had merit. Also, an analysis of roburite showed the chlorine content to be much smaller that the claimed composition of 13% dinitrochlorobenze suggested. However, it came down to the fact that Lamm, in being very specific about the heat-treatment, had made this particular operation a vital part of his patent. He could have left it out, but did not. As the "new" roburite used sufficiently different process conditions, Lord Herschell ruled that no infringement had taken place.

LEC had other problems to contend with apart from frequent court appearances. Attempts to limit workers' exposure to toxic products were evidently ineffective.

Mr George Whalley, another LEC ex-employee interviewed by Albert Gillham, recalled the working conditions.

"Milk was supplied to the employees to drink as this was supposed to neutralise the poisonous fumes and powder which were inhaled. Muslin masks were used over the mouth and nose but in spite of these precautions some of the workers became ill after a few weeks. The legs went weak, the lips blue and the skin yellow. This was known locally as being "BELLITED"."

Verification of the dangers comes from a report in the *Chorley and District Weekly News* of 1 August 1914 with the death of Laurence Hardman and a post mortem finding of "congestion due to Bellite poisoning".

The investors are revolting

Amidst all the legal wrangling with LEC, some Roburite shareholders were feeling they had invested in a dud company. To confront the management they forced an extraordinary general meeting, held at the Cannon Street Hotel, London, on 10 December 1895. Sir John Stokes defended Harris against claims of ineptitude: "People say, 'You ought to have got a first rate manager for it.' Well, I think we did, but he was not a first rate manager in explosives when we first secured him, because he knew nothing about them, nor did anybody else." Harris had worked in a clerical and administrative capacity, with no experience of manufacturing industry, let alone the specialised area of explosives. However, there is good evidence that he threw himself into the job with dedication.

At the same meeting, Sir John put disappointing sales down to the general coal strike of 1893 and the national depression of trade. Export figures were also poor. He explained, "Wherever we go into the colonies, we are met with anti-roburite influence by the dynamiters" and that progress in Australasia looked promising until the banks failed and public works virtually ceased. The "dynamiters" also seem to have resisted the introduction of roburite by dropping their prices.

There had been prior discontent amongst the shareholders, the result of which had been an agreement by the directors to reduce the number of board members and cut their own fees (taking also a percentage of the profits, if any). The shareholder's group, led by Dudley Smith, failed to be convinced by the excuses given. A Mr Samuelson criticised the management for paying the roburite patentee (Carl Roth) "a large sum of money" instead of taking a more prudent course of action by offering shares as part payment.

"Trouble at' pit"

The company advertised roburite as a safe and powerful explosive for mining, free from injurious fumes. An essential quality for safety was an absence of flame when detonated, so that secondary ignition of dust did not occur. Claims and counter-claims followed in abundance as pro and ant roburite factions formed.

Unusually, in what was basically an advertising exercise, Roburite gave details of miners' opposition.[10]

"The miners at the Park Lane Collieries, Wigan, demurred to the use of roburite on the ground that it disseminated noxious fumes at the time of the explosion, and in consequence of the proprietors of the collieries named continuing to employ the explosive, a strike occurred among the workmen about the close of the year 1888."

Obviously, the company disputed this claim.

"The truth is that roburite is now accepted as what it really is – a safe, innocuous, and powerfully efficient explosive, giving every satisfaction when the charge is fired in the proper way."

There must have been some substance to the claims as opposition to roburite caused questions to be asked

in the House of Commons after the Miners' National Conference of 4th July 1889 condemned the product as injurious to heath.

It didn't help matters when a report about the inquest on Edward Sandel, a collier working for Fletcher, Burrows & Co, gave the verdict as "... attributing the cause of death to the inhalation of noxious fumes liberated upon the explosion of a roburite cartridge."[11]

An 1889 report by a group of specialists, headed by chemistry Professor Harold Baily Dixon of Manchester University, supported the Lancashire Miners' Federation in the belief that roburite posed a danger.[12] H.B.Dixon spent much of his time on combustion research and served on the Royal Commissions on Explosions of Coal Dust in Mines (1881-94). He is also known for his disagreements with the famous physicist Ernest Rutherford.

What the Roburite chairman thought about miners, emerged at the shareholders meeting of December 1895 when Sir John Stokes reportedly said "If there is one class of men more rash and foolhardy than another it is miners. But, if they can get gunpowder for a farthing a pound cheaper, they will take the gunpowder and be blown up."

To persuade colliery managers of roburite's virtues, when handled correctly, Harris organised meetings at Gathurst where testing took place. At an event in 1890 attracted a large gathering of those concerned (figure 5).

Figure 5. Colliery managers meeting, 5 September 1890, (Courtesy of wiganworld)

Several British newspapers picked up on a report in the *Sydney Morning Herald* of 19 April 1890. The agent for roburite in Australia had provided a pound of the explosive for an experiment on reducing the number of flying foxes at a gully near to Jamberoo, New South Wales. Dynamite had previously been used on bats and parrots but the safe-handling feature of roburite suggested it would be a better alternative. Unfortunately (or fortunately for the bats), after hoisting the charge into a tree and detonating it electrically, the large blast did not cause the expected carnage. The report explained that sparse foliage on the tree allowed the force to dissipate.

A new century begins

Members of the Roburite Works Club spent their annual outing in 1905 at Morecambe. Representing the management were Harris Bigg-Wither, Volta Moseley, and William Orsman. Harris gave a little speech on behalf of the company, expressing his hope that trading conditions would improve. Indeed, the works had been operating on "short time" and this impacted on the payment of dividends. The 1906 ordinary dividend amounted to 1%, nothing in the years 1907-1909 and only a small recovery up to 1914.[13]

Chemist William James Orsman FIC didn't last long after the 1905 works outing. He died in 1906 at Port Said, Egypt while on a voyage for his heath, at the age of 44. The cause is not known.[14]

Bad press came in 1906 when a factory making roburite in Germany blew up.

According to reports, it started as a small explosion, followed by a fire. Since it was believed that roburite would only burn, and not explode, sightseers were not prevented from approaching to watch the spectacle. The onlookers paid the price when a second, much more powerful explosion occurred. Many were killed and the neighbouring village of Annen severely damaged. Newspaper reports were quite gruesome in their description of injuries. It was later suggested that the explosion might have been caused by dynamite, unlawfully manufactured at the site.[15]

In *The Rise and Progress of the British Explosives Industry* (1909) figures are given for those employed.

Qualified chemist, 1.
Office staff in London, 3.
Office staff in factory, 7.
Male workers, including foremen, 49
Female workers, 29.

This totalled 86 at Gathurst and increased considerably during the two world wars, but by 1969 had changed little from sixty years previously. The company reported a total workforce of 76, split into 14 staff and 62 on "payroll". The male to female ratio remained about the same at 2:1.[16]

Roburite and Ammonal Explosives Ltd

By the time that *The Rise and Progress of the British Explosives Industry* appeared in print (1909), Roburite had a working arrangement with Ammonal Explosives Ltd to produce ammonal at the Gathurst site. The name "ammonal" covered a range of formulations based on aluminium and ammonium nitrate. Safety considerations limited the proportion of aluminium used, but also reduced the potential for greater power. Working with the Ammonal company, chemist William MacNab introduced the addition of potassium dichromate, which allowed increased aluminium content.[17]

Ammonal Explosives (1908) Ltd, a restructuring of the firm first registered in 1903, formally went into liquidation on 25 June 1913 and re-emerged as Roburite and Ammonal Ltd.

Figure 6. Workers at Gathurst 1916 (Courtesy of wiganworld)

The acquisition of Ammonal paid off to some extent during WWI when the government placed large orders for military grade ammonal, albeit after a hesitant start. At the 26th annual general meeting on 27 July 1916, Roburite chairman H. A. Krohn said, "[ammonal] had a high military reputation on the Continent, but our military authorities would have none of it, and when the war broke out it was so little known to the army at large that when the first consignment arrived at the front I am informed on credible authority that it was supposed to be a patent medicine, and reported on as such." However, large orders did not mean huge profits. On 6 March 1916, Roburite & Ammonal Ltd had been declared a "controlled establishment", and under the Munitions of War Act liable to pay back 80% of net profits.[18] The net profit in 1914 stood at £5,800, resulting in a dividend payment of 2% on the ordinary shares. 1915's respective figures were £88,800 and 20%.[19]

After 1915, the prospects were not quite so rosy. The government programme of building ordnance factories reduced the reliance on private companies for supplies. Roburite's contract to supply ammonal expired in March 2017, without renewal.

As a controlled establishment, the profits for 1916 were well down on the previous year and chairman H. A. Krohn complained of the government contract being on "starvation terms".[20] Many companies in the trade were in the same boat, financially, and talk of mergers began.

The retirement of Harris Bigg-Wither on 1 January 1918, due to ill health, ended thirty years of service. He had hoped to spend his twilight years at Wallingford, Berkshire, but it was not to be. The end came soon after, on 29 June of that year at a nursing home in Victoria Park, Manchester. He left £6583, a widow, a son and four daughters.

Volta Moseley

Volta arrived at Roburite in the capacity of accountant in about 1905, possibly working at the London office before then. He would build on this role over the years to become sales manager and Bigg-Wither's "right-hand man".[21] Upon the death of his boss he became the senior manager and the board appointed him, at the age of 34, to succeed Bigg-Wither.

Figure 7. Volta Moseley (Courtesy of the Moseley family)

Walker Moseley, Yorkshireman and father of Volta, lived under a mile away from the Roburite factory in 1907. For a short time he had taken up residence at Orrell House, on what was then Jackson's Road and later a continuation of Gathurst Road, leading to Orrell Post. Walker's patent applications, at least a dozen registered from 1858 to 1908, show that he moved frequently between London and the provinces. In 1876 he could be found at Rockferry, were he had been situated for several years and was the birthplace of Volta on 20 December 1874. Walker died at Camberwell Infirmary on 20 April 1909, just two months after the acceptance of his last patent, for "Improvements in Secondary Electrical Batteries or Accumulators".

