The Institute of Science & Technology

The Journal

Autumn 2016

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The Journal

The Official Journal of The Institute of Science & Technology

Autumn 2016

The Professional Body for Technical, Specialist, and Managerial Staff

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Editor's welcome

Welcome to the autumn 2016 edition of the IST's Journal.

Ian Moulson
Editor

I hope that you enjoy reading this edition. It's one that is packed with interesting and varied articles. My thanks, as always, to each and all of the contributors – please keep your articles and papers coming in. We welcome article submissions from all areas of technical interest, not just pure and applied science, but 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 any 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.

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

Summer 2016
IST newsletter

Our IST One Day Technical Conference, this year held in Manchester, was a terrific success. It was an outstanding overall team performance by our sponsors, our speakers, our workshop presenters, our organising team, our volunteers and helpers on the day, and of course our delegates. Everyone played their part in making the whole day run absolutely brilliantly. Well done all – and thanks to delegates for the encouraging feedback.

At the conference I had an interesting conversation with some of our delegates about how people in the UK rightly or wrongly perceive the role of technician. It led me on to do a little bit of research, and interestingly I discovered a 2011 EU funded research project [1] where one of the their initial tasks was to define the notion of technician, because the meaning of the noun technician did vary across partner countries. And as you know, as linguists will tell us, the actual meaning of words is not presented in dictionaries, but is generated by the society and people who use the words and develop their meaning within a particular context.

For example, in Germany they found that *technician* is defined as "a technician is an expert in the field of technique", or a person who works in a technical profession. It is also considered a professional title, which means a person has a degree from a technical school/technical college in conjunction with the stipulated practical experience.

In Italy *technician* is also classified as a profession, and is defined as a person who is particularly competent in an art, science, or discipline or other activity chiefly in its practical use. Currently, the definition of technician is also given to specialised independent workers, artisans and workers (and in the army to troops and non-commissioned officers), whose competence is based not only on experience and traineeship but also on short educational classes with practical purpose. In the educational sector, a technician is a specialised person working for the upkeep and operation of the equipment necessary for teaching some subjects, or cooperating, within the university, for the implementation of medical, scientific, didactic and administrative activities.

And in Spain *technician* is characterised as someone who belongs, or is related to the world of science and the arts. The term is used to refer to people with extraordinary abilities and talents in the performance

Attendance at our 2016 conference filled the Manchester Conference Centre's main theatre.

of a task. In addition to this, a technician is also a person who has skills or abilities to perform different tasks from knowledge.

So what did they find in the UK? They found that *technician* is described as "someone whose job is to check equipment or machines and make sure that they are working properly" or "someone who is very good at the skills of a particular sport, music, art etc."; or "a specialist in the technical details of a subject or occupation" and "one who has acquired the technique of an art or other area of specialisation." *Technician* is a category meaning that persons in a specific occupation may be theoreticians, workers in abstract definitions etc., or they may be technicians, persons with practical skills enabling them to bring theoretic conclusions into practice. It derives naturally from "technique" meaning practical skill of operation."

The National Classifications of Occupations in all these countries define technician and associate professionals as a major group /category under which up to 600 occupations are listed.[2]

However, the description offered in Wikipedia is a little disappointing. In part it says "Technicians may be classified as either skilled workers or semi-skilled workers, and may be part of a larger (production) process. They may be found working in a variety of fields, and they usually have a job title with the designation "technician" following the particular category of work."

VWR, our main sponsor this year, ran one of the many workshops at the conference.
Think outside the box with VWRCATALYST solutions
Paul Bell VWR International

This I think goes some way toward understanding what the UK's general populace's current perception is of a technician.

So, in the UK professional registration can, and does, offer a way to help enlighten people and improve their perception. Instead of "biology technician", should we be saying "professional technical biologist"? What do you think?

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

1 Lang2Tech project: uk/II/LLP-LdV/TOI-466

2 ISCO---88 International Standard of Occupations

Chairman's view

I have to start my commentary with a big thank you but also an apology. Firstly, for another very successful IST Conference which recently took place in Manchester. Without the help and dedication of our staff and volunteers this event wouldn't have achieved the acclaim it has received. There are so many people to thank from our executive team to our co-opted members who have played a vital role in delivering "our" conference. However here at the IST we all know and appreciate that without Wendy (and Louise) the preparation and the delivery on the day wouldn't run so smoothly making the day engaging and enjoyable for everyone. A big thanks to our sponsors and especially to our key sponsor VWR whose help and support ensured a very topical day for technicians from all sectors, providing advice and equipment demonstrations to meet all areas of industry, analytical services and the education sector. At the heart of the conference was the program of speakers and presenters who made the day with their engaging and inspiring keynote presentations and the session content.

The Environment Agency's National Laboratory Service (an IST Corporate Affiliate) was once again supporting the conference.

Last but not least, congratulations to all the entrants and winners of our conference competitions, which again highlights the skills and contributions the technical community make to the various sectors of UK PLC. Well done!!!

Now the apology: as you can see from the conference photos highlighted in this edition we were full to capacity.

Even though we increased numbers twice to the maximum capacity of the venue, from our waiting list for cancellations I know many people were disappointed. However to ensure we can accommodate everyone in 2017 we will be holding the conference at an even larger venue. We hope to have initial detail out to you in the next several weeks to allow people to book early and avoid disappointment.

The conference allowed technicians and managers from all sectors to meet and discuss common problems and issues that affect the technical community locally and nationally. We will once again create a program that is beneficial to all for the 2017 conference. Details will be available shortly.

Elsewhere the teams have been attending events up and down the country. Through John Dwyer's network of IST Champions we have been able to fulfill more requests for IST presentations and support on topics and issues affecting the technical community. If you feel you too could help in either organising events locally or being involved in one of our national projects then please contact John at:**j.dwyer@lancaster.ac.uk**

One of these projects we have been fully supporting is the Gatsby "Technicians Make It Happen" campaign; from housing the "TMIH" Poster Exhibition at our conference to highlighting technicians' contributions to their employers and public at large through the twitter campaign. See our website for further details at **www.istonline.org.uk**

In the final quarter of the year the IST will continue to work relentlessly on your behalf. If you have any ideas or issues concerning the technical community or would just like to play a role in YOUR Professional Body either locally or nationally then please do contact me at: **t.croft@istoline.org.uk**

Maybe the team will be supporting you at your event or reading your article in our Journal or e-Newsletter. The IST is its members – YOUR Professional Body – so let's hear from you. Don't be bored on those dark nights. As they say on a certain TV program – "winter is coming!"

Terry Croft
Chairman

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
http://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 the editor: **i.moulson@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 2017/2018
   - 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 2016 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)

Communications and the IST

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.

Email – This continues to be our preferred method for direct contact with our members, particularly as we have a significant number of overseas colleagues for whom hardcopy mailings can be problematic (and costly).

Our main email addresses are:

office@istonline.org.uk – general enquiries

memberships@istonline.org.uk – enquiries regarding new memberships and renewals

registrations@istonline.org.uk – enquiries regarding CSci/RSci/RSciTech registrations and renewals

It is important that we have everyone's up-to-date email address so if yours changes please let us know.

Website (**istonline.org.uk**) – We post both important announcements and general information that we think will be useful for our members on our website, so visit us there on a regular basis to see updates.

Social Media – We use social media routes for quick communications, networking and hope to encourage both members and non-members alike to engage in online discussions and provide ideas and feedback. The platforms that we use are:

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

Facebook (institute.of.science.and.technology) – feedback, ideas and comments welcome

LinkedIn and Google+ – join in group discussions, links through to these groups (and our Twitter account and Facebook page) are available on our website.

Applying for Fellowship

FIScT

Fellowship of the Institute is the most senior grade available and is an indicator of a very high level of achievement in the field and an outstanding contribution to the profession.

Fellowship candidates will require considerable experience gained over a number of years of responsible work, and be able to demonstrate important achievements relating to the application of science, technology, or management skills. Fellows of the Institute are elected by the Executive on the recommendation of a Fellowship Panel which comprises at least 3 Fellows of the Institute in good standing. The Fellowship Panel will take into consideration, in support of each application, qualifications, professional work experience, length of service, supervisory ability, contribution to the advancement of science and/or technology, and the candidate's commitment to furthering the aims and objectives of the IST.

Individuals may be nominated for Fellowship by existing members of the Executive of the Institute, or they may apply in their own right using the appropriate form available from the Registered Office or the IST's website. The same criteria apply in either case, although the process differs slightly. Guidance information in respect of the application process is also available on our website.

New Fellows are expected to contribute to the advancement of the IST and to play a full and active role in promoting the institute. In their first year of membership new Fellows will also be encouraged to submit a suitable article for publication in the IST's biannual Journal.

Application forms and guidance documents can be downloaded at (**istonline.org.uk/membership/fellow**).
T: 0114 276 3197
E: office@istonline.org.uk

Application for 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.

Why Join?

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

IST can help by supporting and developing your:

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

Together we can be a voice to be heard and listened to.

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.

Membership fees are:

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

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

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

Payment of subscriptions can now be made online

What we're about

The Institute of Science and Technology has been supporting specialists with the technical skills that the world's economy needs for more than 66 years. We represent all sorts of technical experts, and managers wherever they work: from science labs and engineering facilities to recording studios and IT departments.

As technology continues to develop at a tremendous pace, the IST is there to help people who work in technical roles to be the best they can be. 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.

In that way, we are always thinking about the future for our members and the organisations they work for. It is our mission to ensure that industry, business, research, schools, colleges, and universities have the staff they need to keep up with constant advances in science and technology.

Central to this is the IST's 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 know that our members are skilled professionals, and now we can give them official accreditation as a Chartered Scientist (CSci), Registered Scientist (RSci), Registered Science Technician (RSciTech) or Registered Practicioner (MIScT(Reg) or FIScT(Reg)) to prove it.

By registering, people who work in technical roles are promoting the professional standing of themselves and their colleagues. They are showing that they are making a vital contribution in their fields and achieving a status that makes them a key asset for the long-term.

We are working hard to bring those people from all disciplines who work in technical roles into our international community of specialists. Our members work across a wide range of fields, which gives each of them the chance to make contacts across business, industry, research, and education, and address the challenges these areas face together.

There is advice and guidance available for members (particularly new or young ones) through the IST's Mentoring Support Network. 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.

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

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 one of the Science Council's Licenced Bodies and can now award Chartered Scientist (CSci), Registered Scientist (RSci) or Registered Science Technician (RSciTech) status to experienced technicians.

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**

The Institute of Science & Technology

Kingfisher House, 90 Rockingham Street
Sheffield S1 4EB

T: 0114 276 3197 E: office@istonline.org.uk
F: 0114 272 6354 W: www.istonline.org.uk

Not working in science or science technology?

IST Registered Practitioners

The Institute of Science and Technology is uniquely an organisation run by technical people for technical people. We support these incredibly important staff in all areas, not just science but technologists in all fields.

As the professional body for specialist, technical, and managerial staff, we are actively involved in the professional recognition of technical staff in education, research, government, and industry. It is our view that our Registration Schemes are essential to establish your professional standing, acknowledge your expertise, and to enhance your career prospects.

People who work in technical roles in non-science fields may not be eligible to join the Science Council's Registers, but the IST recognises the exceptional work that these technical people do. We are committed to providing all our members with a means to endorse their status and to enable them to demonstrate transferable skills, up-to-date professional competence, and continuing professional development. We do this through our Registered Practitioner Scheme, and by the designation of **MIScT(Reg)** or **FIScT(Reg)** status to members who meet the criteria.

Registered Practitioners must have attained a high level of technical proficiency supported by sufficient knowledge of modern technology to enable them to relate to operating practises in their chosen field.

Want to find out more?
Visit: istonline .org.uk
Follow us on Twitter @istonline

The Institute of Science & Technology

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

Since 1987, the IST has operated a register of competent and qualified technical practitioners

Criteria for Registration include:

- Corporate Membership of the Institute of Science & Technology
- Higher National Certificate or Diploma (other qualifications judged to be of equivalent standard also satisfy the requirements)
- NVQ/SVQ level 3 or 4 in an appropriate occupational area
- Completion of the HEaTED/IST CPD award*
- Appropriate experience (in terms of breadth, depth, and length)

Importantly, there is also a route for mature applicants who have achieved a high standard of professional competence but who may not have the formal academic qualifications.

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.