Little record has been found of Volta's time as the new general manager, or of his activities as sales manager, and by 1929 he had moved to Camberwell. Away from work, it is known that he supported the Liberal Party and enjoyed singing. A review of the entertainments provided at a Peckham Liberal concert reported on the soloists: "Mr Volta Moseley was conspicuous amongst the artistes for a fine rendition of 'The Windmill' for which he received the compliment of a deserved encore".[22]

Being the son of a prolific inventor must have rubbed off on Volta, if only in a minor way. By 1935 he was living in Beckenham and submitted his "Improvements in or relating to Binocular Protectors and Binocular Aids to Vision", granted patent number 456,668 on 13 November 1936. The invention concerned the adjustment of distance between the two eye pieces "...particularly applicable to goggles such as are used by electrical welders, but is also applicable to motor goggles, to field and opera glasses of the type worn like spectacles..."

Figure 8. Field glasses in spectacle form, but without the advantage of Volta Mosley's adjustable bridge (Advertisement for the "Olympic" Spectacle Binocular, Emil Busch Optical Co Ltd, Nature 25 June 1932)

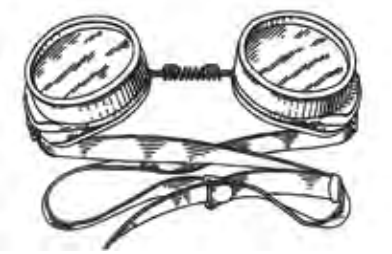

Figure 9. Volta Moseley's goggle with adjustable bridge

Volta's details in the 1939 Register, compiled by the government at the start of the war, indicate that he worked as manager for an industrial goggle maker – hence the patent. Also given is that he was involved in a government contract to supply aviator's goggles.

William Revill

What is not entirely clear is if LEC became a subsidiary of Roburite and Ammonal before the grand merger to form Explosive Trades Ltd, or if LEC joined the group as an independent member. W.J.Reader does not mention LEC at all in his history of ICI. What can be said is that LEC were without a factory from 1920. Mr Rowell, the ex-LEC employee previously mentioned, stated that the closure resulted when the lease expired on land under the control of the Liverpool Water Works.

It is known that an application was successfully made by LEC in 1914 to erect a works at Boar's Head, Standish.[23] Nothing seems to have happened further. At this time, the company had an explosives store on Bolsover Moor, Derbyshire.[24]

The buildings, plant and machinery at Withnell works went for sale by auction on 24 March 1920.[25] A farewell dinner preceded this disposal, held at the White Bull, Blackburn on 3 March 1920. Another established fact is that LEC's ex-works manager, William Revill, was an employee of Roburite and resident at the Mount, Gathurst by the following year.[26]

Figure 10. William Revill and bride-to-be Phyllis, c 1916 (Courtesy of the Revill family)

William Revill's daughter recalls that he met his future wife Phyllis at the Withnell factory. They lived locally and William walked to work each day. This exercise did not counteract the exposure to toxic chemicals and he sustained lifelong damage to his heart, dying at the age of 51. At Gathurst, the family lived in a flat above the offices, i.e. The Mount, once occupied by Harris Bigg-Wither. Later, the Revells moved to another house called The Mount, this one some distance away at Apply Bridge,

Presumably, given his previous role, William Revill joined Roburite with a view to becoming (or as) general manager. He did take up the position but left to join Colliery Explosives Co Ltd, another Wigan based manufacturer. There he remained until his heart condition caused an early death in 1939. Colliery Explosives closed in 1961 under the ownership of ICI.

Figure 11. Plan of the Gathurst site north of the Leeds & Liverpool Canal: map revised in 1971)

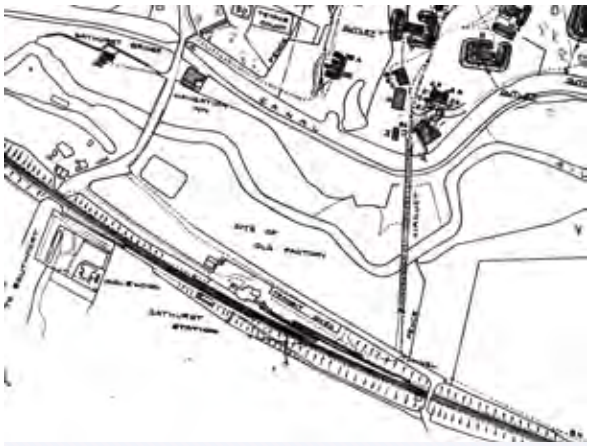

Figure 12. Site of the old factory south of the Leeds & Liverpool Canal: map revised in 1971)

Figure 13. Workers at Gathurst, c. 1930s? (Courtesy of wiganworld)

Nobel Industries Ltd

A letter sent to Albert Gillham from the Explosives Branch of the Home Office starts with "The delay in replying to your letter of 19 October 1972 is regretted." It had taken three months to reply, which doesn't sound too bad for a government department, and the letter did impart some useful information.

LEC had been licensed to make Bellite since 1894 and the authorities knew the Withnell plant as factory number 159. The variations of Bellite were designated Bellite 1, 2, 3 and 4, all of Class 3 Division 2. Class 3 covering nitro compounds and Division 2 all those not included in Division 1 (Division 1 including such explosives as nitroglycerine and dynamite).

The letter, from a Mr J. Mogg, concluded with:

"Towards the latter part of it's [sic] existence, Bellite became associated with alternative names such as Douglas Powder "S" and Explosive No. 696. The Nobel Explosives Co Ltd of Stevenston Ayrshire have a system of numbering certain of it's [sic] explosives and you might wish to approach this company to see whether it can assist you in your research."

Albert Gillham did not record any outcome of contact with Nobel's Explosives. If someone at the firm had the opportunity and inclination to respond, with access to the records, then no doubt further information would have been included in the report. Both LEC and Roburite were previously constituent parts of Explosives Trades Ltd, later to be renamed Nobel Industries Ltd.

Speculation about a mass merger of explosives companies started to circulate during WWI and by 1918 Roburite found itself combined with 36 other companies under Explosives Trades Ltd.[27] Chief architect behind the union, Harry McGowen of Nobel's Explosives Co Ltd, had ambitions for an even bigger goal. His efforts resulted in the 1926 merger of Brunner, Mond & Co Ltd, the United Alkali Co Ltd, British Dystuffs Corporation Ltd and Nobel Industries Ltd to form Imperial Chemical Industries. 1932 saw the formation of the subsidiary ICI (Explosives) Ltd with over a 90% interest in Nobel's Explosives.

Figure 14. Shown (centre) Ernest Cheetham who joined Roburite on 29 November 1926, during the time of ICI's formation, retiring 47 years later. To his left is George Mason, shop steward, and to his right Jack Alexander, works manager (Source: Nobel Times 23 February 1974

Diversification of products continued throughout the years after the early emphasis on roburite production. In more recent times the factory was sub-divided into the Shevington site (the northern end) and the Gathurst site. "Shevington" looked after slurry explosives and resin capsule manufacture[28]; "Gathurst" processed TNT and ANFO (ammonium nitrate and fuel oil) explosives.

Orica

In 1997, the acquisition of Unilever's speciality chemicals division presented ICI with a bill for £4.9 billion. Funding came from a series of disposals, including its exit from the explosives market. ICI's 62% stake in their Australian explosives arm raised about £1 billion through a global share offer. ICI Australia then changed name to Orica and took control of Roburite as part of the deal.

The Gathurst site closed down in 2010 to be re-developed, in part, as a housing estate.

Pictures of the derelict site can be seen at **http://www.nwex.co.uk/showthread.php?t=9092**

Figure 16. Taking in the view from the viaduct (Courtesy of Ian Santus)

Figure 15. The entrance to the Roburite works under Orica (Courtesy of Ian Santus)

Figure 17. A view of the boiler house from south of the canal, 1978 (Courtesy of Ian Santus)

Appendix 1

Details of Roburite's Gathurst site from Hodgetts (1909)

	Chemical Section	Explosives Section
Approximate area	7 acres	33 acres
Purpose	Manufacture, drying and grinding of chemicals for the Explosives Section	Manufacture and storage of explosives
Facilities	Offices, laboratory, stores, printing room, cartridge-case making rooms, carpenter's shop, main boiler house, mechanics shop and smithy (13 buildings)	Work rooms and magazines (24 buildings)
Equipment	2 Lancashire boilers 5 Engines with 26 HP total 1 x 50 amp dynamo 1 x 220 amp dynamo	2 Vertical boilers 1 Engine 15 HP Power received from Chemical Section
General	All buildings connected by tram lines. Steam generation used for power and heating. Specialities manufactured: safety explosives of the Sprengel class including those containing aluminium. Practically all explosives made into blasting cartridges	

Appendix 2

The constituent parts of Nobel Industries Ltd in 1926 (Source: *The Graphic*, 16th January 1926)

African Explosives and Industries Ltd
Amac Ltd
William Benett, Sons & Co Ltd
Bickford, Smith & Co Ltd
British Electric Detonator Ltd
British Pluviusin Co Ltd
British Westfalite Ltd
Curtis's & Harvey Harvey Ltd
"E.C." Powder Co Ltd
Eley Brothers Ltd
Elterwater Gunpowder Co Ltd
Excelsior Motor Radiator Co Ltd
Frederick Crane Chemical Co Ltd
R. & T. Jack & Co Ltd
King's Norton Metal Co Ltd
Kynoch Ltd
Lancashire Explosives Co Ltd
Lighting Trades Ltd
Lightning Fasteners Ltd
John Marston Ltd
Necol Industrial Colloidions Ltd
New Pegamoid Ltd
Nobel (Australia) Ltd
Nobel's Explosives Co Ltd
Paper Goods Manufacturing Co Ltd
Patent Electric Shot Firing Co
Portland Glass Co Ltd
Premier Electric Welding Co Ltd
Roburite and Ammonal Ltd
Rotax (Motor and Accessories) Ltd
Sedgwick Gunpowder Co Ltd
Thermite Ltd
W. H. Wakefield & Co Ltd
A. Walker & Co Ltd

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Daphne Revill, granddaughter of William Revill.
Ian Santus, ex-employee of Nobel's Explosives Co Ltd and Orica UK Ltd.
Kath Williams, genealogical researcher.