** The IST CPD award can be used to demonstrate CPD activity for the RSci, RSciTech and RegPrac schemes and fulfil associated registration scheme competencies. Individuals automatically become members of the IST, and although the IST CPD award is not a qualification it does allow the individual to formally demonstrate work based experience and learning.*

New members and registrations

New members April 2016 - October 2016

Membership No.	Name	Grade
T15647	Dr M T B H Sultan	MIScT
T15649	Mr F Fletcher	MIScT
T15650	Ms M H Craigon	MIScT
T15651	Dr E J Bennett	MIScT
T15652	Mrs A J Valentine-Baars	MIScT
T15653	Miss E K Igbinigie	MIScT
T15525	Miss T L Webster	MIScT
T15654	Miss K R Barnes	MIScT
T15655	Dr S Ansell	FIScT
T15656	Dr Halcovitch	MIScT
T15657	Miss L K Pearce	MIScT
T15658	Mrs M F Oyeleke	MIScT
T15659	Ms A Hallows	MIScT
T15660	Dr G Hessman	MIScT
T15661	Dr Bashir	MIScT
T15662	Mrs L Allan	MIScT
T15663	Mr A Clunie	MIScT
T15664	Mrs L Kernweiss	MIScT
T15665	Ms M Wilson	MIScT
T15666	Mr K Leong	AssocIScT
T15668	Mr I Patel	MIScT
T15669	Ms J Brigham	MIScT
T15670	Ms E Northey	MIScT
T15671	Miss M Neilan	MIScT
T15672	Mr R A Metcalfe	MIScT
T15673	Mr D Gaskell	MIScT
T15674	Miss O Okoro-Obaraye	AssocIScT
T15675	Mrs D Corscadden	MIScT
T15676	Miss O Okoro-Obaraye	AssocIScT
T15677	Dr G S Flint	MIScT
T15678	Miss J L Plachta	MIScT
T15679	Mr J M Robertson	MIScT
T15680	Mr D Bowdrey	MIScT
T15681	Mr H J Simpson-Hutchinson	MIScT
T15682	Mrs B M McCabe	MIScT
T15683	Mr J Ben-Awuah	MIScT
T15684	Miss P O Ozolua	AssocIScT
T15685	Dr J Fraser	MIScT
T15686	Miss E Keen	MIScT
T15687	Miss J Hooson	MIScT
T15688	Mr A Scott	MIScT
T15689	Mrs J Copping	MIScT
T15690	Miss E T Braithwaite	MIScT
T15691	Mr K J Bright	MIScT
T15692	Mr A Platts	MIScT
T15693	Mr M Cook	MIScT
T15694	Ms D McLean	MIScT
T15695	Mr N Asante	AssocIScT

Membership No.	Name	Grade
T15696	Mrs R Savidis	MIScT
T15697	Miss S Greener	MIScT
T15698	Mr P Freeman	MIScT
T15699	Mr J D Coe	MIScT
T15700	Miss Gonzalez Anton	MIScT
T15701	Dr J E Stirrup	MIScT
T15702	Ms B J Areh Adano	AssocIScT
T15703	Dr S E James	MIScT
T15704	Miss M V Keith	MIScT
T15705	Dr A P Kent	MIScT
T15706	Dr T C B Huggins	MIScT
T15707	Ms E J Rix	MIScT
T15708	Mr M S Gillman	MIScT
T15709	Mr I A Boasiako	AssocIScT
T15710	Mr R Owusu	AssocIScT
T15711	Mr P M Leather	MIScT
T15712	Mrs S T Lidstone	MIScT
T15713	Miss N Phillips	MIScT
T15714	Miss L Oldershaw	MIScT
T15715	Mr Woodhams	AssocIScT
T15716	Dr A Y Bani Hashim	MIScT
T15717	Mr S F Hale	MIScT
T15718	Dr M P Ariaans	MIScT
T15719	Dr. Yu Liu	AssocIScT
T15720	Mr A Walker	MIScT
T15721	Mrs K Bolden	MIScT
T15722	Dr M Mroczek-Zdyrska	MIScT
T15723	Miss L O Uzzi	AssocIScT
T15724	Miss N J Gale	MIScT
T15725	Miss K Hopkinson	MIScT
T15726	Ms R Prawer	MIScT
T15727	Dr B S Durham	MIScT
T15728	Mr J Tweedie	MIScT
T15729	Mrs O O Arinola	MIScT
T15730	Dr D Georgiev	FIScT
T15731	Mrs G Ashby	MIScT
T15732	Miss K Bladon	MIScT
T15733	Miss M Burdon	MIScT
T15734	Mrs J C Brett	MIScT
T15735	Mr K R Ekundayo	MIScT
T15736	Mrs A Yohanna	MIScT
T15737	Mrs G A Dike	AssocIScT
T15738	Mr P Disdle	MIScT
T15740	Dr G Anderson	MIScT
T15741	Miss P Kalombodza	MIScT
T15742	Mr J Rowett	MIScT
Total: 93		

Science Council Registrations

Membership No..	Name	Grade
T15369	Mr M M Leitch	CSci
T15458	Mr J Sellwood	CSci
T15484	Dr A J Callaway	CSci
T15499	Mr K A Gorringe	CSci
T15551	Mr R W Carter	CSci
T15588	Dr S Krishnan	CSci
T15707	Ms E J Rix	CSci
T14547	Ms A M Leese	RSci
T14855	Mr S Franey	RSci
T14935	Mr A Grundy	RSci
T15124	Mr O Cooper	RSci
T15188	Dr G D McAllister	RSci
T15255	Mr D Wilson	RSci
T15352	Dr A Vijay	RSci
T15428	Mr L Walker	RSci
T15497	Miss N J Nicholson	RSci
T15501	Ms S L'Amie	RSci
T15508	Mrs Keat	RSci
T15531	Miss E Markham	RSci
T15539	Mr J D Wright	RSci
T15575	Miss Sherrington	RSci
T15592	Mr R J Pedrick	RSci
T15644	Dr Z Daniel	RSci
T15741	Miss P Kalombodza	RSciTech
T15742	Mr J Rowett	RSciTech

Membership No..	Name	Grade
T15654	Miss K R Barnes	RSci
T15657	Miss L K Pearce	RSci
T15662	Mrs L Allan	RSci
T15663	Mr A Clunie	RSci
T15664	Mrs L Kernweiss	RSci
T15670	Ms E Northey	RSci
T15693	Mr M Cook	RSci
T15694	Ms D McLean	RSci
T15696	Mrs R Savidis	RSci
T15711	Mr P M Leather	RSci
T15713	Miss N Phillips	RSci
T15720	Mr A Walker	RSci
T15738	Mr P Disdle	RSci
T15740	Dr G Anderson	RSci
T15130	Mr L R Callaghan	RSciTech
T15131	Mr M G Herbert	RSciTech
T15527	Mr K A Burnett	RSciTech
T15545	Mrs C L Davies	RSciTech
T15620	Mrs G Newsome	RSciTech
T15659	Ms A Hallows	RSciTech
T15665	Ms M Wilson	RSciTech
T15697	Miss S Greener	RSciTech
T15700	Miss Gonzalez Anton	RSciTech
T15704	Miss M V Keith	RSciTech
T15741	Miss P Kalombodza	RSciTech
T15742	Mr J Rowett	RSciTech

Total: 49

Higher Diploma Examinations

Membership No.	Name	Grade
T13833	Mr I S George MIScT	Pass with Merit
T14811	Miss A Noi MIScT	Pass
T15229	Mr H B Quadri MIScT	Pass
T15438	Mr I E Nnodim MIScT	Pass
T15470	Mrs J Doubell MIScT	Pass

Total: 5

IST Conference 2016

IST's 2016 technical conference was at the Manchester Conference Centre on the 15th September

Our two keynote speakers at the conference this year were

Professor Malcolm Press, Vice Chancellor of Manchester Metropolitan University ***Technicians for the 21st Century***

Helen Sharman OBE FRSC, IST President
Travels with a Space Technician

There were also three parallel sessions of workshops and talks throughout the day plus tours of The Manchester Synthetic Biology Research Centre research laboratories.

Here are just a few of the 12 workshops that were available during the day

How flavours are created and applied at El – Science, *Peterborough – Geoff Passmore MIScT CSci, Master Flavourist, and Daniel Gordon Senior Retail Manager, and Flavour Application and technical specialist at EL Science and applied at El – Science, Peterborough*

TechNet Technicians Network – by technicians, for technicians
Natalie Kennerley FIScT CSci, Project Manager, University of Sheffield, & Kevin Oxley FIScT CSci, Resources and Operations Manager, University of Sheffield

Greening Labs – how to engage people to embed sustainable practices, *Charlotte Bonner NUS and Helen Cutts, Environmental Sustainability Project Officer, University of Manchester*

Proactively manage your personal development for career benefit
Katherine Forsey, Membership & NetworksManager, HEaTED

A delegate's view: Andy Kowalski MIScT MCMI

The introduction was given by Professor Malcolm Press, VC at Manchester Metropolitan University, Professor Press gave a short speech on Technicians for the 21st Century and the varied work they do which is used to support both Teaching and Research.

Delegates were then able to go to their chosen workshops which lasted approx. 40 minutes. My first workshop was the one run by Tim Haycock "The pro's and cons of Health & Safety a manager's perspective". I had a lot to do with this in my former role, and this was well delivered, with many salient points that managers need to deal with in order to comply with legislation.

A coffee break followed and everyone was able to tour the exhibitor stands, and also see the various posters that had been put up by the attending delegates including my own.

The second workshop I attended was run by Chris Turgoose entitled "A strategic approach to technical support, redefining career structures and roles". Chris said that there was a significant shortage of trained technicians in all sectors and why it's necessary to widen the perception of Technician as a profession. Chris explained how this is being managed by HEFCE, given that a lot of technicians work in HEI sector, and their status and expertise needs to be highlighted along with other professionals working there.

After the morning's workshops a great hot lunch was served, and this was also a good opportunity for doing more viewing of the stands but also doing some essential networking. You never know when you may need to contact someone on a technical matter, and this was a very good opportunity for this to occur!

After lunch we headed back to the Pioneer Theatre for the second keynote speech.

This was delivered by Dr Helen Sharman who spoke of her "Travels as a Space Technician" after which followed a Q&A session.

Thereafter followed more workshops and tours before we broke for coffee and cake in late afternoon.

I attended the afternoon workshop presented by Dr Katherine Forsey (HEaTED) who spoke about how to "Proactively manage your personal development for career benefit". There was a lot of hands-on contribution, pasting notes on boards, with people's views on a number of questions set by Katherine.

She also reinforced what Chris said about the need to get more technicians trained, especially in new technologies, and the need for them to be more visible. She underlined the importance of the image and perception of technical staff needing to be better represented. I personally concur with this as technical people in some HE departments are regarded as more backroom technical support, being seen just to set up equipment for students to use.

Finally, the presentations to the winners of Best Trainee/Apprentice and Conference Posters were made and the day closed with farewell and thank you speeches.

In all, approx. 230 delegates attended this prestigious event with VWR being Key Sponsor and 8 other sponsor companies.

Career Zone Supporters were HEaTED, UBMA &TMU.

IST support staff were on hand to answer any questions and deal with queries which delegates had and also had their own stand in the foyer.

I would recommend highly attendance at this event as it was very well organised and supported, and I cannot fault it in any way.

A view from a non-technical delegate

"I thought the conference was brilliant. I found the workshops interesting and it was good to see a range of topics. I really enjoyed the keynote from Helen Sharman.

The whole event really did make me think more of the technicians who may not be within the natural sciences and feel that there may be a place for them within the institute too. Particularly within psychology as some of the experiments run by students can be quite ambitious.

I thought that the whole event was useful (I know this is not particularly useful for feedback, but it is true). It gave me a great opportunity to talk to people from all sorts of fields and made me realise how underappreciated technicians are within universities."

Sarah Flint, who has just finished a Master of Research in social science

IST Conference 2016 Awards and Prizes

IST award for Outstanding Trainee/Apprentice

For the best nominee, as selected by the IST's Awards panel, Llewellyn Lee received 1 year's IST membership, an iPad mini, & Certificate of Achievement.

The IST award for 'Outstanding trainee or apprentice' acknowledges the exceptional contribution that newly trained technicians are bringing to the technical workforce, and recognises the effort and dedication required to successfully qualify.

Terry Croft presents Llewellyn Lee, Trainee technician, Neuroscience Unit of Psychology, University of Sheffield, with the 2016 IST award for Outstanding Trainee/Apprentice

Award for Best Conference Poster

For the best poster presented at the IST's Awards panel, Liaque Latif received 1 year's IST membership, an iPad mini, & Certificate of Achievement.

The IST award for 'Best Poster Presentation' recognises the most outstanding poster presented during the IST Conference 2016.

Terry Croft congratulates Liaque Latif, University of Nottingham Medical School, School of Life sciences, Queen's Medical Centre for winning the best conference poster award

The winner of this year's conference # competition is Jess Mehers, Lancaster University

#ISTConference2016 competition

For being the best social media activist, as selected by the IST's prize Panel, Jess Mehers received a £150 Amazon Gift Card & Certificate of Achievement.

The prize for the #ISTConference challenge acknowledged the value of networking and sharing of skills across disciplines and recognised the most outstanding individual's commitment to social networking up to, during and following the IST Conference 2016.

EANLS at the IST Technical Conference 2016 – James Trout

The Environment Agency's National Laboratory Service has been working closely with the Institute of Science & Technology (IST) for the past 2 years. During this time we have formed a fantastic partnership, which is now really supporting the development of our team. The IST have supported us in introducing the Science Council's professional registration scheme, with now 20 of our team having achieved one of the professional registrations, and a further 40 more working towards them.

Each year, as part of their continued professional development (CPD), we ask for volunteers to present at the IST's conference. This is often a huge challenge for our technical people. Standing on a stage and

delivering a technical talk to an audience of 30 to 40 people from the UK technical community is not something that comes naturally to everyone, certainly not me anyway!

Edyta and Louise present their workshop at the IST's One Day Technical Conference 2016 at the Manchester Conference Centre

This year Edyta Bartkowska and Louise Pearce volunteered to present a workshop at the conference. Edyta and Louise work in our Microbiology Department and deliver one of our most important pieces of work, the bathing water monitoring programme and Microbial Source Tracking service.

Both Edyta and Louise are members of the IST and have become Science Council registered scientists (RSci), and they are really keen to continue to develop their communication skills. I am incredibly proud that they put themselves forward to do this.

Having a safe and welcoming environment to practice communicating at this high level is fantastic, and I will be discussing how we can do more of this at next year's conference with the IST executive.

Edyta said: **"Before going to the conference I was worried I would not do well. I have no experience of talking to large groups of people. I wasn't sure what to expect from myself, and if I would cope with the pressure. The other presentations I attended were great so I had no time to start worrying. I think it went quite well; people got involved and were responding to us. Whilst standing there I realised what a nice feeling it was to be able to share my knowledge with people. Of course not everything I did was perfect but I am really pleased I did it."**

Louise said: **"I had mixed emotions about doing the presentation, but when I had finished and received the positive feedback I felt really happy, especially as someone told me they had learnt a lot from our talk. I am now actually looking forward to my next presentation."**

Dr Jonathan Porter is responsible for introducing molecular biology to the NLS and Environment Agency. He added:

"Applying molecular biological tools within routine environmental testing offers us the opportunity to access information that is perhaps unavailable any other way, or perhaps deliver information more easily. Microbial source tracking is one example of accessing extra information. Traditional microbiological techniques provide information on general numbers of bacteria in a sample; microbial source tracking analyses very specific bacteria to assess the numbers from different animal groups (for example, human and cows). This ability to see where the microbiological pollution originated allows us to target remedial work.

Other applications of molecular biology allow assessment of rare or endangered species; monitoring the spread of invasive species; identification of arthropods during the larval or pupal stages of their life cycles or providing detailed information on the presence and type of viruses that cannot be analysed with standard methods.

The microbiology team from the NLS offer many such services within a UKAS accredited framework. The work has developed since its inception to deliver relevant information to the Environment Agency.

It is great that the team are developing the skills to help us share the fantastic work we do to protect the environment".

Jonathan will be writing a full article for a future IST Journal.

James Trout
MIScT, CMgr, (IST Advisor/ Industry Liaison)

James is the Laboratory Manager at 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 is helping the IST develop industrial links and promoting frameworks for professionalising science/technical staff working in that sector.

E: j.trout@istonline.org.uk

The IST would like to thank all the sponsors of our One-day Technical Conference 2016

Career Zone supporters

Our Key Sponsor this year was:

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Cellulose recovery from waste

Raffaele Conte

Abstract

Environmental issues such as the depletion of non-renewable energy resources, pollution, and saturation of landfills need more scientific attention in order to be addressed in a way beneficial to life. The extent of solid waste production is a global concern and the recovery of cellulosic components can solve this problem. This paper describes how cellulosic biomass and wastepaper materials, major components of solid wastes, can be treated to produce biofuel and recycled raw materials.

Introduction

The reduction of wastes is the target of environmental groups all over the world. The efforts made to convert wastes into useful products are achieved and maintained by biotechnology, chemical, and physical measures that include the action of microorganisms, enzymes, inorganic additives, and mechanical technologies. These procedures are environmentally safe and support sustainable growth. A major area where these applications succeed is in the transformation of cellulosic solid wastes into bioenergy or into raw materials. Cellulosic biomass is obtained from a variety of sources, such as agricultural residues (corn stover, sugarcane bagasse, spent sugar beet pulp, and sweet sorghum, etc.), forestry residues (fallen branches, leaves, twigs, saw dust, etc.), municipal solid wastes (paper and paperboard products), industrial wastes (papermaking sludge), and agricultural feedstock grown as energy crops (herbaceous and woody crops, such as switchgrass, fast-growing hybrid poplar and leucaena trees, etc.). Cellulose biomass consists of three main components, cellulose, hemicellulose, and lignin together with a small amount of pectin, waxes, water soluble sugars, and organic acids.[1] Cellulose, hemicellulose, and lignin are interwoven to form the networking structure of the plant cell wall in which the lignin fraction acts like "glue" holding the cellulose and hemicellulose fibres together. Cellulose represents 40-60 % of municipal solid wastes (table 1).[2] The recycling of cellulose biomass into useful products reduces the weight of solid residues and abates pollution. Additionally, combustion of biofuel does not contribute to the increase of the concentrations of heavy metals in the environment maintaining the low quantity of sulphur dioxide and nitrogen oxides in the air, reducing greenhouse gases.

CELLULOSE CONTAINING WASTE	
CONSTITUENT	**WEIGHT (%)**
Wood waste	3.0
Food waste	14.2
Yards waste	14.6
Paper and paper products	37.8
TOTAL: Cellulose waste	69.6
CELLULOSE FREE WASTE	
Rubber and Leather	2.2
Miscellaneous	3.1
Textiles	3.3
Plastic	4.6
Metals	8.2
Glass and ceramics	9.0
TOTAL	100

Table 1. Average composition of municipal solid waste

Cellulose definition and properties

Cellulose (fig. 1) is an organic polymer with the formula $(C_6H_{10}O_5)_n$ consisting of a linear chain of ß(1→4) linked D-glucose units[3] that react by combining the -OH groups and the hydrogen when water is eliminated. The disaccharidic structure is the cellobiose.[4] Cellulose is obtained by linking additional sugars with the same chemistry. The length of the obtained chains varies greatly, from a few hundred sugar units in wood pulp to over 6000 for cotton.[4] The tri-dimensional structure of this polymer is given by the formation of many hydrogen bonds between -OH groups on adjacent cellulose bristles. These chains react to form hard, stable crystalline regions with high tensile strength (fig 2). In general, cellulose has a crystalline matrix and non-crystalline regions (the amorphous zones) which are more susceptible to degradation (crystalline cellulose requires a temperature of 320°C and pressure of 25 MPa to become amorphous in water).[4-5]

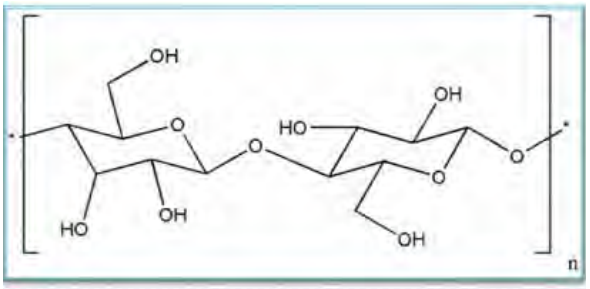

Figure 1. Chemical structure of Cellulose

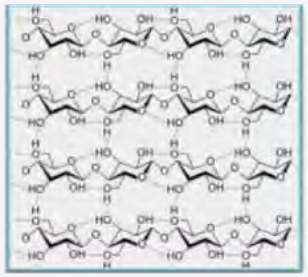

Figure 2. Cross-linked Cellulose chains

Chemically, cellulose has no taste, is odourless, insoluble in water and like most organic solvents, chiral and biodegradable. It melts at 467°C.[6] In nature, cellulose is an important structural component of many forms of algae, oomycetes, and of the primary cell walls of green plants.[7] For example, the cellulose content of cotton fibre is 90%, that of wood is 40–50%, and that of dried hemp is approximately 57%.[8] Several different crystalline structures of cellulose are known, corresponding to the location of hydrogen bonds between and within strands. Natural cellulose is type **I** (cellulose with all parallel chains) with structures **Iα** and **Iβ** (α and β indicate the different torsional conformations). Cellulose produced by bacteria and algae is enriched in **Iα** while cellulose of higher plants consists mainly of **Iβ**. Regenerated cellulose fibres (recycled cellulose) are type **II** (with anti-parallel chains). The conversion of cellulose **I** to cellulose **II** is irreversible, suggesting that cellulose **I** is metastable and cellulose **II** is stable.[9] Plant derived cellulose is usually found in a mixture with hemicellulose, lignin, pectin, and other substances. While bacterial cellulose is pure, with higher water content and tensile strength due to increased chains length.[7] In cellulose containing materials, the carbohydrate portion that does not dissolve in a 17.5% solution of sodium hydroxide at 20 °C is α cellulose. Acidification of the extract precipitates β cellulose. Cellulose is assayed using the Updegraff's method in which the sample is dissolved in acetic and nitric acid to remove lignin, hemicellulose, and xylosans. The resulting product reacts with anthrone in sulphuric acid. The treated coloured substance is assayed spectrophotometrically at a wavelength of 635 nm.[10] Cellulose is soluble in Schweizer's reagent, cupriethylenediamine (CED), cadmiumethylenediamine (Cadoxen), N-methylmorpholine N-oxide, lithium chloride / dimethylacetamide[11] and ionic liquids.[12]

Cellulose applications and derivatives

Cellulose is the major constituent of paper, paperboard, card stock, and the main ingredient of textiles made from cotton, linen, and other plant fibres. Also, with a simple physical treatment it can be turned into cellophane and rayon. Other applications include the utilisation of cellulose as a stationary phase for thin layer chromatography and as a filter bed of inert material for liquid filtration (in combination with diatomaceous earth or other filtration media). Microcrystalline cellulose (E460i) and powdered cellulose (E460ii) are used as inactive fillers in drug tablets or as thickeners and stabilisers in processed foods.[13] In addition, cellulose based building materials with hydroxyl bonding of cellulose in water are able to produce mouldable composites used as an alternative to plastics and resins, and the treatment of recycled cellulose with boric acid (a fire retardant) is used for the production of building insulation material.[14] New applications of cellulose regard the conversion of this polymer into biofuels (e.g. bioethanol)[15] and the production of nano-crystalline cellulose (with strong acid treatment) used as filler phase in bio-based polymer matrices to produce nano-composites with superior thermal and mechanical properties. [2]

The hydroxyl groups of cellulose can be partially or fully reacted with various reagents to create derivatives with useful properties, mainly cellulose esters (Table 2) and cellulose ethers (Table 3).

Cellulose esters	Example	Reagent	Group -R
Organic esters	Cellulose acetate	Acetic acid and acetic anhydride	H or -(C=O)CH3
	Cellulose triacetate	Acetic acid and acetic anhydride	-(C=O)CH3
	Cellulose propionate	Propanoic acid	H or -(C=O)CH2CH3
	Cellulose acetate propionate (CAP)	Acetic acid and propanoic acid	H or -(C=O)CH3 or -(C=O)CH2CH3
	Cellulose acetate butyrate (CAB)	Acetic acid and butyric acid	H or -(C=O)CH3 or -(C=O)CH2CH2CH3
Inorganic esters	Nitrocellulose (cellulose nitrate)	Nitric and or another powerful nitrating agent	H or -NO2
	Cellulose sulfate	Sulfuric acid or another powerful sulfating agent	H or -SO3H

Table 2. Cellulose esters derivatives

Cellulose ethers	Example	Reagent	Group -R
Alkyl	Methylcellulose	Chloromethane	-CH3
	Ethylcellulose	Chloroethane	-CH2CH3
	Ethyl methyl cellulose	Chloromethane and chloroethane	-CH3 or -CH2CH3
Hydroxyalkyl	Hydroxyethyl cellulose	Ethylene oxide	-CH2CH2OH
	Hydroxypropyl cellulose (HPC)	Propylene oxide	-CH2CH(OH)CH3
	Hydroxyethyl methyl cellulose	Chloromethane and ethylene oxide	-CH3 or -CH2CH2OH
	Hydroxypropyl methyl cellulose (HPMC)	Chloromethane and propylene oxide	-CH3 or -CH2CH(OH)CH3
	Ethyl hydroxyethyl cellulose	Chloroethane and ethylene oxide	-CH2CH3 or -CH2CH2OH

Table 3. Cellulose ethers derivatives

Examples of cellulose derivatives with widespread applications are cellulose acetate and cellulose triacetate used as film and fibre-forming materials. Nitrocellulose (cellulose nitrate), used as an explosive and film forming composite that produces celluloid after reaction with camphor and sodium carboxymethyl cellulose that, in the cross-linked form, gives the croscarmellose sodium (E468) used as disintegrant in pharmaceutical formulations. Cellulose is also converted into cellophane, a thin transparent film which was utilised for photographic and movie films until the mid-1930s. Also, methyl cellulose and carboxymethyl cellulose make water-soluble adhesives and binders found in wallpaper paste and in hydrophilic and highly absorbent sponges.

Methods of cellulose recovery from waste

The use of waste as an alternative and renewable resource requires the separation and purification of the cellulosic components and their transformation into energy or into high quality raw materials. The production of energy from cellulose is obtained through the composting of cellulosic materials or the transformation of cellulose into bioethanol, while the formation of new products uses the incorporation of this polymer into synthetic materials or the purification of recycled cellulose.

Composting of cellulosic materials

Composting is a dynamic procedure in which a variety of microorganisms act in synergy to recycle cellulosic materials. The cellulose biomass is treated with compost piles that consist mainly of bacteria (including actinobacteria) and fungi. Polymers are degraded when the more easily degradable compounds are consumed. Afterwards the lignocellulosic residues are partly transformed into humus. The compost microbiota changes with time. At the beginning of the composting mesophilic bacteria are predominant while, once the temperature reaches more than 40°C, thermophilic bacteria and fungi appear in the compost piles. At 60°C the microbial activity decrease and when the compost pile cools mesophilic bacteria appear again. Anaerobic bacteria (e.g. actinobacteria) carry much of the cellulolytic activity and play a major role in the biodegradation of lignocellulosic materials. Finally, thermophilic and thermotolerant fungi are critical to the degradation of lignocellulosic materials due to their cellulolytic and ligninolitic activity.[16] The products obtained can be used as fertiliser (after chemical analysis for potentially toxic or hazardous substances) or displaced in landfil.

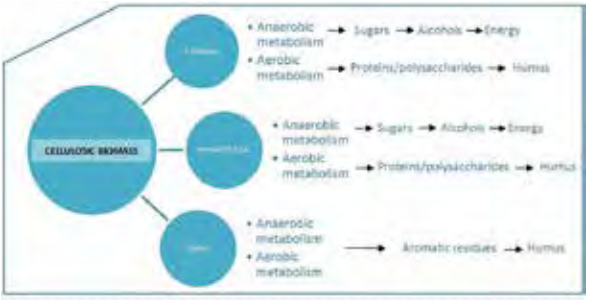

Figure 3. Diagram of the process of composting of cellulosic materials

Transformation of the cellulosic biomass into bioethanol

The efficient development of waste as energy resource relies on the maximum degradation of cellulose into fermentable sugars that are utilised for the production of combustibles. The bioconversion of cellulose into fermentable sugars is performed by enzymatic catalysed hydrolysis with a multicomponent enzyme system called cellulase that is present in microorganisms (bacteria or yeast). However, the bioconversion efficiency must be improved through an accurate pre-treatment of the cellulosic biomass aimed to breaking down the plant cell wall network structure, removing the lignin and hemicellulose which block the cellulose inside the cell wall.[17]
In general, the transformation of the cellulosic biomass into bioethanol consists of four steps: pre-treatment, enzyme hydrolysis, fermentation, and distillation. The pre-treatment step can be done by using acid, alkali, organic solvents, heat treatments, etc. Some options for pre-treatment are steam explosion, liquid hot water, lime-ammonia, and acid treatment.[18] Enzyme hydrolysis usually occurs immediately after the pre-treatment step and is useful to convert the polysaccharides into simple sugars, which can be fermented by bacteria or yeast. The high cost of enzymes is the greatest issue in this processing step.[19] Fermentation converts the single sugars obtained from the enzyme hydrolysis step to fuel ethanol through microorganisms such as yeast (Saccharomyces cerevisiae) or bacteria (Escherichia coli). In the separate hydrolysis and fermentation (SHF), the fermentation step usually follows enzymatic hydrolysis, as a separate step. However, the most commonly used technique is the simultaneous saccharification and fermentation (SSF) process, which is carried out by combining fermentation and enzyme hydro¬lysis in the same step. Normally, higher ethanol yield is achieved with SSF due to the reduction of inhibitory end-products (e.g. glucose and cellobiose).[20] Ethanol is recovered from the fermentation broth by distillation, on the basis of the lower boiling point of ethanol (78.3°C)

compared to water (100°C). The lignin residues, along with unreacted cellulose, hemicellulose, ash, enzymes and microorganisms, remain in the bottom of the distillation column. These compounds have high energy content and can be used as fuel or converted to various value-added products.