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4. Joan Austen-Leigh, "New Light Thrown on JA's Refusal of Harris Bigg-Wither", *Journal of the Jane Austen Society of North America* (1986).

5. Joan Austen-Leigh, "New Light Thrown on JA's Refusal of Harris Bigg-Wither", *Journal of the Jane Austen Society of North America* (1986).

6. Obituaries of Harris Bigg-Wither (junior) say that the disused works at Gathurst belonged to the Lancashire Tar Dyes Company.

7. *The Manchester Times*, 12 February 1887.

8. Apparently, Loewe was brought in for his business skills after shareholder complaints.

9. There was already a roburite Number 2 consisting of the original Roburite mixed with ammonium chloride and magnesium sulphate.

10. *Industries of Lancashire* (c1889).

11. The Times, 2 March 1892.12. "The Use of Roburite in Mines", *Lancashire Evening Post*, 5 July 1889.

13. "Roburite's Day", *Financial Times*, 21 July 1916.

14. Information on W. J. Orsman from Kath Williams.

15. See for example the *Daily Telegraph*, 30 November 1906. *The Illustrated London News* of 8 December 1906 showed pictures of the devastation.

16. Nobel's Explosives Co Ltd, an internal document dated 1 June 1969, compiled by works manager Tom Forrester.

17. British patent 16514 of 1905.

18. *Financial Times,* 29 July 1916.

19. *Financial Times*, 21 July 1916.

20. Report of the 27th general meeting in *The Times*, 5 July 1917.

21. Report of the 28th general meeting in *The Manchester Guardian* 14 August 1918.

22. "Peckham Liberal Concert", *South London Press*, 15 April 1899.

23. *Wigan Observer*, 27 June 1914.

24. *Derbyshire Courier*, 10 October 1914.

25. *Lancashire Evening Post*, 20 March 1920.

26. Albert Gillham's report includes a letter dated 29 August 1921 from Brinscall Council to William Revill at the Mount, asking for payment of a gas bill.

27. Based on the list given by W. J. Reader in Table AI (f) of *Imperial Chemical Industries: A History, Volume 1*.

28. Resin capsules are used to anchor roof-support bolts in mines.

Andrew Schally – from technician to Nobel Prize

Andy Connelly

There are technicians for whom being a technician is a career, a life-long passion. Then there is Andrew Schally who, throughout his life, always wanted more. Even after winning the Nobel Prize he said of his future plans, "Maybe I'll win another Nobel Prize - Madame Curie won two."[1]. Schally's journey is one of industrial-scale laboratory science, perseverance, and sheer bloody-minded competitiveness; a journey that started with Schally working as a technician.

Schally's childhood was defined by the Second World War and his Jewish heritage. Born in 1926; in Wilno, Poland* his father was a major general in the Polish army who left to join the Allied forces when the war broke out. Schally's father's government connections meant he was able to survive the Holocaust living among the Jewish-Polish community in Romania. In 1945 Schally travelled across war ravaged Europe to Edinburgh where he had to assimilate to a new culture, a new language, and attend school to prepare for university.

Andrew Schally (photo credit: nobelprize.org)

Aged 20, he enrolled to study chemistry at the University of London. His passion for chemistry was already present and disrupted the training which may have resulted in an alternative career as a football goalkeeper. He showed early promise as a chemist and, on graduation, he gained a prestigious job as a technician at the National Institute of Medical Research in Mill Hill.

Mill Hill was one of the leading centres for biological research in England and the two and a half years Schally spent there as a technician at Mill Hill were truly formative. The other scientists at Mill Hill made him feel that his work was appreciated and they helped him develop technical expertise, an understanding of the philosophy of research, and a systematic approach to scientific investigations. Of this time, he has written, "I endured my 'baptism of fire' in medical research and became addicted to it." [1]

Mill Hill could not hold Schally's level of ambition and so in 1952 he moved to Montreal to become a technician, and later a PhD candidate in the Allan Memorial Institute for Psychiatry at McGill University. According to *The Nobel Duel*, a book about Schally's quest for the Nobel prize, the head of the laboratory at McGill, Murray Saffran, returned from a trip away to find "a new technician who paid no heed to the clock with his enthusiasm and even worked without interruption while nursing a broken foot." [2] Saffran involved Schally in a project looking at hypothalamic hormones and even put Schally, who was still a technician at the time, as second author on two papers that came from the work. This was Schally's first taste of the topic that would define his career, the search for the mysterious hypothalamic hormones.

These hormones were the subject of a controversial theory that had been put forward by British anatomist Geoffrey W. Harris. Harris had suggested that part of the mammalian brain, known as the hypothalamus, used signal chemicals, called hormones, to control the pituitary gland and so the endocrine system. The endocrine system is the collection of hormone releasing glands: including the pancreas, ovaries, and testes. Previously, it had been believed that the brain's control over the pituitary gland and endocrine system was via nerve cells. While Harris supported his hormone hypothesis with various anatomical experiments, he was unable to isolate or identify the hormones responsible. Schally devoted his life to the hunt for these hypothalamic hormones knowing that whoever isolated, identified, and characterised these hormones first would stand a very good chance of winning the Nobel Prize. He was not the only one to enter what was to become a race for the ultimate scientific prize.

Houston-based Roger Guillemin had already entered the race and, in 1957, after Schally received his doctorate in endocrinology he decided the most effective way to continue his research was to join forces with the competition. Guillemin, a physiologist, was working on finding and extracting hormones from brain material. He needed a biochemist to purify and identify the structure of the hormones. Schally was perfect for the role. Initially, both seem to have

been impressed with the other's qualifications and commitment. However, after five years' hard work they had made little progress. Arguments over priorities, a series of poor decisions, some bad luck, and a fair amount of arrogance left them with little publishable science and a deep hostility towards one another. It was a hostility that would guide and energise their future work and in 1962 push Schally to New Orleans to form his own team and start his own campaign.

Professor Andrew V. Schally, Ph.D., M.D.h.c., D.Sc.h.c (photo credit: miami.edu)

The acrimonious nature of the split meant that collaboration was clearly no longer an option. The two teams soon became locked in a neck and neck race. However, it was to be a race held in slow motion as the first breakthrough would not come for seven years. Schally won the first heat; he was the first to extract and identify the structure of the hypothalamic hormone known as TRF. However, it was close: in this seven-year race Schally's paper came out only six days before Guillemin's. The competition continued in the same way, with one pulling ahead and the other pipping him to the post, their competitive personalities driving them on day after day. However, it was usually Schally who got there first.

According to *A Nobel Duel*, socially the two scientists were quite different. Schally was blunt and single minded, while Roger Guillemin was an urbane conversationalist with interests outside the laboratory.[2] However, when it came to their work they were more similar than they might have wanted to admit. Both were forceful and aggressive, practical men who were well-suited to the technical, rather than imaginative, task of pursuing control hormones. The minuscule amount of hormone present in each hypothalamus meant that it was tedious, expensive, industrial-scale biotechnology. Tens of thousands of sheep and pig hypothalamuses were required to collect just a few milligrams of pure hormone. At times, Guillemin and Schally spent more time in slaughterhouses than they did in their laboratories. For one experiment, Guillemin collected half a million sheep hypothalamuses. The experiment failed. Schally, with smaller resources, made do with a paltry 200,000 pig hypothalamuses at a time for his experiments. These were battle-like campaigns, not mere science experiments.

What is often forgotten about Nobel Prize winners is that there is the team of people behind them. This is never truer than with Schally and Guillemin. Neither man invented the techniques they used in their hunt for the hypothalamic hormones. For the most part, they adapted existing techniques, or at least their teams did. Their achievements were as much about fundraising to pay for their team as time at the laboratory bench; a point that Schally seems to have been much more willing to admit than Guillemin – possibly as a result of his time as a technician. Schally directed his research as his father may have directed his troops, knowing when to deploy each unit for the maximum effectiveness. He fought head-on and took few prisoners.

The whole process was a massive gamble, staking huge amounts of time, money, and multiple careers. Neither knew whether Harris's theory was correct. In fact, neither knew whether the hypothalamic hormones were there at all and certainly not whether they would be the one to find them. Both made enormous and costly errors and it is unclear whether it was the Nobel Prize, the science, or their mutual hatred drove them forward.

Whatever the motivation, they shared the ultimate accolade, they proved Harris's theory and, may be more importantly for them, won the Nobel Prize. They shared the 1977 prize for their work "for their discoveries concerning the peptide hormone production of the brain"[1]. Schally put his success down to his grounding in the learning of the fundamentals of the scientific method during his time as a technician in Britain. This grounding, and Schally's drive and determination, got him where he wanted to go...well, nearly. Both Schally and Guillemin might have won the Nobel Prize, but they were denied the ultimate victory that they both craved: the final triumph over the other.

Author

Andy Connelly is a technician and laboratory manager in the School of Earth and Environment at the University of Leeds. Alongside his day jobs, Andy has been writing and publishing both academic papers and popular science articles since 2007. His articles have appeared in *Physics World, Physics and Chemistry Review*, and on **Guardian.co.uk.** More recently, he has focused on practical science for his blog (**andyjconnelly.wordpress.com**) and writing about technicians, recent, historical, and fictitious.