Figure 4. Diagram of the process of transformation of the cellulosic biomass into Bioethanolmaterials

Incorporation of cellulose into synthetic materials

This methodology consists of converting cellulosic waste materials such as sawdust, wastepaper, corncob, and sugarcane bagasse into nanostructured ceramics and nano-composite materials by impregnating them with silica solutions (SiO_2), with a subsequent calcination under controlled conditions. Such derived products are utilised as catalyst supports, automotive components, armour, and light-weight porous ceramics for the aerospace industry.[21] In this process, the cellulosic samples are dried at 70°C for 24 hours and ground into powder form. Further purification consists of soaking the samples in a solution mixture of acetic acid and hydrogen peroxide (1:1 v/v) at a temperature of 70°C for 4 days, and then leaching with a solution 1.0 M HCl at 60°C for 24 hours, to separate lignin from cellulose. The compounds obtained are washed with ultrapure water and dried at 60°C for 24 hours. The silica nanoparticles solution is prepared by hydrolysis of tetraethylorthosilicate (TEOS) in ethanol medium in the presence of ammonium hydroxide.[22] TEOS (30:1 v/v) is added in a solution water/ethanol 1:5 v/v. Ammonium hydroxide is then used as catalyst to promote the condensation reaction. The mixture is stirred for 1 hour to obtain a white turbid SiO_2 solution. The pre-treated cellulosic materials are then submersed into the silica solution and continuously shaken for 16 hours. The resulting cellulosic/silica nano-composites are air-dried at 100°C for 3 hours. Calcination of such nanostructured materials is obtained by heating at 550°C for 1 hour and a subsequent cooling to room temperature at the rate of 5°C/min. Nitrogen calcination produces SiO_2 nano-composites while air calcinations SiO_2 ceramics.[21] These nanostructured materials exhibit defined and specific arrangements depending on the types of cellulose used.

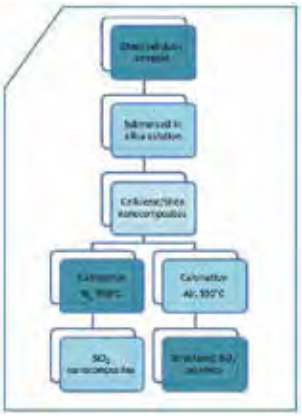

Figure 5. Diagram of the process of incorporation of cellulose into synthetic materials

Production of raw materials

An important portion of solid wastes is composed of disposable nappies and other similar non-woven cellulose articles such as sanitary towels, panties, sick-bed under sheets, and other hygiene products. For example, a child until the age of 30 months uses approximately 6 disposable nappies a day. Each of the nappies has an average volume of 500cc. Thus, one child produces an average of about 3000cc of waste a day, which adds up to 1.092 cubic meters per year. There are about 50,000 nappy users per million population, so that during one day it is necessary to remove from a city of one million inhabitants 150 cubic m of such waste.[23] Similarly paper, paperboard products, and papermaking sludge are more than 40% of municipal solid wastes.[1] With regard to the recycling of disposable hygiene products, all these cellulose-containing articles also have an envelope of non-woven tissues, plastics or rubber, and a cellulose-flock padding milling mixed, in most cases with superabsorbent polymers. Most patents suggest one common process for separating the cellulose from the other materials of the used hygiene articles which includes disintegration (shredding, cutting) of the disposed articles, followed by separation of the cellulose fibres from the cover materials by screening. Hygiene products are sliced into two parts that are then held by movable gripping means and moistened by repeated dipping in water in order to separate the cellulose flock component containing the superabsorbent polymer from the plastics components. The gripping process is made in a circular trajectory at a low velocity in one sense while the dipping into water comes in the two opposite

directions along an angle ranging from 45° to 90°, to release the plastics covers that are also tangentially removed by suction. The problematic dispersion of the wadding-type mass is carried out with the aid of a highly accelerated airstream. The products are then conveyed pneumatically in order to have pure cellulose.[23] Similarly, the isolation of the cellulosic components of the municipal solid wastes is obtained through the transformation under heat and pressure of the whole cellulose biomass into a fairly uniform material that is separated from most of the metals, plastics, textiles, and glass by vibratory or trommel screening over a 1.3cm screen. This thermal treatment is done in a steam process unit with vapour

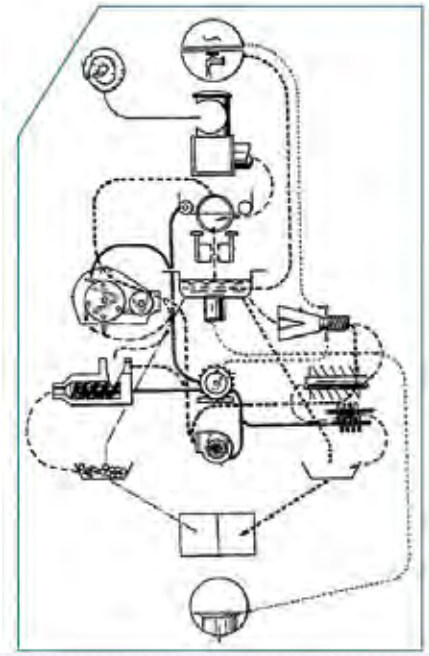

Figure 6. Schematic representation of the machine for disposable nappies' recovery

in continuous agitation at the internal pressure of 380kPa and temperature of 150°C for 30 minutes. The wet < 1.3 cm material is usually contaminated with about 20% plastics and broken glass. Some of these contaminants are removed from the wet or dry material by stoner processing. Pure cellulose mass is obtained after vibratory screening and destoning.[24] The products of both these categories of waste can be melted and reutilised as raw materials.

Conclusion

With a growing global population the increased waste production and its management is one of the most important challenges to face. Cellulosic biomass, a major component of solid wastes, is a renewable energy resource which simultaneously limits the enormous amounts of rubbish produced. The use of biomass energy in fact minimises the production of greenhouse gases and avoids the saturation of landfills. The development of biomass materials as an alternative and renewable energy resource then offers a way of ensuring sustainable growth and of producing clean energy.

Author

Raffaele Conte MIScT, RSci is a research fellow for the "Institute of Biosciences and BioResources" of the Italian National Research Council (CNR) in Naples, Italy. His research interests are focused on the design of novel delivery platforms able to minimise degradation, prevent undesirable side effects, and increase bioavailability of drugs or genetic materials. He also follows different projects as an independent researcher and has authored several research papers. In 2015 he started to study for a PhD degree at University of Naples "Federico II" with a project on the synthesis of polymeric fillers with anti-biofilm activity for dental composites. His email address is **raffaele.conte86@tiscali.it**

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The engineer Chas W. Cook – Part two

This article is dedicated to Marjorie Cook, daughter of Charles William Cook, who died recently at the age of 104.

Alan Gall, IST Archivist. Episode two

Recap

A job with the engineering firm Lennox, Reynolds and Fyfe, and the shortcomings of a technician at the Royal Institution, started Charles William Cook on a career as a scientific apparatus maker. Surviving eight years at the Royal Institution under James Dewar[1], he was invited to take up a position as instrument maker at the University of Manchester in 1905 on the recommendation of Joseph Petavel. The terms of his contract encouraged work for outside customers and this led to the foundation of a lucrative business.

Figure 1. Chas Cook's employer at Lennox, Reynolds & Fyfe, and the chief assistant to Sir James Dewar. A side view, presumably because of the eye lost in a laboratory accident at the Royal Institution (image courtesy of Frank Shaw)

Figure 2. Joseph Ernest Petavel FRS, director of the National Physical Laboratory for 17 years from 1919. He greatly influenced the course of Chas Cook's career (image courtesy of the NPL)

The arrival of Ernest Rutherford at Manchester in 1908 introduced Chas Cook to the construction of instruments for research on radioactivity. Other departments also called on Chas for special equipment, so enabling him to build up a wide experience of scientific applications. At the same time, he developed further expertise in constructing high-pressure pumps and vessels. A long-standing product, the Mahler-Cook bomb calorimeter, was introduced at this time.

New premises

The building at 18 Coupland Street that Chas much liked "on account of the large gates opening on to the pavement" occupied land needed for a new engineering department block. Directory listings indicate that Chas moved to temporary accommodation between the time that the old buildings were pulled down and his eventual relocation to a purpose-built workshop. The family home changed to 93 Lloyd Street, a short distance away, where his neighbours included a sea captain, an inland revenue officer and the rector of St John the Baptist, Hulme.

Figure 3. The inner part of a Mahler-Cook bomb calorimeter made at Manchester. It was used as a doorstop in more recent times (calorimeter saved for posterity by Mike Allsop)

For a year or so it was business as usual in property provided by the University on Huntingdon Street. This road stood to the rear of the physics building (built in 1900). The whole of Huntingdon Street and part of Eagle Street vanished under the University's development program. Cleared of the old houses, Bridge Street was extended to meet Oxford Road and would eventually be renamed Bridgeford Street (see figure 5).

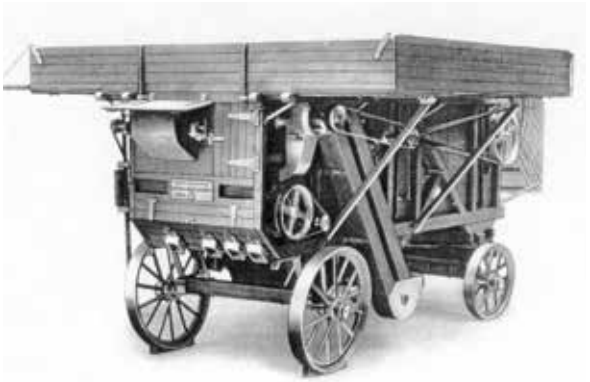

Figure 4. A model of a threshing machine made from oak and polished aluminium, about one quarter scale. It appears in the c.1953 catalogue but was made at Manchester prior to 1912

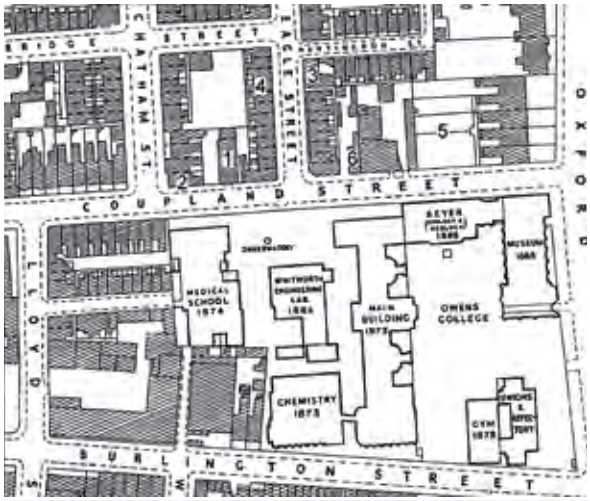

Figure 5. The University campus in 1890 (H. B. Charlton, 1951). Numbered are: (1) Chas W. Cook's works at 18 Coupland Street from 1905. (2) Chas Cook's house at 97 Higher Chatham Street. (3) Probable location of Cook's temporary workshop on Huntingdon Street. (4) The block of houses demolished for the building of University Works. (5) Site of Physical Laboratories, completed in 1900. (6) William Stelfox, tinsmiths, at 12 Coupland Street. (1) & (2) were demolished for the 1909 engineering building.

Also occupying University buildings, and operating as independent concerns under contract to service the University of Manchester's requirements, were the glassblower Otto Baumbach and tinsmith William Stelfox. When the University completed the Electrotechnics Extension in 1912, provision was made to house Stelfox on the ground floor and Baumbach on the first floor.[2] This brought them into close proximity to Chas Cook's "University Works". An account of the physical laboratories, published in 1912, describes the new facilities.

The Laboratory contains a workshop in which simple apparatus is constructed and minor repairs are undertaken by the steward of the Laboratory[3] and his assistants. The construction of more complicated apparatus is carried out in the University Engineering Works, close by the Physical Laboratory, which are in the charge of Mr Charles W. Cook, assisted by a staff of trained mechanics. This arrangement has proved of great advantage not only to the Physical Department but to the University as a whole. Recently a special building has been erected adjoining the new Electrical Laboratory, in which the University glass-blower, Mr. Baumbach, and the University tinsmiths, Messrs. Stelfox, are housed. Special workshops of this character are essential for the efficient working of the scientific Departments of the University. The Department of Physics makes continual use of these three workshops for the construction of apparatus required in teaching and research.[4]

Mention has been made in Part One of the apparatus made by Chas Cook for Professor Sheridan Delépine. Joint authorship of academic papers on the subject of hygiene shows a connection between Delépine and the Medical Officer of Heath to Essex County Council, John Clough Thresh. Considering the location of Thresh, down in Chelmsford, the fact that he became a director of William Stelfox Ltd on formation in 1902 suggests an investment opportunity recommended by Delépine. Indeed, Thresh designed an incubator made of tinplate that went on general sale, most probably made in Stelfox's works.[5] Otto Baumbach later remarked to his son Geoffrey that the Stelfox business was basically sound, but poorly managed, and went into liquidation in 1928.[6] More successful, the glassblowing activities of Otto Baumbach led to the formation of two separate businesses: The Scientific Glassblowing Company (see later) and J. C. Cowlishaw. [7]

Figure 6. Chas. Cook's workshop at "University Works" (University of Manchester Faculty of Science, Engineering Department, 1914)

Figure 7. External view of "University Works" (the building with the smaller chimney) and boiler house from Bridge Street (University of Manchester Faculty of Science, Engineering Department, 1914)

Henry Gwyn Jeffreys Moseley

H. G. J. Moseley arrived at Manchester in September 1910. He soon proved to be an industrious and talented experimentalist. His paper on "The High-Frequency Spectra of the Elements" in the *Philosophical Magazine* concluded that the square root of the frequency of lines in the X-ray spectrum were proportional to an element's atomic number. Not only did this order the elements correctly in the periodic table, it predicted that there were three missing elements: one between molybdenum and ruthenium, one between neodymium and samarium, and one between tungsten and osmium. These were later found and named as technetium, rhenium and promethium. There was, in fact, a fourth element missing in the range – atomic number 72, hafnium. Moseley had assumed this to be a recently (and incorrectly) identified element celtium.[8]

One characteristic Moseley did not seem to possess was an inclination to acknowledge help given by technical staff. There is no mention of Cook's involvement in constructing some of the equipment he used. However, Otto Baumbach received a vote of thanks in one of Moseley's papers. This may have been a calculated move: German glassblowers had a reputation for being temperamental and hence more likely to be co-operative when praised. Moseley's spectrometer cost £12 12s and Kristen Frederick-Frost has calculated that its manufacture would have taken about 260 hours based on Cook's rate of pay.[9] Otto Baumbach provided an X-ray tube at £1 16s, these costs being covered by a grant from the Solvay Institute.[10]

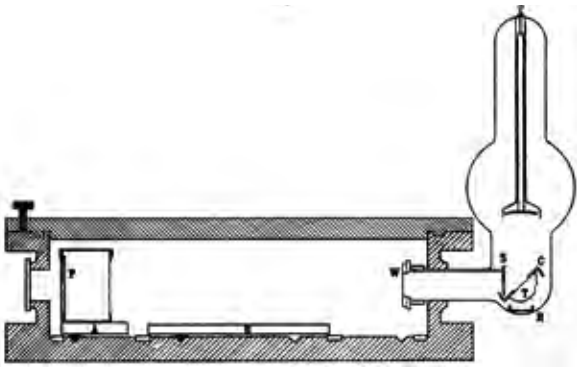

Figure 8. X-ray tube connected to the spectrometer constructed by Chas Cook as shown in the Philosophical Magazine of 1914. The steel box is circular of 30 cm diameter and height 8 cm.[11]

An interesting comparison between the severity of punishment in 1913 and today is given by the theft of Moseley's coat. While in lodgings, his Burberry and items of apparel owned by others were stolen. The thief, Reginald Wolstencroft Booth, received one month's hard labour at Strangeways prison, in Manchester.[12]

With such an important scientific contribution at an early age, Moseley's career should have been spectacular. It was not to be. At the age of 27 he died from a Turkish bullet during the ill-fated landing at Gallipoli in 1915. Moseley's mentor Ernest Rutherford wrote: "It is a matter of great regret that the services of Moseley could not have been utilised for the war in some scientific capacity rather than as a combatant in the firing line."[13]

Figure 9. A studious H. G. J. Moseley as shown in J. B. Birks (1962)

The Curnon steam meter

Hiscox's Mechanical Movements of 1907[14] shows details of the St. John's steam meter (figure 10). Differential pressure lifts the conical valve and an arm can be made to record the rate of steam flow on a moving strip of paper. Young engineers Edgar Parr Gabbott and Arthur Carlyle Timmis developed a more sophisticated device, patented in 1910. In their instrument, pitot tubes pointing upstream and downstream transmit the differential pressure to a diaphragm, which is translated into a flow rate and recorded.

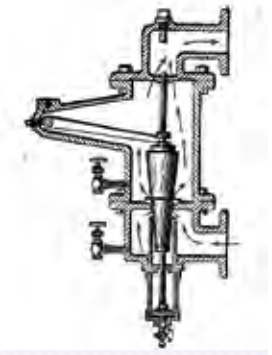

Figure 10. St John's Steam meter (Hiscox, 1907)

At an exhibition held in the Physical and Electrochemical Laboratories of the university (1912), Chas Cook set up his wares in room 18 on the ground floor. On show were furnaces, the bomb calorimeter, electroscopes, a high-pressure filter apparatus for cancer research and "the Cook Air Compressor, with automatic electric circuit-breaker, shown working in conjunction with the Curnon Steam Meter and Recorder"[15].

Edgar Parr Gabbott and Arthur Carlyle Timmis graduated with BSc degrees from the University of Manchester in 1907. They enlisted the aid of Chas Cook with construction of their meter. Edgar's grandson, Trevor Gabbott, says that the name Curnon came from the Latin meaning "why not" (cur = why, non = not), as in "Why not start a company to make the steam meter?" Several language versions were considered but Edgar Gabbott liked the look of the Latin.

Figure 11. Pitot tubes used in the Curnon steam meter (from Curnon Engineering sales literature, courtesy of Trevor Gabbott)

A curiosity is that the Cook catalogue shows the box housing the recording mechanism with the inscription on top: "COOK (Late Curnon) STEAM METER". This implies the demise of Curnon when in fact the business of Curnon Engineering continued well after.

Fermentation studies

In July 1904 Chaim Weizmann, later to become the first president of Israel (1949-1952), arrived at the University of Manchester having received an invitation from the professor of organic chemistry, William Henry Perkin.[16] At first, Weizmann rented laboratory space before being officially appointed as a research fellow in January 1905. Also that year, Lottie Cook gave birth to Albert Leslie.

Russian born Weizmann had passed his oral doctorate examination in 1899 at the University of Freiburg, Switzerland after, apparently, just one year of study. At Manchester he was awarded MSc (1906), DSc (1907) and LLD honoris causa (1919).

He never achieved his ambition to become a professor, his final status at Manchester being that of reader in biochemistry (1913-1915).

A former science student identifying herself only as W. G. W. wrote for the *Manchester Guardian:*

It was in October 1906 that I went into Dr Weizmann's laboratory. He had not long left Russia them. We were rather nervous of him at first: we thought we might not be able to understand his very "foreign" English, or grasp what particular chemicals he meant to use. He would refer, for instance, to calcium chloride as chlor calc, to sodium hydroxide as hydrox sod, and so on. We soon got used to him, however, as time went on, and his speech grew less guttural to our ears.[17]

Of interest to the Cook story are the experiments on the fermentation of carbohydrates by Weizmann in collaboration with others. The work began around 1910 with a contract that Perkin had agreed with the Synthetic Products Company Ltd to investigate methods of producing isoprene (a precursor of synthetic rubber) by fermentation. A few years later, at the factory of the Synthetic Products Company in Rainham, Essex the fermentation of starch yielded, amongst other products, acetone. As war approached, acetone assumed a major importance because of its use in the manufacture of the smokeless propellant Cordite (figure 12). Effort now concentrated on the production of acetone.

It was natural to involve the explosives industry and Weizmann contacted Nobel's Explosives Company based at Ardeer. As it happened, the head of research at Nobel's, William Rintoul, had been to witness the fermentation of potatoes at the Synthetic Products Company, which at the time produced only a small percentage of acetone. Rintoul quickly descended on the University with plans to return with a group of experts. Jehuda Reinharz (1993) says: "Weizmann had in the meantime checked with Charles Cook, the engineer at the university who had built for him the apparatus at the laboratory on a two-kilogram scale, to make sure that all would be ready for Rintoul's visit."

178. A. III$_1$. **Cordite** is the smokeless powder adopted by the British Government. Its composition is as follows:—

Nitro-glycerine	58 per cent.
Gun-cotton (insoluble)	37 „
Mineral jelly (vaseline)	5 „

The ingredients are kneaded together with acetone as a solvent, and the dough is then squirted through dies of various sizes according to the calibre of gun for which the Cordite is to be used. The cords so formed are then cut into lengths and the solvent is driven off. Finished Cordite is of a leathery consistency, and is yellowish brown in colour.

Figure 12. Cordite as described by Lieutenant Colonel J. P. Cundill (1895)

Weizmann filed a patent "Improvements in the Bacteriological Fermentation of Carbohydrates and in Bacterial Cultures for the Same" on 29 March 1915. That year he accepted the post of "Chemical Adviser to the Ministry of Munitions on Acetone Supplies" and so left Manchester for the Lister Institute in London. He was later embroiled in legal actions taken against the Synthetic Products Company Ltd for infringement of one of his patents.[18]

Figure 13. A note written to Manchester's glassblower Otto Baumbach from London. It is signed Ch Weizmann. On many of his papers and patents Weizmann adopted "Charles" in place of "Chaim" (courtesy of the Baumbach family)

War time adventures

WWI saw the internment of Chas Cook's colleague and friend, Otto Baumbach. However, Fritz Hartwig, who worked for Baumbach, escaped the same fate, presumably because he kept quiet about the Germany army's prowess when Otto didn't. Fritz adopted the name Fred and formed a partnership with laboratory steward Alfred Edwards under the name of The Scientific Glassblowing Company. [19]It was Edwards who had been asked to provide Weizmann with space for a laboratory and "found a dirty cob-webbed room in the basement".[20]

Chas W. Cook Ltd received its Certificate of Incorporation on 5 February 1917. The Articles of Association allowed a wide range of engineering activities including the manufacture of "Munitions of War of all descriptions, Guns and Cannon". There is much to be discovered about the wartime activities of Chas W. Cook. By Chas Cook's own account his talents were utilised on the development of depth charges, hydrophones, torpedoes, precision gauges for shells, aircraft engines, and tools "for the mass-production of parts by female labour".[21]

After WWI broke out, the newly knighted Sir Ernest Rutherford turned a considerable part of his attention to harnessing science in the aid of the war effort. A. J. Balfour, First Lord of the Admiralty, established the Board of Inventions and Research (BIR) in 1915. The body looked at various proposals for war-winning schemes and possibilities for their development. David A. H. Wilson (2006) notes that a gentleman (un-named) suggested to Admiral Jellicoe that barrels of Eno's fruit salts could be used to force submarines to the surface "on a mass of effervescent bubbles".[22] In a more practical approach Rutherford took up the problem of detecting submarines acoustically as part of a BIR sub-committee and was from 1917 technical adviser to the Lancashire Anti-Submarine Committee. Chas Cook was involved in the construction of devices to implement the results of Rutherford's researches, although exact details are still lacking.

Other activities at Manchester

A previous article[23] describes the meteorological station that Chas Cook constructed and equipped on Glossop Moor. There, Ludwig Wittgenstein, yet to make his mark on the world of philosophy, helped out by assisting the launch of instrument-laden kites.

Wittgenstein then turned his attention to a novel propulsion system and Chas Cook was called upon to make the combustion chambers. Ian Lemco has extensively explored Wittgenstein's aeronautical engineering work at Manchester.[24]

One of the last projects to be undertaken while still at Manchester was a stress testing machine destined for the Imperial Japanese navy. Designed by W. Mason of the University of Liverpool it applied torsional and bending stresses at a rate of 200 cycles per minute (figure 14).

Many of the items of apparatus conceived and fabricated at Manchester around the time of the First World War and before were still used to illustrate the Cook catalogue of c.1953, by which time the firm had moved to Birmingham. A nice example of precision toolmaking is the extensometer (figure 15) used to determine the elastic limit of metals. It was designed by James Edgar Hurst, a metallurgical Chemist, and George Tomlinson of the National Physical Laboratory. Petavel probably had a hand in directing the designers in Chas Cook's direction as Petavel had served on the NPL's general board from 1911 to 1916.

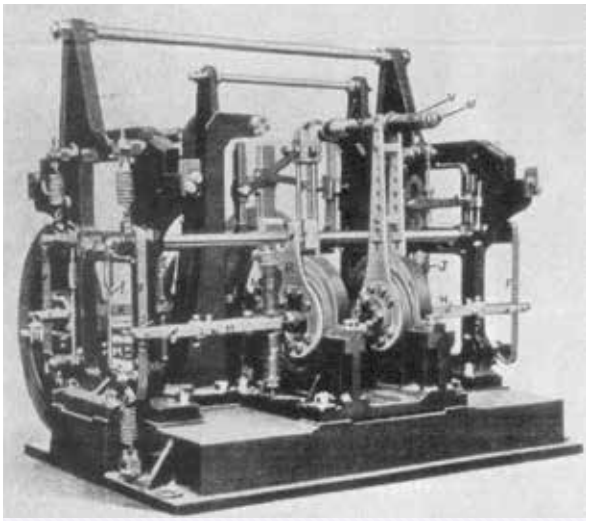

Figure 14. Alternating stress-testing machine as shown in The Engineer, 20 May 1921.

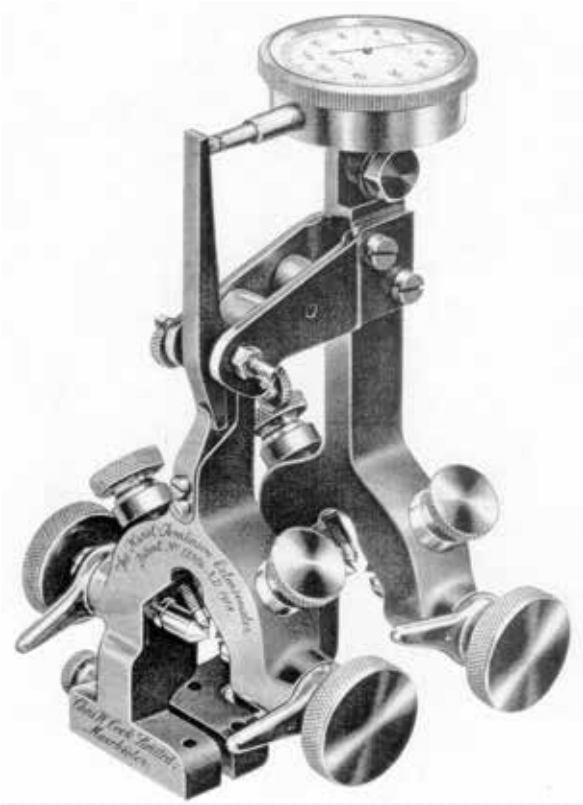

Figure 15. The extensometer designed by James Edgar Hurst and George Arthur Tomlinson

Figure 16. An electromagnetically agitated autoclave made by Baskerville and Lindsay Ltd as shown in a leaflet of 1964 (courtesy of Edward Underwood)

Baskerville & Lindsay

The British Association of Chemists organised an exhibition of scientific apparatus held at the Donnan Laboratories of Chemistry, University of Liverpool on the 4th and 5th of April 1962. Exhibiting in one of the ground floor laboratories was Chas W. Cook & Sons Ltd and on the next floor, Baskerville & Lindsay Ltd. The connection between the two firms went beyond the fact that both made high-pressure equipment. Thomas Walter Baskerville had been a draftsman and designer for Chas Cook until teaming up with another Cook employee, John Lindsay. They were important to the Cook business and, moreover, regarded by Chas as friends. Their plan to set up in competition was seen as a betrayal and, according to daughter Marjorie, "caused great upset". In 1922 Baskerville & Lindsay set up shop at 45A Claude Road, in the Manchester district of Chorlton-cum-Hardy, where they were joined by the Curnon Engineering Company.