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Building your own Raspberry Pi microscope: a technical team project

Tim Self

Tim Self, Seema Rajani, Robert Markus, Ian Ward, Denise Mclean, and Chris Gell - all of the School of Life Sciences imaging (SLIM), University of Nottingham.

Introduction

Since the invention of one of the first microscopes in the 1600s by Antonie van Leeuwenhoek, microscopy and imaging have been instrumental in many of the advances in science and scientific research. The microscope is a familiar tool to both research scientists and teaching staff in universities, whereas the teaching of microscopy is often seen as difficult and expensive to do in schools. An understanding of microscopy and its application can allow one to enter a wonderful and beautiful world beyond the limits of one's own eyesight. The School of Life Sciences Imaging (SLIM) team are all passionate and enthusiastic microscopists and wanted to bring this fascinating microscopic world to schools and the general public through "a build your own microscope" project.

The inspiration initially came from Kenji Yoshino's idea of building a simple microscope using a smartphone (**http://makezine.com/projects/smartphone-microscope**). Tim Self took his slant on the idea to the SLIM team and following a number of group discussions it was modified and refined into the solution I describe here, namely, a simple yet unique microscope using a Raspberry Pi computer running Linux with a built in camera plus a few nuts and bolts, Perspex and MDF. The step change from my original idea came when Robert Markus proposed the replacement of the smart phone with a Raspberry Pi computer with a camera and lens. Sitting with a piece of paper and pencil we sketched out a design that could create an upright or inverted Raspberry Pi microscope as well as a smart phone microscope. This model provides a simple and flexible imaging system from scratch using inexpensive components in order to develop an understanding of basic physics, biology and computing.

I subsequently wrote a proposal and submitted it to the University of Nottingham for a widening participation award which was successful and provided funds to make a number of microscopes to take to local schools and public outreach activities.

The project had a number of aims:

- To inform the students about how imaging is used at the University of Nottingham to conduct research into health and disease.
- To engage them and inform them that they too could follow a career in science at a range of levels and qualifications.
- To promote an interest in biology, technology and physics through practical exercises, with the exercises leading to enhanced teamwork and the production of images.

A number of the SLIM team had also recently qualified through the Associate Teachers' Programme (ATP) and saw the project as an opportunity to put some of the teaching methods they had learnt into practice. Seema Rajani took this on board and created a number of detailed lesson plans for both year 6 and year 10 students.

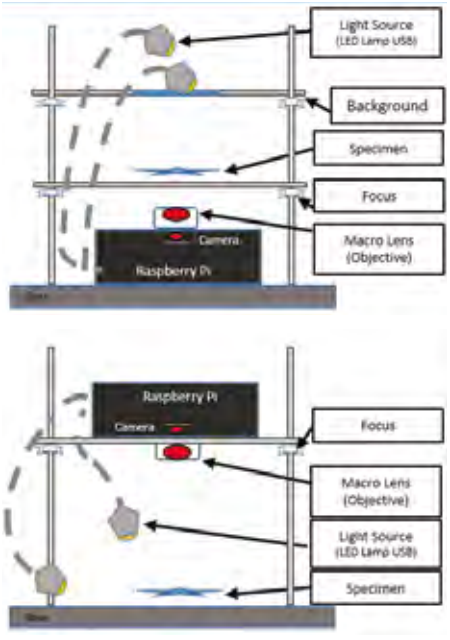

Fig1: Raspberry Pi microscope set up options.

The project in action at primary and secondary schools

The SLIM team have visited several schools in the past year to run practical sessions on the raspberry pi microscope. Target groups for the project were primary years 5/6 and secondary years 9/10, deemed to be optimal age groups during the planning stage. The students are given an introduction to microscopy and the lesson aims before building the microscope system in small groups (assisted through demonstrations and full written instructions). Upon completion of the microscope the students are given a range of biological samples such as cumin seeds, sand, flying ants and pond water to look at with the microscopes and capture/save those images using simple Linux commands on the raspberry pi computer. They are also encouraged to be creative in how they acquire the images and to image samples from the environment around them.

Fig 2: Raspberry Pi in action

The images allowed us to assess how well they were completed and the quality and range of the images produced.

The students were encouraged to experiment and to be creative in the specimens they used and how they imaged them with guidance from the SLIM team and school teaching staff.

Each visit would commence with an introductory talk about the history of the microscope, who we are, and an outline of the lesson. Members of the SLIM team took it in turns to lead the visit and to give the opening presentation. The students would then build the microscope under the guidance of a SLIM team member and then commence acquiring images and movies. After imaging the samples provided by us the students were encouraged to go outside to collect specimens of their own and to think of creative ways to image them.

Promoting and expanding the project

All schools who take part in the project are provided on request with an on-line teachers pack to enable the school to build the microscope and to continue the project into the future. We are also in the process of training post-doctoral (PD) and post-graduate (PG) scientists to undertake the project, so that it continues to grow and to also provide new ideas and directions from a talented group of research scientists. The training of the PD & PG scientists is being conducted by the SLIM team and going forward will eventually only necessitate one of the SLIM group to be present during an outreach visit.

Concluding remarks

Bringing a talented team such as SLIM group and involving them in a project such as this has resulted in a rewarding dynamic where the application of their experience and knowledge of microscopy and the new ideas they had learnt during their ATP course has led to a really successful project. I have new plans in mind to develop the project further that will build on the experience gained over the last year.

Author

Tim Self, Head of SLIM- School of Life Sciences Imaging Facility, Faculty of Medicine & Health Sciences. Tim has spent his professional life applying microscopy and preparation techniques to answer complex scientific and biological research problems. He has roles in academia and for the Medical Research Council where he has supported full time research projects alongside setting up and developing high end imaging facilities at each institution. He has acted as advisor for Zeiss, Molecular Devices, Phasefocus, Nikon, BBSRC on a number of occasions.

Tim is a founder member of UK Light Microscope Facility Managers Group and UkBioImaging. He is also Chair of the University of Nottingham Facility Manager Group and organised the inaugural Zeiss Elyra Super Resolution user group meeting in 2017.

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Titanium production in molten electrolytes

Charles Osarinmwian

Recent years have witnessed advances in the solid state electro-deoxidation of TiO_2 to Ti in $CaCl_2$ melt[15]. Here, a description is given of the effect of thermodynamics, kinetics, and molten electrolyte on the electro-deoxidation of TiO_2 as well as an outlook on the development of the Fray-Farthing-Chen process. This innovation will make Ti cheaper if the Fray-Farthing-Chen process can be scaled up[6].

Introduction

The production of Ti sponge, using the pyrometallurgical Kroll process, is of strategic importance owing to its usage in manufacturing Ti alloys for aerospace and defence applications. However, the Ti industry has a long history of seeking low cost Ti production processes in combination with low cost direct consolidation or powder metallurgy production routes. The latter is a mature commercial metal-forming technology with the intrinsic advantage of near-net-shape capability; the drive for near-net Ti manufacture is associated with the traditionally high buy-to-fly ratio of Ti components[7,8]. In contrast to current incumbent technologies for Ti production, the Fray-Farthing-Chen process is a simple, inexpensive, and environmentally friendly process capable of directly producing Ti from the electro-deoxidation of titania ore. In particular, this process could reduce the *cradle-to-gate* environmental impacts for Ti production by 30-35% relative to the Kroll process[9] and the buy-to-fly ratio of near-net-shape components and low cost powders in aerospace applications from 10:1 to 5:1[10].

Electrode Thermodynamics

Overall, electro-deoxidation can be described by the electron transfer half-cell reaction $TiO_2 + 4e^- \rightarrow Ti + 2O^{2-}$ in which the Nernst equation determines its thermodynamic feasibility:

1. $$E = E^o - \frac{RT}{nF} \ln \frac{a_{Ti} a_{O^{2-}}^2}{a_{TiO_2}}$$

where E is the electrode potential, R is the universal gas constant, T is the temperature of electro-deoxidation, n is the number of electrons transferred, a is the activity, and $E° = -\Delta G/nF$ is the standard electrode potential where ΔG is the standard energy change. The thermodynamic complexity of multivalent nature of Ti in $CaCl_2$ melt (Fig. 1) can be addressed using Ti-Ca-O-Cl predominance diagrams, where electrode potentials are plotted against negative logarithms of oxide-ion activity pO^{2-}, since they indicate whether electro-deoxidation is thermodynamically effective (i.e. high $pO^{2-} > 6$ and < 500 ppm oxygen in Ti at $a_{Ca} > 10^{-3}$) or severely diminished (i.e. low $pO^{2-} < 3$ and < 500 ppm oxygen in Ti at $a_{Ca} < 10^{-6}$) [11,12].

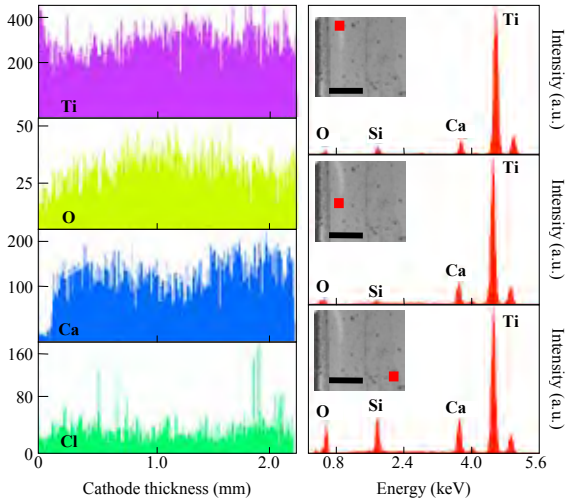

Fig. 1. Element line-scan and spot-analysis (X-EDS) across a polished cathode cross-section after electro-deoxidation. Scale bar: 100 µm.