Why Chas decided to leave Manchester is uncertain. It may have been as a direct result of Baskerville & Lindsay's actions or disenchantment with the city. As Mark Twain once said: "I would like to live in Manchester, England. The transition between Manchester and death would be unnoticeable."[25]

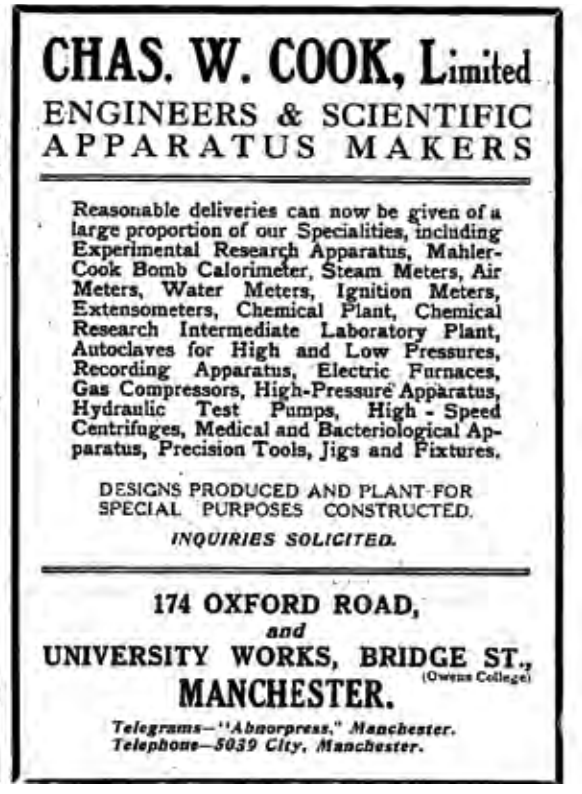

Figure 17. From Nature 4 Sept 1919. By this time, Chas Cook had moved part of his operation to 174 Oxford Road in preparation for vacating University Works

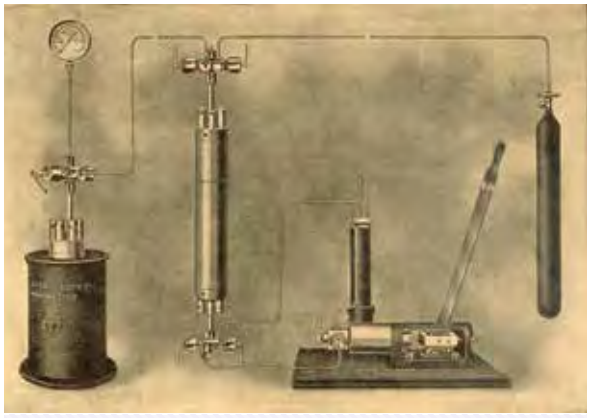

Figure 18. Apparatus for research on gases at high pressures and temperatures. Constructed at Manchester and shown in the 1955 Chas W. Cook & Sons Ltd catalogue (courtesy of Professor Hans Michels)

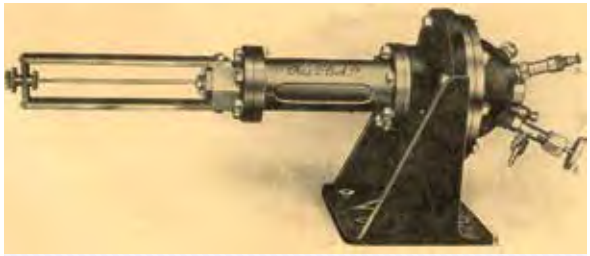

Figure 19. A spherical chamber for the combustion or explosion of gases. It is fitted with a pressure gauge devised by Joseph Petavel. Shown in the 1955 Chas W. Cook & Sons Ltd catalogue (courtesy of Professor Hans Michels)

To be continued

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Acknowledgements

Many thanks to Mike Allsop, ex-employee of Legrand Electric Ltd (which acquired Tenby Industries and with it, Chas W. Cook & Sons). The late Geoffrey Baumbach and his son Philip. Sarah Clack and Sam Gresham of the National Physical Laboratory. Trevor Gabbott, grandson of Edgar Parr Gabbott. Dr Jeff Hughes, Centre for the History of Science, Technology and Medicine, University of Manchester. Professor Robin Marshall FRS, University of Manchester. Professor Hans Michels, Imperial College London. Frank Shaw and Bill Harrison of Kestner Chemical Pumps Ltd, a successor company to Lennox, Reynolds & Fyfe. Edward Underwood, ex-employee of Baskerville & Lindsay. Ted Cook, grandson of Charles William Cook, and the late Marjorie Cook, daughter of William Cook.

References

1.Robert Lennox and John Heath (assistant from 1881-1925) both lost an eye during experiments at the RI.

2.A plan of the Electrotechnics Extension in Broadbent (1998) shows the allocation of a ground floor room to the "Tinsmith's Workshop" but the 1916 Manchester Poor Rate book for the All Saints district indicates that both Stelfox and Otto Baumbach were paying rates for a workshop on the first floor and the loft, perhaps suggesting a sharing of the rooms

3.William Alexander Kay was the laboratory steward at this time. See Alan Gall, "William Alexander Kay – Technician Supreme", *Science Technology*, April 2003, 9-12.

4.*An Account of the Physical & Electrochemical Laboratories and of the New Extensions Opened on Friday March 1st 1912 by Prof. Arthur Schuster.* John Rylands University Library Archives ref. UA/87/1 p.15.

5."Dr Thresh's Incubator of tin, felt covered for Petri-dishes" is offered in the Gallenkamp catalogue of 1902 for 7 shillings.

6.Conversations between the author and Geoffrey Baumbach 2001.

7.Alan Gall, "Rutherford's Glassblowers: Otto Baumbach and Felix Niedergesass", *Science Technology*, December 2004, 3-8.

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9.Kristen M. Frederick-Frost, "An Artifact Based Study of Henry Moseley's X-Ray Spectroscopy", MSc Dissertation (University of Oxford, 2012), 75.

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15.*Physical and Electrotechnical Laboratories. Experiments and Exhibits at a Conversazione Held on the Occasion of the Opening of the Extensions by Prof. Arthur Schuster PhD, DSc, LLD, FRS on Friday Evening, March 1st, 1912* (The Manchester Courier Ltd, 1912).

16.Son of Sir William Henry Perkin, famous for his discovery of the dye Mauve.

17.W.G.W, "A Woman Science Student Fifty Years Ago", *The Manchester Guardian*, 19 July 1957, 5.

18."Injunction to Restrain Infringement of a Patent", *The Times*, 31 March 1926, 5.

19.The Scientific Glassblowing Company Ltd is still trading, based at Royton, Oldham.

20.See http://www.manchesterjewishstudies.org/weizmann-manchester-university/

21."An Interesting Engineering Concern", *Town and Country News*, 13 July 1934, 22.

22.David A.H.Wilson, "Avian Anti-Submarine Warfare Proposals in Britain, 1915-18: The Admiralty and Thomas Mills", International Journal of Naval History, 5/1 (2006), 8.

23.Alan Gall, "From the Archives: Go Fly a Kite", *IST Journal*, Summer 2012, 88-95.

24.Ian Lemco, "Wittgenstein's Aeronautical Investigation", *Notes and Records of the Royal Society*, 61 (2007), 39-51.

25.With thanks to Prof. Robin Marshall who used the quotation in "The Birth of the Atomic Nucleus". ***See prometeo.sif.it/papers/online/sag/026/01-02/pdf/08-percorsi.pdf***

Marketing titanium products

Charles Osarinmwian

The advent of solid state electro-deoxidation has led to a paradigm shift in extractive metallurgy.[1-4] As an emerging technology, semi-continuous electro-deoxidation has a disruptive impact across the periodic table while targeting metal powder markets that are specialist low volume, high value metals (e.g. titanium). This paradigm is capable of producing low-cost titanium powder that can expand the market beyond aerospace, biomedical and defence.[5] Herein a comprehensive evaluation of the benefits and limitations of marketing strategies that could prove useful in marketing next-generation titanium products from semi-continuous electro-deoxidation is outlined.

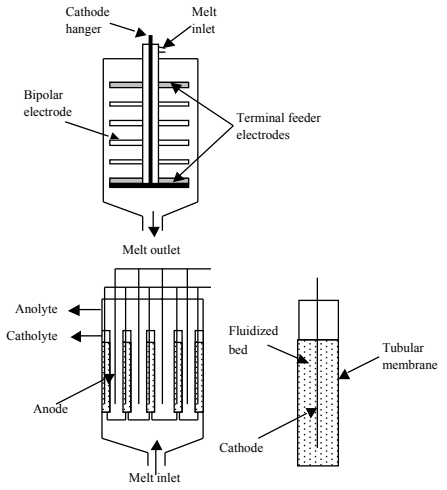

Fig. 1: Next-generation electrochemical reactor designs for the production of titanium powder

Titanium has a large market which could be transformed by the introduction of a low-cost production process using next-generation electrochemical reactors (Fig. 1). To develop a framework for marketing next-generation products it is important to clearly distinguish marketing orientation from marketing concepts. Marketing orientation is the behavioural manifestation of the extent to which the marketing concept has been implemented, whereas marketing concepts focus on customer needs and wants, deciding which needs to meet, and ensuring customer satisfaction. The literature describes marketing orientation and marketing concepts as follows:

The process of planning and executing the conception, pricing, promotion and distribution of ideas, goods and services to create exchanges that satisfy individual and organizational objectives.[6]

The achievement of corporate goals through meeting and exceeding customer needs and expectations better than the competition.[7]

These definitions start with a well-defined market that focuses on customer needs, coordinates all marketing activities affecting customers, and generates profits by creating customer satisfaction. In semi-continuous electro-deoxidation, customer expectations can be exceeded by tailoring titanium particle size and shape during additive manufacturing to meet specific customer requirements for important applications.

Inherent problems of implementing and assessing the marketing orientation in titanium products could be exacerbated by competition orientation (in particular strategic planning). However, competition orientation lacks customer orientation since its main focus is solely on increasing productivity, decreasing costs and improving market share.[8] Further, the use of reward systems as a motivation tool for achieving these goals is in conflict with marketing orientation;[7] this lack of customer orientation neglects the premise of customer value. Also, market saturation, economic crises, and increasing global competition in recent years have led to consumers criticising strategic planning procedures and their inability to solve implementation problems. This demonstrates that the marketing orientation lacks strategic content for defining opportunities and threats for next-generation titanium products.

Implementing an integrated approach (i.e. spreading marketing knowledge and skills across non-specialist groups) rather than a functional approach (i.e. concentrating marketing knowledge and skills within a specialist marketing group) would facilitate a product-based understanding of marketing concepts. The functional approach challenges coordination between titanium product lines causing inter-group conflict through personal ambitions of individuals while lowering information sharing. In contrast, an integrated approach allows multiple groups to share information about emerging products and customers

in order to engage in activities designed for customer satisfaction.[7] This would significantly avoid conflict, increase communication and foster innovation. Embracing an integrated approach leads to more marketing training that make marketing concepts a philosophy within product development [6]:

- **Marketing orientation.** Focus on the visions and aspirations of an emerging product in user-friendly terms. The content should feature product applications in high-tech sectors, testimonials and customer service/satisfaction guarantees.
- **Marketing concepts.** Focus on marketing concepts (e.g. marketing segmentation and mix) in a technical-user manual format.
- **Marketing strategy.** Use marketing audits (e.g. SWOT analysis) to assess the effectiveness of 'marketing concepts' and 'marketing orientation' manuals. Also, beyond word-of-mouth promotions, promote product capabilities at relevant trade shows while developing would-like objectives (preferred solution) and *must-have* objectives (minimum requirements) as part of a marketing implementation strategy.
- **Benefits of marketing.** The different layout and content of marketing manuals allows the functional approach to compliment the integrated approach as the effectiveness of marketing orientation depends on a strong functional approach. This reinforces marketing capabilities while focusing discussions on the benefits and value offered to customers through product and service offerings.

An implementation strategy involving the market segmentation of titanium customers in terms of demographic profiles, socio-economic qualities and psychographic values (i.e. needs, wants and interests of target markets) allow responsiveness measurements of each market segment to relevant components of the marketing mix.[9] This should satisfy the wellbeing of both the consumer and society in the long-run. Further, reducing market segments into even smaller segments (i.e. micro-marketing) targets customer needs with greater precision.[10] This increases customer-service delivery practices, which include relationship management and customer service in order to better satisfy and retain customers in an ongoing relationship. Micro-marketing aims for high customer retention levels because it usually costs more to attract new customers than to retain existing customers.