The standard reduction potentials for the following anodic reactions describing electrochemical oxidation during electro-deoxidation are calculated from a thermodynamic database using a Ca/Ca^{2+} reference [13]:

2. $2Cl^- \rightarrow Cl_2 + 2e^-$ $\quad E^o = +3214$ mV

3. $2O^{2-} \rightarrow O_2 + 4e^-$ $\quad E^o = +2657$ mV

4. $C + 2O^{2-} \rightarrow CO_2 + 4e^-$ $\quad E^o = +1631$ mV

5. $C + 2O^{2-} \rightarrow CO + 2e^-$ $\quad E^o = +1541$ mV

However, little is known about anode reaction kinetics despite the application of Tafel reaction kinetics at the cathode. By using the anode reaction $O \rightarrow G^+ + e^-$ to describe Reactions 2-5, the kinetic equation at the assumed electroneutral, isothermal anode surface

can be derived from a linear flux-force relationship for the oxidant (O) converted to anodic gas (G^+). According to non-equilibrium thermodynamic theory, the excess entropy production rate at the anode surface gives the following macroscopic flux-force relationship[14]:

6.
$$j_a = -L_o\left(\Delta\varphi + \frac{\Delta G_s}{F}\right)$$

where j_a is the current density on the anode surface, $\Delta\varphi$ is the electric potential energy, ΔG_s is the Gibbs free energy change for the anode reaction, and L_o is an Onsager coefficient. Consistent with the second law of thermodynamics, the local entropy production rate, assuming that the anode surface is defined with excess thermodynamic variables (i.e. Gibbs surface) and local electrochemical equilibrium, gives the following mesoscopic flux-force relationship in reaction coordinate γ space[15]:

7.
$$j_a = -\frac{L(\gamma)}{F\Gamma}\exp\left(\frac{C+\varphi F}{RT_s}\right)R\frac{\partial}{\partial\gamma}\exp\left(\frac{\mu}{RT_s}\right)$$

8.
$$j_a = -\frac{R}{I}\left[\exp\left(\frac{\mu_2}{RT_s}\right) - \exp\left(\frac{\mu_1}{RT_s}\right)\right]$$

where $L(\gamma)$ is an Onsager coefficient in which the probability $P(\gamma)$ is a state variable in the thermodynamic sense[14], Γ is the excess surface adsorption of oxidant and anodic gas in γ space, C is the intrinsic barrier that the oxidant has to pass on its way to anodic gas, μ is the effective chemical potential; at equilibrium μ lies between μ_1 and μ_2. The integral I of the inverse mobility weighted with a Boltzmann factor is given by

9.
$$I = \int_1^2 u_+^{-1}\exp\left(\frac{C+\varphi F}{RT_s}\right)\mathrm{d}\gamma$$

where u_+ is a coefficient of transport describing the electric mobility for the motion of G in the complex e^-G in the polarized anode (i.e. the motion of the electron is not rate limiting). By deriving the Butler-Volmer equation from Eq. 8 [15] and assuming a large over potential, the far-from-equilibrium anode reaction is described by the anodic Tafel equation:

10.
$$j_a = j_{0a}\exp\left(\frac{\alpha_A nF}{RT}\eta_A\right)$$

where j_{0a} is the exchange current density, η_A is the anodic over potential, and α_A is the anodic transfer coefficient.

Current Efficiency

High electronic background currents in $CaCl_2$ melt (Fig. 2) incur low current efficiency and high electrolytic energy consumption during the electro-deoxidation of TiO_2 at voltages exceeding the decomposition potential of CaO.

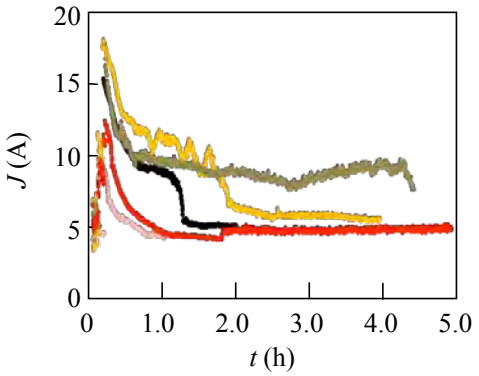

Fig. 2. Current-time plots for electro-deoxidation kinetics.

Electronic background currents in the bulk melt is inevitable since CaO decomposes at -2.6 V (applied potential = -3.2 V) leading to the detrimental dissolution reaction of Ca in the melt $Ca + Ca^{2+} \leftrightarrow (Ca_2)^{2+}$ [16]. At low Ca concentration (i.e. Ca mole fraction $x < 0.001$) in the melt, spin-paired electron states (or bipolarons) bind and localize in anion vacancies, which closely resemble *F*-centres, in the melt [17] with an electron pair exchange equilibrium $(Ca_2)^{2+} \leftrightarrow 2Ca^{2+} + e_2$ described by non-stoichiometric compound theory[18]. The diffusion of these electrons involves electron hopping between bipolarons as well as between different localised metallic M states according to

11.
$${}_AM(\mathrm{I}) + {}_BM(\mathrm{II}) \leftrightarrow {}_AM(\mathrm{II}) + {}_BM(\mathrm{I})$$

where *M* is Ca and/or other multivalent metals in which the front subscripts represent localized positions of the *M* states[19]. In contrast to polaron motion in solids, the hopping of bipolaronic electrons is likely to involve diffusive and vibrational ionic contributions from the melt. The activities of the melt are consistent with an ideal Temkin solution of $(Ca_2)^{2+}$ at low Ca concentration and negative relative partial molar entropy of Ca [18]:

12.
$$\Delta S_{Ca} = -R\left[\ln x + T(1-x)^2\frac{\partial A_2}{\partial T} + A_2(1-x)^2 + T\frac{\partial A_3}{\partial T} + A_3\right]$$

where A_2 and A_3 are temperature-dependent empirical parameters. Eq. 12 contributes to the positive deviation from an ideal Raoult solution (i.e. $\gamma_{CaO} > 1$) of the melt [20]:

13.
$$\gamma_{CaO} = \exp\left(\frac{8669 + 6.146T}{RT}\right)$$

where γ_{CaO} is the activity coefficient of CaO in $CaCl_2$

melt. Increasing Ca concentration (i.e. $x > 0.005$) during CaO decomposition exacerbates current inefficiency by lowering the contribution of repulsive Coulomb interaction between like ions [21] while inducing the equilibrium $e_2 \leftrightarrow 2e$. The latter is derived by subtracting equilibria at high and low Ca concentration in which the equilibrium constant is 4x and $(Ca_2)^{2+} \leftrightarrow 2Ca^{2+} + 2e$ at $x > 0.005$ [18].

The equilibrium $e_2 \leftrightarrow 2e$ indicates an increase in the van't Hoff factor between 1 and 2, a more positive ΔS_{Ca}, and an increasing degree of electron pair dissociation. The delocalized electronic states near the Fermi energy for increasing electron pair dissociation induce *metallic* melt behaviour via percolating bipolaronic clusters. These clusters preserve ionic stability in the melt despite alteration of the localised charge distribution. Hence, to improve current efficiency it is important to lower Ca concentration and carbon impurity levels in the melt by using inert anodes and pre-electrolysis under positive inert gas pressure [19].

Outlook

The random packing of porous TiO_2 preforms or powder particles (i.e. feedstock) on bipolar electrodes (Fig. 3) minimize settling, ordering, and alignment, which would otherwise hinder fluid and current flow through the feedstock.

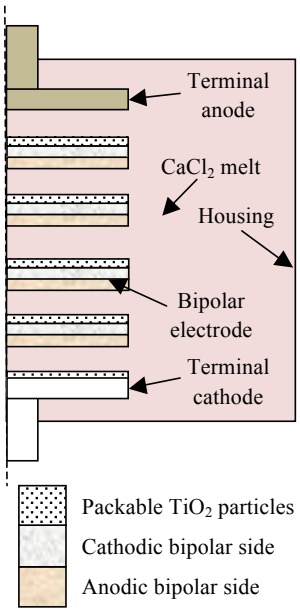

Fig. 3. Bipolar reactor containing 2-25 electrodes at a 20 cm inter-electrode gap with random packings of TiO_2 particles (62.5 µm-4 mm diameter) at a packing void space > 43%.

This also minimises the pumping pressure of $CaCl_2$ melt across the depth of feedstock[22]. Along with cost savings, this low pumping pressure requirement of the melt through the reactor could facilitate higher Ti productivity by the electro-deoxidation of greater feedstock depths. The large number of discrete points at a preform/bipolar electrode interface, attributed to the 50-80% void space (excluding microscopic porosity) and 600-1000 $m^2\ m^{-3}$ surface area to volume ratio of feedstock [22], could facilitate more uniform current distributions. Similarly, the random packing of 62.5 µm to 4 mm diameter synthetic and natural rutile ore particles facilitates fluid and current flow [23].

Apart from the supply and demand trends of the Ti market, it is necessary to consider the impact of technological innovations that could help to reduce the cost of Ti production[8]. In recent years, optimizing the balance of performance and cost of increased Ti productivity using predictive visualization models of reactor operations could help in scheduling movements around the reactor while optimizing the achievable throughput for commercial Ti products[24]. As the adoption of components fabricated via Ti powder metallurgy techniques becomes more prevalent over the next decade, especially in the field of additive manufacturing, there is a necessity to increase Ti powder production capacity from the current annual level of 6,000 tonnes per annum[25]. For instance, in the field of commercial aviation, a demand for more than 28,000 new large commercial aircraft on the global market is expected for the period of 2012-2031[26].

Electro-deoxidation could be applied in solid-state metal fuel production. This is an emerging technology since metal fuels, which present an inherently low safety risk and have high energy densities, have been proposed as advanced storage and transport systems for large quantities of clean energy[27]. It is probably fair to say that most of the "low-hanging fruits" of solid-state extractive electrometallurgy have already been harvested. Thus, the rotationally symmetric electrochemical reactor could aid further research into liquid-state extractive electrometallurgy including the direct production of metal in the liquid state from oxide feedstock[28] and in the scalable electrolysis of molten semiconductors[29].

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Applying for IST Fellowship

FIScT

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Fellows may be nominated (by two or more Executive members) and/or applications made on the designated form, which is available for download. Nominated candidates would be subject to the same review/assessment channels as per individual personal applications.

Derek Sayers FIScT IST Fellowship & Overseas Officer

Application forms and guidance documents can be downloaded at **(istonline.org.uk/membership/fellow).**
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Dozens of projects announced as EPSRC welcomes Year of Engineering

As the Year of Engineering gets underway, the Engineering and Physical Sciences Research Council (EPSRC) has announced support for 28 pioneering new research projects.

EPSRC, alongside the UK's other Research Councils and Innovate UK, is supporting the Year of Engineering, a year-long government-wide campaign to celebrate UK engineering and inspire a new generation into engineering careers.

Throughout 2018, hundreds of organisations across the UK will showcase the world of engineering and look to inspire the next generation of engineers by bringing young people face-to-face with engineering experiences and role models.

In January EPSRC announced an investment of £6.6 million through the Engineering for a Prosperous Nation call to support projects with potentially transformative impact in fields ranging from autonomous vehicles to energy storage and healthcare technology.

As part of the Engineering for a Prosperous Nation call, EPSRC encouraged bids for creative, novel engineering research projects with the potential to contribute to EPSRC's four "Prosperity Outcomes" for the UK.

Applicants submitted anonymous outline proposals before pitching their ideas in a Dragon's Den-style interview process.

Twenty-eight projects at 17 different universities have been supported, with grants awarded to researchers across all career stages and representing a diverse range of fields.

Research areas include the development of intelligent driver seats to act as co-pilots in autonomous cars; the use of diamond quantum technology to investigate neurological diseases such as Alzheimer's Disease; the use of novel materials to create artificial leaves for use in solar power generation; and the investigation of new solutions to antimicrobial resistance in wastewater systems.

EPSRC's Chief Executive, Professor Philip Nelson, said: "Engineers are creators, innovators and problem solvers; their pioneering work creates a better future for us all.

"EPSRC continues to invest in this vision by supporting the engineers of tomorrow, and the projects announced today are testament to our firm belief that novel, transformative research will help to make the UK a more prosperous nation.

"The Year of Engineering is a fantastic opportunity to celebrate the UK's proud heritage in this field and highlight the impact that engineering has on the UK and the world. Through this, we hope to inspire a future generation to continue and improve on that legacy in the future."

Full list of projects funded through the Engineering for a Prosperous Nation call:

- CoTRE – Complexity Twin for Resilient Ecosystems, EP/R041725/1
  Led by: Dr Weisi Guo, University of Warwick
- Randomness: A Resource for Real-Time Analytics, EP/R041431/1
  Led by: Dr Nicholas Polydorides, University of Edinburgh
- iSeat – Towards an Intelligent Driver Seat for Autonomous Cars, EP/R037795/1
  Led by: Dr Bani Anvari, University of Southampton
- Improving Protocol Standards for a More Trustworthy Internet, EP/R04144X/1
  Led by: Dr Colin Perkins, University of Glasgow
- Bandwidth and Energy Efficient Compact Multi-Antenna Systems for Connected Autonomous Vehicles, EP/R041660/1
  Led by: Dr Petros Karadimas, University of Glasgow
- Q-NEURO: Diamond Quantum Technology for the Investigation of Neurological Disease, EP/R034699/1

Led by: Professor Richard Jackman, UCL

- Healing Tissues via Programmable DNA Nanotechnology, EP/R041628/1
  Led by: Dr Ben Almquist, Imperial College London
- REALiTY: REmoving Allergens with pLasma TechnologY, EP/R041849/1
  Led by: Dr James Walsh, University of Liverpool
- Nanoparticle Imaging Method for Drug Discovery and Cancer Therapy in Humans, EP/R04192X/1
  Led by: Professor Richard Bayford, Middlesex University
- Born Slippy: A Tribological Discourse on Hysterosalingography as a Therapeutic Treatment for Infertile Women, EP/R041407/1
  Led by: Dr Karl Dearn, University of Birmingham
- Engineering Novel Imaging Technologies for Reproductive Health: Transforming IVF Outcomes, EP/R041814/1
  Led by: Dr Sumeet Mahajan, University of Southampton
- In-shoe Sensory Systems to Assess and Avoid Diabetic Foot Disease, EP/R041776/1
  Led by: Dr Pete Culmer, University of Leeds
- Automatic Cell Fate Engineering Using Microfluidics Devices, EP/R041695/1
  Led by: Dr Lucia Marucci, University of Bristol
- INSHEP: Intelligent RF Sensing for Falls and Health Prediction, EP/R041679/1
  Led by: Dr Francesco Fioranelli, University of Glasgow
- Artificial Transforming Swimmers for Precision Microfluidics Tasks, EP/R041555/1
  Led by: Dr Thomas Montenegro-Johnson, University of Birmingham
- When the Drugs Don't Work... Manufacturing our Pathogen Defences, EP/R036748/1
  Led by: Dr Candice Majewski, University of Sheffield
- Engineering Halide Perovskites for Artificial Leaves, EP/R035407/1
  Led by: Dr Salvador Eslava, University of Bath
- Bioinspired Green Manufacturing of Next Generation Energy Storage Materials, EP/R041822/1
  Led by: Dr Siddharth V. Patwardhan, University of Sheffield
- Freeform Composites: Breaking Free from the Mould, EP/R041733/1
  Led by: Professor Patrick Fairclough, University of Sheffield
- Ahead of the Curve: Engineering Simulation for Computers of the Future, EP/R04189X/1
  Led by: Dr Steven Lind, The University of Manchester
- Renaissance of Alloys: Nanocrystalline Bimetals, EP/R041768/1
  Led by: Professor Thomas Polcar, University of Southampton
- Carboglass: Transformative Engineering Materials for Reduced Energy and Waste Consumption, EP/R036225/1
  Led by: Dr Paul Bingham, Sheffield Hallam University
- Biopolymer Treatment for Stabilisation of Transport Infrastructure, EP/R041903/1
  Led by: Dr Paul Hughes, Durham University
- Tackling AMR in Wastewater Systems with Sneaky Bacteria, EP/R036705/1
  Led by: Professor David Graham, Newcastle University
- Harnessing Free Energy – the Microbial Way, EP/R041644/1
  Led by: Dr Jan Dolfing, Newcastle University
- Development of a Novel Self-healing Composite for Sustainable and Resilience Concrete Infrastructure, EP/R041504/1
  Led by: Dr Mingzhong Zhang, UCL
- SPINE: Resilience-based Design of Biologically Inspired Columns for Next-Generation Accelerated Bridge Construction, EP/R039178/1
  Led by: Dr Mohammad Mehdi Kashani, University of Southampton
- PLAIN-GG: Phase-Locked Atomic INterferometers for Gravity Gradiometry, EP/R041806/1
  Led by: Dr Matt Himsworth, University of Southampton

Year of Engineering

The Year of Engineering is a government campaign, which celebrates the world and wonder of engineering.

From spaceships to ice skates, the bubbles in chocolate bars to life saving cancer treatment, engineering touches every part of our lives. However, not enough young people – especially young women – think it's a world for them. As a result, the industry is struggling to recruit future talent. What's more, young people are missing out on the chance to make a positive difference to both their futures, that of the planet and everything that calls it home.

For further information visit the Year of Engineering website **yearofengineering.gov.uk**

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Registration is renewed each year with evidence of Professional and Personal Development. There is a small fee for admission to the Register and a nominal annual renewal fee.

First gas jet detection from a massive young star outside our galaxy

An international team of astronomers, including two STFC scientists, have made the very first detection of a jet from a very young, massive star in a galaxy that is not our own. The paper was co-authored by Pamela Klaassen, instrument scientist at the STFC's Edinburgh site, the UK Astronomy Technology Centre (UK ATC), and UK ATC's Head of Science Chris Evans.

Dr Klaassen said: "With this observation, we see that the details of star formation we see in our galaxy are also possible elsewhere, even when the conditions and material available are quite different to those we're used to."

Stars like the Sun are constantly forming in our galaxy and further afield in more distant galaxies. They form in predictable ways, emerging from their natal environment often surrounded by a system of planets which formed from a disk. Stars with more mass, upwards of eight times that of the Sun, are much rarer and their formation remains something of a mystery. These more massive stars form deep within their natal clouds of gas and dust and are generally too obscured to be visible with optical telescopes. Under the right conditions, it is sometimes possible to see a jet or outflow of expelled gas, but only if it's powerful enough to push out of the natal cloud. These narrow streams of gas move away from the forming star at high speeds – and often the bigger the star, the bigger and faster the jet.

Astronomical instruments like MUSE (Multi Unit Spectroscopic Explorer) on the European Southern Observatory's Very Large Telescope (ESO VLT) in Chile are vital for understanding these jets of gas.

Dr Klaassen said: "In this paper, we present the first evidence for such a jet from a young stellar object in another galaxy, the nearby Large Magellanic Cloud (LMC). The LMC has a lower abundance of "metals" (atoms heavier than hydrogen and helium) than our own galaxy, which means that the environment of the young star is less opaque than an equivalent region in the Milky Way helping make this detection robust.