The approach of relationship marketing is at odds with the relatively impersonal approach of marketing orientation. Human factors underline the personal nature of relationship marketing and play crucial roles in customer persuasion and perception about the quality of a product or service delivered. Relationship marketing orients itself toward the long-term value of each customer by defining a set of interrelated consumer segments that are engaged in reaching a shared goal through building long-term network-partnership relationships.[10] In terms of perceived personal similarities and trust, relationship marketing creates added value for the customer.[8] An example of added value includes a demonstration of next-

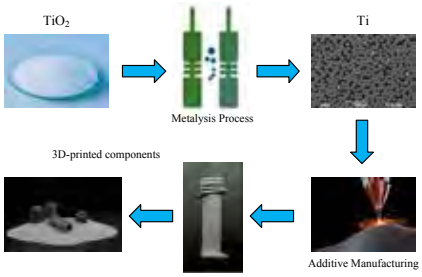

Fig. 2: Titanium powder could replace mill products and enable near-net shape production and 3D printing [5]. The market for additive manufacturing is worth over $1 billion and is growing at 20 % CAGR (additive-manufacturing grade titanium powder prices range from $200-400/kg) (Source: Roskill ITA SMR, 2014). The market for powders is expected to grow to ~$30 billion by 2025.

generation titanium powders in the fabrication of an automotive turbocharger component and an aerospace turbine guide vane using additive manufacturing (Fig. 2). It is important to note that relationship marketing uses retro-marketing (Table 1) and experiential marketing to provide a way of implementing and assessing the marketing orientation.

Exclusivity	*Deliberately hold back supplies of titanium products or services and delay gratification. Consumers will be encouraged to 'buy now while stocks last'.*
Secrecy	*Tease the customer by withholding information about a product or service. Then release this information intermittently so that the customer is left wanting more.*
Amplification	*Create outrage, controversy or surprise in marketing campaigns (e.g. predicted biocompatibility performance of titanium). This will spark interest while promoting word-of-mouth.*
Entertainment	*Excite and motivate the customer through a unique event (e.g. 3D-print customized titanium products).*
'Tricksterism'	*Use panache and audacity to engage customers (e.g. report momentary declines in global titanium supply).*

Table 1: Principles of retro-marketing. Competitive superiority allows marketing to drive strategy through answering industry demand via an externally supportive operations function (see Hayes and Wheelwright diagram).

Experiential marketing focuses not only on customer satisfaction but also on an ongoing emotional attachment between product and consumer. The network-partnership relationships in experiential marketing are more powerful than those created from market segmentation and micro-marketing[11] as problems such as communication across market segments (e.g. different age groups and demographics) do not exist. This is because the market is segmented based on more detailed and

personalized psychographic values (e.g. enjoyment levels and personality type). These values are tailored to create strong emotional relationships and customer loyalty through the delivery of a unique and preferably life changing experience in the form of an event or interaction generated by the brand developed from the application of the product:

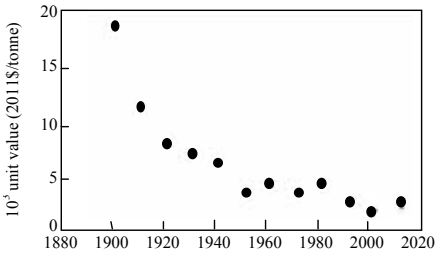

Fig. 3: Halving the price of aluminium generates at least a ten-fold volume growth for this metal (Source: USGS, European Aluminium Association).

- A new titanium ATI 425 Alloy was introduced by Allegheny Technologies Inc. at the Farnborough International Air Show in the UK. This could offer the aircraft designer new opportunities for improving the manufacturing operations of aerospace components.[12]
- RTI International Metals Inc. modified a long-term agreement with Airbus for more flexibility in near-term supply of titanium mill products.[13]
- Boeing signed a new 5-year contract extension with titanium producer Russian Technologies VSMPO AVISMA Corporation for titanium forgings. These forgings could be used on the Boeing 787 Dreamliner, 777 and 373 commercial aircraft.[14]

Emphasis on customer satisfaction, customer value and competition in marketing concepts can generate dull marketing campaigns, copycat promotions and marketplace stagnation.[7] Also, relying on customers to guide the development of new titanium products may be counter-productive as they have difficulty in articulating needs beyond the realm of their own experiences. Retro-marketing offers customers what they want by "teasing, tantalizing and torturing them" and thus creates demand as oppose to reflecting it (Table 1). The service marketing aspect of retro-marketing is significant in product differentiation and forms an important basis of competitive advantage (over stainless steel and aluminium) as it realizes that building customer loyalty and holding onto existing customers is as important as attracting new customers.[8] This achieves product design goals by meeting and exceeding customer needs and expectations better than the competition.

The implementation of retro-marketing should be limited to titanium products with established and high profile impact (i.e. strong "brand" equity). Customer preference data in e-marketing reduces the relatively high cost of relationship marketing with respect to the tedious generation of psychographic data required while raising the question of whether psychographic data is useful[10]; new consumers may be less sensitive to brands and marketing cues. Despite the criticisms of the marketing orientation, many accept the use of marketing orientation as a tool of e-marketing while others would prefer modifying the marketing orientation to make it more suitable for the internet environment.[8] It is important to note that the use of marketing orientation as a tool of e-marketing contributed to the failure of the dot.com era during the 1990s.

Excessive use of e-marketing could adversely affect social involvement and the psychological wellbeing of society. This would be akin to the barter exchange economy that existed in economically underdeveloped societies. However, the highly turbulent e-market environment, arising from rapid technological advances, market uncertainties and intense risk from "Brexit", make marketing efforts even more important to the success of next-generation titanium products than in relatively stable market environments. This suggests a need to focus on both e-marketing and relationship marketing to survive in future markets. Lowering titanium prices (faster than aluminium prices, Fig. 3) and product innovation on a global scale relies on the ability of semi-continuous electro-deoxidation to produce titanium powders suitable for additive manufacturing applications while tailoring particle size and chemical composition to meet customer demand.

Author

Charles Osarinmwian MIScT, RSci, is in the School of Chemical Engineering and Analytical Science, The University of Manchester, Oxford Road, Manchester M13 9PL, United Kingdom.

E: charles.osarinmwian@manchester.ac.uk

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Domestic plugs and sockets

Oof Oud

Collecting plugs and sockets is a rather unusual hobby. When looking for missing plugs in a small shop in the States I told the shopkeeper "I am collecting plugs from all over the world." He was convinced that I was fooling him. Why should there be any other system than the US straight-blade plug? He was hardly able to grasp the fact that worldwide there are at least twelve different standards of domestic plugs and many more uncommon types for special purposes.

Initially, electricity in homes was only used for illumination. Homes were hard wired. By the late 19th century portable lamps and electrical appliances became available. They generated the need of plugs and outlets. Not surprisingly, the first plugs were lamp holder screw-in models, but quite soon more practical, separate sockets were developed. In Britain and continental Europe, plugs often had two round pins. In the US, Hubbell's straight-blade plugs became the preferred model.

Many, locally operating companies, promoted electrification. They offered mostly 110 or 220 volt, direct or alternating current. For commercial reasons electricity companies chose a particular type of plug, often different from other companies that were active in a neighbouring region. Gradually, cooperation between companies and authorities resulted in standardisation. In Britain the first standard for 5 Amp plugs with two round pins was BS 73, published in 1915. German standards for 2-pin plugs and sockets were published in 1924 (DIN-VDE 9400 series). In Germany electrical industry managed - unlike in France and Britain - to keep authorities and other public bodies largely out of their business. That, and the First World War, has delayed standardisation in Germany considerably. In France, one of the tasks of the Union des Syndicats de l'Électricité (USE), founded in 1907, was participating in standardisation. Everywhere, the prime reason for standardisation was, and still is, ensuring safety, which results in a degree of uniformity. However, bodies involved in standardisation never give preference to the products of one or another company.

BS 1363 that became effective in 1947 is a good example. For safety reasons plugs must have a fuse. Three companies developed very different fused plugs:

Thomas Atherton, director of Dorman and Smith. It is said that the idea for the company's fused plug came to him after finding his maid attempting to connect two cables directly together after a fuse had blown.

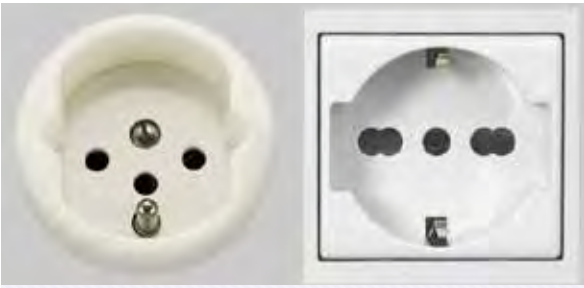
Dorman & Smith, MK Electric and Wylex. Sockets of each of three companies were installed in new homes and public buildings, but through the years MK became the preferred 13A model.

Left: Dorman and Smith 13A plug; the live pin is a fuse.
Right: Wylex 13A plug.

Earthed plugs were already made in the early 1900s, but before 1930 they were rarely used in homes. In 1915 George Knapp, working at Harvey Hubbell Incorporated, designed an earthed plug with angled flat pins. The model has never been successful in the US, but became the standard domestic plug in Australia, New Zealand, Argentina, Uruguay and China. Philip Labre had developed the earthed plug that is now commonly used in North America in 1928. One of the oldest British earthed plugs was the Tripin model, made by Lundberg & Sons of London around 1910. Tripin 2.5A and 5A plugs are similar to BS 317 (1928) and BS 546 (1934).

In continental Europe there was already in the 1910s a remarkable conformity with respect to unearthed plugs. 4A (later 6A) plugs had pins with a diameter of

Examples of classic earthed pins. Models are still in use. Left: Hubbell plug, designed by George Knapp (from 1938 Australasian standard plug). Middle: wooden Tripin-like 5A plug (comparable to BS 546).
Right: early 1930s Schuko plug with earth clips (essentially unchanged in almost 90 years).



Left: obsolete Swiss socket, transition model
Right: universal socket for 10 and 16A Italian plugs and Schuko plugs

4 mm and a pin spacing of 19 mm (three quarter of an inch). Differences between countries in Europe started in the early 1930s when earthed circuits in homes were introduced.

Not the oldest, but by far the most successful German earthed plug is known as Schuko (Schutzkontakt = protective contact, by means of earth clips). Schuko plugs and matching sockets had been designed by Wilhelm Klement, working at Siemens-Schuckertwerke in Berlin. It was based on an earlier model designed by Albert Büttner (ABL Company). The Schuko patent was filed late in 1929.

France Legrand in Limoges introduced a 3-pin plug. Later the earth pin moved from plug to socket. Unfortunately it is not clearly documented why sockets with an earth pin were preferred. Switzerland had for some time also sockets with an earth pin, but it was replaced in 1954 by a unique 3-pin plug design. For 20 years transitional type plugs and sockets were available that could be used for both the old and new system.
Denmark has always had its own 3-pin standard. Danish earthed plugs do not fit in any other type of socket. Plugs and sockets were almost exclusively made by Lauritz Knudsen, but the European Union has forced Denmark to accept other standards to break the monopoly of LK. First, import of French and finally also German plugs was allowed. However, because all homes have Danish sockets, adapters are needed to plug in equipment with a French or German plug.

The third continental European country that has an incompatible earthed plug system is Italy. The earth pin, in line with the power pins, is positioned in an exact intermediate position. Nowadays sockets that accept Italian and German (Schuko) plugs are installed more often.
Finally, Israel has 3-pin plugs with a triangular pin orientation that differs from BS 546, Danish and Swiss plugs. Initially Israeli plugs had flat pins, but in an attempt to have a better contact between pin and socket contact it was decided to switch to round pins. Transition sockets that accept both types of plugs were introduced in 1989, but round pin plugs not before 2000. At that time there were sufficient sockets that accepted new and old plugs.

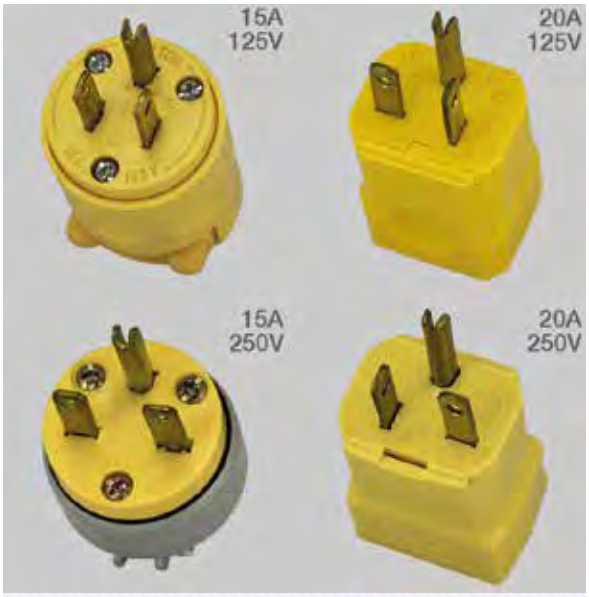
When traveling to other countries it is often necessary to carry various adapter plugs to make a foreign socket usable for your electrical equipment. Already in the 1930s the International Electrotechnical Commission (IEC) noticed the disadvantage of not having one worldwide-accepted standard plug. About half a century later, the IEC proposed two international standards for 230V and 100-125V household plugs. The 230V IEC 60906-1 standard, resembling the Swiss 10A plugs has been adopted by South Africa since 2014. The IEC 60906-2 110V international standard is identical to the US 15A-125V straight-blade plug. Brazil has introduced two variants of IEC 60906-1 that are used for both 220 and 110V. It is a pity that the decision to modify the plug, and use the same model for both voltages, undermines the idea of a world standard.

British Standard 1363 describe just one type of plug and matching socket, rated at 13 Amp, 250 volt. However, about half of the main standards of domestic plugs and sockets consist of a number of variants for different currents and/or voltages. That results in a substantial increase in the number of plug types that are used worldwide.

The number of US NEMA[1] variants is unsurpassed. The total number of straight blade configurations is 42 and there are an equal number of locking configurations.