"The jet spans about 36 light years (or 11 parsecs), which makes it among the largest jets of its kind ever found. The star powering the jet appears to be about 12 times as massive as the Sun, and its velocity structure was revealed by the high spectral resolution of MUSE – we know which part of the jet is angled towards us, and which is angled away."

The data used for this work comes from the VLT in Chile's Atacama Desert, which is among the largest optical telescopes in the world and is one of the most competitive telescopes on which to obtain precious observing time. It is only with this kind of instrument that this could be done; regular instruments would not have detected the jet. The VLT can detect objects roughly four billion times fainter than can be detected with the naked eye.

The project team was led by Dr Anna McLeod from the University of Canterbury in New Zealand, who says this discovery will drive significant advancement in the field of star formation: "The formation mechanism of massive stars was predicted three decades ago and involved an accretion disk, similar to how their lower-mass siblings form. Over the years numerical simulations were produced which support this scenario. Recently there has been some initial observational evidence that this might indeed be the case. In our paper, we present compelling evidence that high-mass stars form in a similar way to Sun-like stars.

"We have detected a very young and still forming massive star – a so-called young stellar object – which is launching a bipolar jet. The jet is direct evidence for what we call an accretion disk, i.e. a disk around the equator of the star through which the star is gathering matter and thus growing, which is what we see in low-mass stars."

This discovery brings direct evidence that massive stars up to 12 times that of our Sun form like low-mass stars. More information is available on the University of Canterbury website.

Bacteria block transmission of Zika and dengue viruses

Scientists at the University of Glasgow's MRC Centre for Virus Research (CVR) have found a bacterial strain which blocks dengue and Zika virus transmission from mosquitoes.

In a new study, published in *PLOS Pathogens*, the scientists show that a novel strain of the inherited bacteria, called Wolbachia, strongly blocks transmission of dengue and Zika virus in infected mosquitoes. This finding could offer a potential alternative to strains already being tested as virus control tools.

The scientists have already carried out the research in the mosquito species *Aedes aegypti*, notorious for spreading several dangerous human viruses, including dengue, Zika and chikungunya.

Previous research in the scientific community has shown that transmission of these viruses among mosquitoes is stalled if the flies are deliberately infected with one strain of Wolbachia bacteria. With this knowledge, several countries are testing whether infecting local mosquito populations with Wolbachia could lead to lower rates of viral disease in humans.

This time, the MRC scientists in Glasgow found that a novel strain – called "wAu" – is even more effective for virus transmission blocking than the strains currently being used. The effect is emphasised in hot, tropical climates where there is a high prevalence of these diseases.

Lead researcher, Professor Steve Sinkins, specialising in microbiology and tropical medicine at the MRC CVR, said: "The Wolbachia transmission blocking strategy shows great promise for the control of mosquito-borne viruses, and is now starting to be deployed on a large scale in a number of tropical countries.

"Our results with the wAu strain showed by far the most effective transmission blocking for all the viruses we tested, and it provides an exciting new option to explore for disease control programmes."

Several Wolbachia strains have already been tested in the field, but there is evidence to suggest that some strains may not block transmission very effectively or may not be inherited efficiently at high ambient temperatures. In the new study, the research team performed laboratory experiments to test the potential promise of alternative Wolbachia strains.

The researchers introduced four Wolbachia strains into *Aedes aegypti* mosquitoes, which do not naturally carry these anthropod-infecting bacteria. Two of the strains, wMel and wAlbB had already been evaluated in prior studies, and the scientists wanted to compare their effects with those of two novel strains, wAu and wAlbA.

The analysis revealed particularly promising results for strain wAu. After feeding on blood infected with dengue or Zika virus, mosquitoes infected with wAu had lower levels of viral RNA in their body tissue than did mosquitoes infected with the other strains. wAu also showed very high rates of inheritance, including under high-temperature conditions.

Professor Sinkins holds a Global Challenges Research Fund (GCRF) grant, which is jointly awarded by the Biotechnology and Biological Sciences and Medical Research Councils (BBSRC and MRC). With the funding, he will lead a global network studying vector-borne diseases, such as malaria, dengue and Zika. The goal is to reduce and block the transmission of pathogens by releasing specific insect disease vectors.

Dr Jonathan Pearce, Head of Infections and Immunity at the MRC, said: "This is incredibly relevant research with implications that can be applied to pressing issues on the ground in many parts of the world. These findings may be the key to uncovering a new tool in the fight against the spread of mosquito-borne diseases.

"Meanwhile, the international network is pulling together experts from a wide range of scientific disciplines to exchange knowledge and brainstorm promising new ways to target vector-borne diseases."

Future research could explore strategies to maximize the effectiveness of wAu in the field, such as combining it with a second strain to help it spread throughout local mosquito populations.

The study, "The Wolbachia strain wAu provides highly efficient virus transmission blocking in Aedes aegypti"was funded by Wellcome and the MRC.

Insight into heavy periods could pave the way towards new treatment

Scientists from the MRC Centre for Reproductive Health at the University of Edinburgh have uncovered a cause of heavy menstrual bleeding – a finding that offers hope for a new treatment for women living with the condition.

Researchers at the unit identified a key protein that could explain why heavy bleeding occurs, paving the way for potential treatments that avoid the need to take hormones. For their study the researchers studied the womb lining, known as the endometrium. This is shed during menstruation, leaving behind a wound-like surface that must heal to limit blood loss. They discovered that lowered levels of oxygen – known as hypoxia – stimulates production of a protein called HIF-1, which drives repair of the womb lining.

The findings showed that Women with heavy periods had reduced levels of HIF-1 compared with women with normal blood loss.

Tests on mice using a drug to boost levels of HIF-1 led to improved tissue repair and reduced blood loss. The results offer hope for therapies, the scientists say.

Study lead author, Dr Jackie Maybin, Clinical Lecturer in Obstetrics and Gynaecology at the MRC Centre for Reproductive Health, said: "Our findings reveal for the first time that HIF-1 and reduced levels of oxygen in the womb are required during a period to optimise repair of the womb lining. Excitingly, increasing levels of the HIF-1 protein in mice shows real promise as a novel, non-hormonal medical treatment."

Heavy menstrual bleeding is one of the most common reasons for visiting the gynaecologist – about 20 to 30 per cent of pre-menopausal women deal with heavy bleeding, according to the researchers. Over 800,000 women per year seek treatment in the UK alone. The medical term for heavy periods is "menorrhagia".

Diagnosing heavy menstrual bleeding can be subjective, but the medical community defines it as blood loss of more than 80 millilitres per menstrual cycle.

The condition can lead to severe anaemia – where there are not enough red blood cells to carry oxygen around the body. It can lead to severe abdominal pain and disrupt daily life, as well as giving rise to other symptoms, such as bloating, unscheduled bleeding, and fatigue.

Current therapies to ease heavy bleeding are hormone-based and often prevent pregnancy. Hormonal treatments can result in side effects and in many cases, women experiencing heavy periods may have to undergo a hysterectomy. The researchers say there's a "clear, unmet" need for treatment that doesn't tamper with hormones and fertility.

Dr Neha Issar-Brown, Head of Population and Systems Medicine at the MRC, welcomed the findings: "Heavy bleeding is a debilitating condition that a staggering number of women have to live with. Unfortunately, there aren't many therapies to help alleviate discomfort from menorrhagia which, added to the obvious emotional impact, can severely impact women's day-to-day activities and well-being.

"This research, spearheaded by the MRC Centre for Reproductive Health, lays the much needed groundwork to developing new treatment options for women grappling with this condition. The fact that preliminary results suggest no interference with fertility makes it even more promising."

The study, published in Nature Communications, was primarily funded by Wellcome with support from the MRC, the Academy of Medical Sciences and Wellbeing of Women.

Air quality research supersites set for Manchester, Birmingham and London

A new network of advanced air quality monitoring instruments will detect harmful air pollutants and their sources in greater detail than ever before at existing research sites in three UK cities.

Three urban air pollution research laboratories, or "supersites", are expected to be operational in London, Birmingham, and Manchester by the end of 2018. The new equipment will allow researchers to gather higher-quality data on the content of harmful urban air pollution and where the gases and particles that pollute our air are coming from.

Funded by the Natural Environment Research Council (NERC), the £4·3million investment will see eight universities led by the NERC Centre for Atmospheric Science (NCAS) set up and run the new equipment. As well as sensors to detect toxic air pollutants, the investment will include new instruments to detect a variety of greenhouse gases and ozone-depleting chemicals. These will be placed at a range of UK tall tower and coastal observatories run by the universities of Bristol, East Anglia, and Edinburgh. This will help the UK comply with legally-binding targets set out in the Climate Change Act.

On top of NERC's funding through the Department for Business, Energy & Industrial Strategy (BEIS), the Department for Transport (DfT) has funded £600,000 for new training and research posts to work on the enhanced air pollution monitoring sites and vehicle emission testing equipment.

Science & Research Minister Sam Gyimah said:

"The establishment of the air pollution research supersites highlights our commitment to improving air quality, enhancing our public health as well as tackling the growing threat of climate change to our environment. We have put research and development at the heart of our modern industrial strategy by increasing R&D funding by £2·3 billion to 2022 and these enhanced laboratories, spread across the country, will showcase our world class scientific expertise in developing solutions to global challenges."

Climate Change Minister Claire Perry said:

"The UK is a world leader in tackling climate change, and monitoring our greenhouse gas emissions underpins the government's commitment to the

Climate Change Act and the Paris Agreement. Our Clean Growth Strategy sets out how we plan to reduce emissions through the 2020s, and further research into tackling air pollution will not only improve our health, it will help us meet our climate change targets."

Professor Alastair Lewis of NCAS, science coordinator for the investment, said:

"Air pollution in cities doesn't just come from the exhaust fumes from cars, lorries, and other vehicles. It also comes from our homes, cooking, industry, and commerce, generating energy and other sources. We still don't know exactly which sources release the nitrogen dioxide and particles we find in our city centres. Improving air quality in UK cities is a national priority and challenging targets for cutting emissions are in place over the next decade. It is vital to strengthen the scientific evidence needed to design solutions that will be successful in cleaning up our air.

"This new research infrastructure will complement the programmes of air quality and emission measurements being made across government, by Defra, the Department for Transport and BEIS. Combining new data from the UK's leading research institutions in air pollution with the data from government will create a very powerful and insightful evidence base."

The supersites will include a range of advanced instruments (that detect the individual chemicals contained inside atmospheric particles) to measure the size and physical properties of particles, and identify volatile organic chemicals, nitrogen, and sulphur oxides and greenhouse gases. In addition, detailed meteorological information will be collected along with new measurements of vehicle emissions under real-world conditions. All the data generated will be open-access and, for most measurements, will be available to the public via a website in real-time.

The Manchester site will be located in the Botanical Gardens on the Fallowfield Campus of the University of Manchester. In Birmingham, the new air pollution equipment will be installed on the University of Birmingham campus in Edgbaston. Two potential sites in London are currently being considered with a decision due in February following completion of technical assessments. The potential sites are the Defra North Kensington site and a research site at the King's College London campus.

The consortia of universities to receive funding are King's College London, University of Manchester, University of Birmingham, University of Bristol, University of York, University of Cambridge, University of East Anglia, and the University of Edinburgh.

The Faraday Institution announces £42 million for energy storage research

In January 2018 The Faraday Institution announced up to £42 million in new government funding to four UK-based consortia to conduct application-inspired research aimed at overcoming battery challenges to accelerate the electric vehicle (EV) revolution.

If successful, this research will put the UK on the map as being at the forefront of battery technology worldwide. It has the potential to radically increase the speed with which we are able to make the move to electric vehicles, as well as the speed with which we can decarbonize our energy supply, with obvious benefits to the environment.

The Faraday Institution is the UK's independent national battery research institute, and was established as part of the government's £246 million investment in battery technology through the Industrial Strategy. Its formation was announced in October 2017 by the Business Secretary Greg Clark.

The Faraday Institution's goal is to make the UK the go-to place and world leader for battery technology research and it has a clear mission to ensure the UK is well placed to take advantage of the future economic opportunities from this emerging technology.

Business Minister Richard Harrington said, "With 200,000 electric vehicles set to be on UK roads by the end of 2018 and worldwide sales growing by 45 per cent in 2016, investment in car batteries is a massive opportunity for Britain and one that is estimated to be worth £5 billion by 2025. Through our flagship Industrial Strategy and its Future of Mobility and Clean Growth Grand Challenges, we are committed to making Britain the 'go-to' destination for the development and deployment of this game-changing technology. Government investment, through the Faraday Institution, in these projects will deliver valuable research that will help us seize the economic opportunities presented by battery technology and our transition to a low-carbon economy."

The topics for the four projects were chosen in consultation with industry, who will partner closely with each of them. This unique collaboration will help to ensure that the research is producing findings and solutions that meet the needs of business. In addition, industrial partners will contribute a total of £4.6 million in in-kind support to the following four projects:

Extending battery life

Led by the University of Cambridge with nine other university and 10 industry partners, this project will examine how environmental and internal battery stresses (such as high temperatures, charging and discharging rates) damage electric vehicle (EV) batteries over time. Results will include the optimization of battery materials and cells to extend battery life (and hence EV range), reduce battery costs, and enhance battery safety. With Cambridge, university partners include University of Glasgow, University College London, Newcastle University, Imperial College London, University of Strathclyde, University of Manchester, University of Southampton, University of Liverpool and Warwick Manufacturing Group.

Battery system modelling

Imperial College London (ICL) will lead a consortium of six other university and 17 industry partners to equip industry and academia with new software tools to understand and predict battery performance, by connecting understanding of battery materials at the atomic level all the way up to an assembled battery pack. The goal is to create accurate models for use by the automotive industry to extend lifetime and

performance, especially at low temperatures. With ICL, university partners include University of Southampton, Warwick Manufacturing Group, University of Oxford, Lancaster University, University of Bath, and University College London.

Recycling and reuse

A project led by the University of Birmingham, including seven other academic institutions and 14 industrial partners, will determine the ways in which spent lithium batteries can be recycled. With the aim to recycle 100% of the battery, the project will look how to reuse the batteries and their materials, to make better use of global resources, and ultimately increase the impact of batteries in improving air quality and decarbonisation. With Birmingham, university partners include the University of Leicester, Newcastle University, Cardiff University, University of Liverpool, Oxford Brookes University, University of Edinburgh, and the Science and Facilities Technology Council.

Next generation solid state batteries - The University of Oxford will lead an effort with six other university partners and nine industrial partners to break down the barriers that are preventing the progression to market of solid-state batteries, that should be lighter and safer, meaning cost savings and less reliance on cooling systems. The ambition of this project is to demonstrate the feasibility of a solid state battery with performance superior to Li-ion in EV applications. With Oxford, university partners will include the University of Liverpool, University of Glasgow, University of Strathclyde, University of Cambridge, University College London, and the University of St. Andrews.

Peter B. Littlewood, founding executive chair of the Faraday Institution, said: "To deliver the much needed improvement in air quality in our cities and achieve our aspiration for cleaner energy targets we need to shift to electric vehicles quickly. These research programmes will help the UK achieve this. To be impactful on increasing energy density, lowering cost, extending lifetime, and improving battery safety requires a substantial and focused effort in fundamental research. Through steady investment in basic research on specific societal challenges identified by industry and government, the UK will become a world-leading powerhouse in energy storage."

Professor Philip Nelson, EPSRC's Chief Executive, said: "There is an urgent imperative for us to increase the efficiency of energy storage as we move towards low-carbon economies and attempt to switch to clean methods of energy production. The Faraday Institution will bring leading academics in the field of battery development together with industry experts to explore novel application-inspired approaches that will address the challenges we face. The UK has an opportunity to accelerate the development of new products and techniques. EPSRC will be working with the Institution and the academic community to help it succeed and keep the UK a prosperous and productive nation."

Richard Catlow, Foreign Secretary of the Royal Society and professor at University College London, said: "Using more electricity will be key in reducing greenhouse gas emissions. Last year the European Academies Science Advisory Council found that advances in large-scale electricity storage is a priority to manage our increasing dependence on renewable energies. The Royal Society welcomes the Faraday Institution's much needed investment in energy storage research."

The "Faraday Battery Challenge" is to develop and manufacture batteries for the electrification of vehicles - £246 million over four years - to help UK businesses seize the opportunities presented by the move to a low-carbon economy. The challenge will be split into three elements: research, innovation, and scale-up. It is among the first of six investment areas announced by the government to be funded through the Industrial Strategy Challenge Fund.

Zoology Robotics Medicine IT Music Psychology

iST

Chartered Scientist
Registered Scientist
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Registered Science Technician
IST CPD Award

Art and Design Earth sciences Materials Social science Biology Biomedical Neuroscience Physical sciences Life sciences Marine biology Interdisciplinary Engineering Graphic design Criminology Physics Applied science Environmental Food Technology Healthcare Chemistry Arts and Media Forensics Software AI Immunology Space sciences Textiles Technology

Leading Your Technical Team

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

Leading Your Technical Team & Building on Your Leadership Skills

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 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.

Leading Your Technical Team has a long and well respected history. It has been running for over 30 years with more than 2,000 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 programmes 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.
- Influencing skills and analysing your network.
- Managing and leading your team through change.
- People management issues & case studies.
- Emotional intellegence and its effect on leadership and team members.

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 instituion 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 leading, 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.

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 instituion 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 Oxley

Kevin is the Programme Director for the LYTT & BYLS courses, which are now run through the Institute of Science & Technology (IST). He is the Head of Technical Services in the Faculty of Health Sciences at the University of Hull. He began his career at the University of Sheffield as a trainee Medical Laboratory Scientific Officer over 38 years ago and has subsequently experienced a series of diverse technical roles within the Medical School. Over the last 17 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 university wide in Sheffield before moving to Hull in May 2018. Kevin is actively involved in both promoting and delivering staff development and training at Sheffield and Hull. Kevin is a member of the Executive Board at the IST and promotes and assesses Professional Registration for both the IST and the Science Council.

Lisa Woods

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

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IST

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.

For Dhanisha, being a lab technician is more than a career, it's a state of mind.(Credit: Technicians Make it Happen)

Technicians Make it Happen

Technicians are the lynchpin of our economy and yet we continue to face a chronic technical skills shortage in the UK.

Technicians Make it Happen seeks to inspire the nation's next generation of makers and creators and celebrate the 1.5 million technicians working across the UK.

Front cover

Jane: Senior Technician Jane uses her knitwear knowledge to stitch ideas together.

Gabriel: Gabriel writes the code that unlocks the awesome potential of wind power.

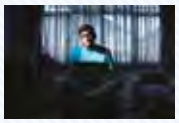
Sally: To find her ideal job as a Horticultural Technician, Sally simply followed her passion.

Inside front cover

Anjna: Anjna is an award-winning school Senior Science Technician, but her real reward is the success of her students.

Back cover

Lauren: From a Saturday job to saving lives, Pharmacy Technician Lauren's medicines help give children a fighting chance.



Yogi: Software technician Yogi has always loved a challenge. Now he's using that drive to start his own business.

Camile: At the National Theatre in London, Scenic Metal Fabrication Apprentice Camile puts the pieces together.

Inside back cover

Andrew: From school leaver to award winner, Veterinary Technician Andrew is at the top of his field.

For more information go to: ***technicians.org.uk***

Production: touchpointdesign.co.uk

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