Notes

1. NEMA stands for National Electrical Manufacturers Association, de facto the standard for US plugs.



Four examples of US plugs showing a specific pin configuration for each combination of amperage and voltage

They have curved plug blades, oriented in a circle; after inserting in a socket you can lock the plug by turning it through 30°. The number of 42 relates to combinations of 15, 20, 30, 50 or 60 Amp and 125, 250, 277 or 347 volt single phase and various 3-phase voltages. Restricted to domestic use (15-20A /125-250V single phase), there are 10 configurations, but some 30 and 50A plugs are used also in homes, for dryers and stoves.

Four 250 volt standards have defined different plug configurations for various amperages, a safety feature that prevents misuse of sockets, and its wiring, with too low a rating. The size of plugs and diameter of pins differ for BS 546 2A, 5A and 15A plugs. The Australasian standard describes different widths of angled blades and shape of earth pins for 10, 15, 25 and 32A plugs. Switzerland has 10A plugs with round pins and 16A plugs with rectangular pins. The difference between Italian 10A plugs (4 mm pins, 19 mm apart) and 16A plugs (5 mm pins, 26 mm apart) is directly related to the fact that in the past houses had both 127 and 220 volt. The lower voltage was meant for illumination only and higher voltage for other purposes. Each house had two separate, metered circuits with different sockets. 127 and 220V were sold at different tariffs. Distinction in voltage doesn't exist anymore, in favour of 230V, but the difference between 10 and 16A plugs still exists.

With respect to non-earthed plugs you can find three types in continental Europe. The 2.5A flat Europlug with two partially insulated 4 mm pins is very common. Its use is also allowed in many countries outside Europe. For more powerful equipment there is a model that has shape characteristics of the Schuko plug, but without earth clips. The plug outline also allows the use in French earthed sockets, which have an earth pin. Identical to Schuko plugs, pins have a diameter of 4.8 mm and rating is 16A. In the Netherlands and Sweden,

Left: 16A plug that fit in Schuko and French sockets. Right: 16A plug only for not earthed sockets.

a third type still exists. It is essentially a 1910s model with a fully round base. They were abundantly used in the 1920s-'70s. Compatible, not unearthed sockets can be found in dry rooms of older houses. Earthed sockets do not accept round base plugs. The incompatibility dates back to an old regulation that earthed sockets may not allow acceptance of unearthed plugs. To block these unearthed plugs, Schuko sockets have always had notches. In French sockets it is the earth pin that blocks round base plugs

Worldwide there are even more types of plugs; because quite a number of plugs exist that have an uncommon pin configuration. They are meant for special purposes in which it is important that only a particular type of equipment uses a socket that is connected to a special local circuit, separated from the mains. Special circuits are used for:

1. Electronic and medical equipment that have to be protected against voltage fluctuations, and/or require uninterrupted power supply;

2. Equipment that must have a zero volt ground connection (so-called clean earth);

3. Equipment that need a deviant voltage and/or direct rather than alternating current.

Special sockets, connected to a standard network, are also used for situations in which the possibility of reversing the line and neutral poles has to be avoided. BS 1363 and many other earthed plugs can be inserted in a socket in only one orientation; they are polarised. However, Schuko plugs are not polarised; they can be inserted in two ways. A German Terko plug is one of the polarised alternatives.

Left: Danish EDB socket with slots for angled flat pins, rather than standard round pins. Right: Polish data socket and plug; the left pin has a V-shaped groove. EDB and DATA devices are used for powering electronic equipment.

Left: polarised Terko socket. Right: British EPOS key plug; when in socket, turn to make connect.

Finally, special plug-socket combinations have been designed that can't be disconnected easily. An example is a key plug that after insertion in an EPOS socket has to be rotated 90° to make contact. These British EPOS (Electronic Point of Sale) devices are frequently used in shops connecting cash registers. A variant key plug is used for uninterrupted power supply (UPS).

Epilogue

An important aspect of collecting classic and current plugs and sockets is to preserve a representative, worldwide selection of devices that are used each day by everybody, without the users paying much attention to them. Usually sockets don't survive redecoration of homes or knocking down buildings; the destiny of plugs is hardly better.

I hope that the collection will give next generations the opportunity to look back on a variety of indispensable electric devices that were used in the past. To reach that goal it is important to share the collection with others. The best way of doing that is a Digital Museum. You will find it at **http://plugsocketmuseum.nl**

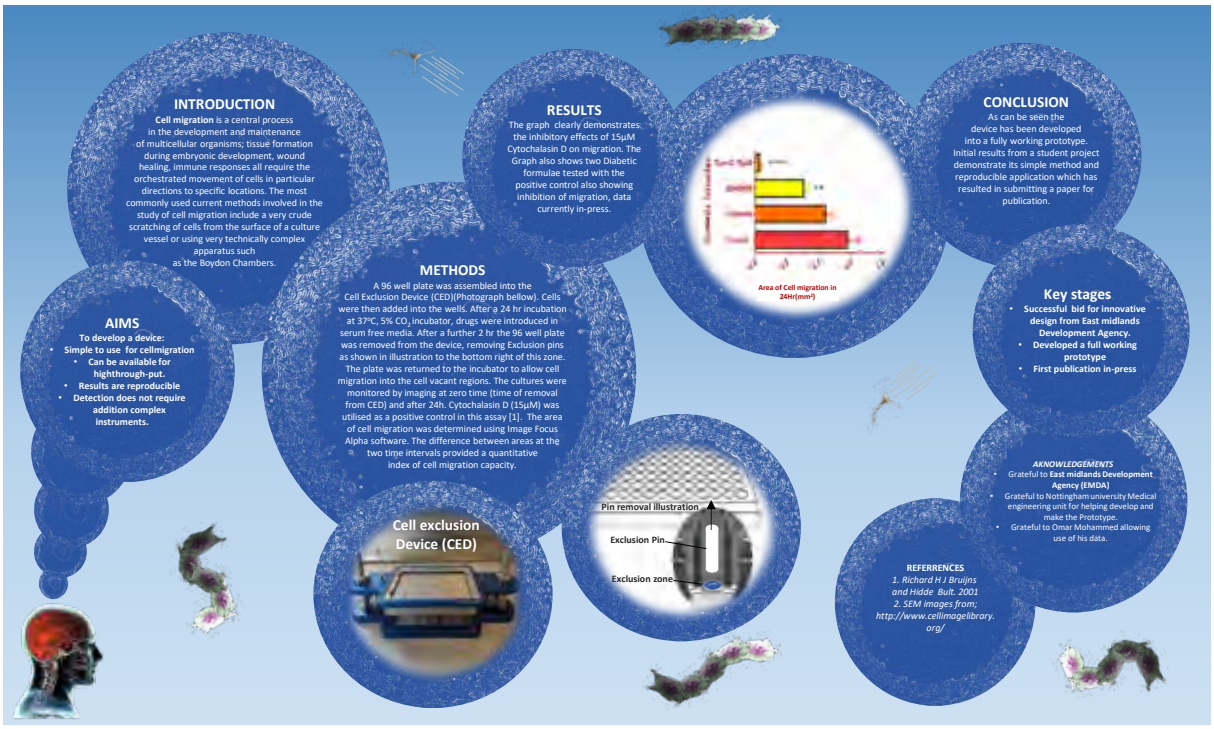
It shows about 1000 classic and current plugs and sockets and gives details about their use and origin.

Author

Oof Oud is a retired reader in Genetics at the University of Amsterdam, Netherlands. Because of projects with colleagues abroad and congresses all over the world he was confronted with many types of plugs and sockets. Gradually he became fascinated, rather than frustrated, by the diversity of incompatible plug standards.
info@plugsocketmuseum.nl

Developing the novel re-usable high through put in vitro cell migration device

Liaque Latif – Winner of the 1st prize poster presentation at IST's Technical Conference 2016



As on previous occasions, I was just not satisfied with the cell migration experiment that I had just carried out. It had taken me a whole week, from seeding the Chinese hamster cells in 24 well plates to recording images of the cells possibly migrating into the area where I had scratched away the cells with a sterile yellow pipette tip. Although we can now image deep into a cell using a scanning electron microscope (SEM), we had such a crude method to observe how the cell moved, I needed more accurate, reproducible, and reliable data. The initial idea started from a simple observation anyone doing cell culture would have witnessed when growing cells on a coverslip. Once the coverslip is removed, you would leave behind a very clear cell free zone. I played around with a variety of circular objects of varying size that I could autoclave and stick into a culture vessel with some cells. The main problem was been able to reproduce the data; the big scientific conundrum needed statistically viable data!

I was fortunate enough to be working for Professor David Kendall and Dr Stephen Alexander and as the idea grew both where very supportive and encouraging. Along with their help, support, and Professor Kendall's enthusiastic view of funding, "there is always small cash that had been left lying around", we managed to persuade the Medical Engineering Unit along with a technician called Mr Stephen Hall, the man with all the right tools, to make the first very crude prototype of what we were designing. Once it was made we were able to demonstrate how it worked, providing a proof of concept. We had to then register the idea with the University of Nottingham by filling out disclosure forms. This was a good way of protecting the device as it became university property. I never considered making money from it; this was purely in the name of science.

I then contacted Dr Adele Horobin from Research Innovation Services, again very fortunate as Adele was amazingly helpful. Over several meetings she recorded

our findings and the design, highlighted marketing strategies, and identified other similar designs out in the market already. Thankfully ours had the advantage that it was reusable, and required no other complex assay to assess the results. Adele also recommended submitting a grant application to the East Midlands development agency. My supervisors, Professor David Kendall and Dr Stephen Alexander submitted the grant application. On a wonderful lunchtime we received an e-mail that said "The Fellowship Appraisal Board met yesterday, and your application was successful. Many congratulations!" As you can imagine I was ecstatic!

Over the following year there were lots of ups and downs as the design evolved, from a simple device fitting into a single 24 well cell culture plate, into 48 wells on a 96 well plate of the design you see today on the poster presented at Manchester IST conference 2016. There were several points at which it became quite difficult, when things out of our control did not work, like machining the 2mm end pins with the machining tool we had, which kept snapping bits of the end, but after some superb experimentation from Stephen hall (our medical engineering unit Technician) he identified a suitable material. Polytetrafluoroethylene (PTFE), which worked out perfectly as it was also autoclavable.

Figure 1. Photograph of final working Prototype.

Once we had a working prototype (figure 1) we then started the experimental work. Initially, I fitted it in with various work experience/ training programs that I had running in the labs which I managed. The first Person to use the Device was Miss Zainab Abbas (PhD), followed by Mr Litaf Latif (Work Experience), Miss Shu Ling (MPharm Student on work experience), and most recently and the most thoroughly by Mr Omar J. Mohammed (PhD student). His research, including the cell exclusion device, is titled "Diabetes-induced cardiomyocyte defects in chick embryonic heart micromass and mouse embryonic D3 differentiated stem cells" and is at the moment eagerly anticipating referees comments.

The final protocol used was as follows; The 96 well plates were coated with 1% gelatine and the plate was placed into the Cell exclusion zone Device (CEZ Device). Mouse Embryonic Stem cells Day 3 (ESD3) cells were seeded, using ESD3 culture medium, into the wells of the 96 well plate, at a cell density of 5x105cells per well in order to approach 100% confluency next day. After 24h, and before the 96 well plate was removed from the CEZ device, the ESD3 culture medium was aspirated and replaced with serum-free medium (to reduce any effects of exclusion zone been occupied by proliferating cells) with or without diabetes-like formulas. The plate was incubated at 37oC in 5% CO2 (v/v) incubator for 2h followed by removal from the CEZ device to allow cells to start migrating into the previously excluded area. The cultures were monitored by imaging at zero time (time of removal from CEZ device) and after 24h. Cytochalasin D (15µm) was utilised as a positive control in this assay. The areas of migrated cells were determined using Image Focus Alpha software. The difference between areas of the two time intervals shows the cell migration capacity. All the people involved in the testing contributed to the final protocol we have today.

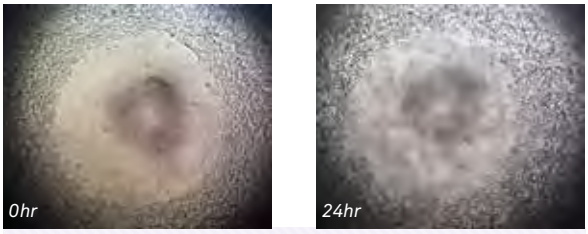


Figure 2. Here are a few of the many images showing a typical example of cell migration over 24 hours using phase contrast microscope at 10X magnification.

Two formulas were tested in this assay, at different concentrations of drugs tested, diabetic formulae used was 10:20mM and 20:40mM. The results indicated the inhibitory effect of hyperglycemia on stem cell migration. Three independent repeats with 8 intra experimental repeats for each tested formula were carried out. The mean ± SEM data clearly demonstrated the effects on stem cell migration. The positive contro (cyto-D) showed complete inhibition of any migration occurring in absence of any drugs as seen in the control.

Aknowledgements

I am grateful to Dr Michelle Jackson for asking me to do the poster and allowing me to go to the conference.

Also, the Staff Development Committee for funding my place.

It was a very memorable technician's conference, listening to Helen Sharman (First Britain in Space, in case you missed that) alone, was so uplifting, one minute in a Chemistry lab in a Mars chocolate Factory and the next in SPACE, that is one giant leap!

Author

Liaque Latif BSc.

The development of cleanrooms: an historical review

Part 1 – From civil war to safe surgical practice, Tim Sandle

Introduction

Cleanrooms provide the technological solution for contamination control in relation to pharmaceutical production and healthcare operations. Cleanrooms are designed to protect products, personnel, and equipment from being adversely affected by contaminants, through creating clean and controlled areas. Cleanrooms are additionally used in other sectors including microelectronics, semiconductor manufacture and optical applications.

This article discusses the development and progress of cleanrooms and describes the significant historical milestones, taking the eighteenth century concept of a "clean space" to the twenty-first century cleanroom. The history of cleanrooms is intimately entwined with two strands of technological development: medicine and military. The medical origins can be traced back to the attempts to create a clean environment, first for field surgery and later for operating theatres; whilst the military applications stem from attempts to assemble precision engineered mechanisms in environments where dust particles posed a risk to the device mechanics. Further on, the developments with atomic power, spacecraft, and electronics, followed by the later application of cleanrooms in the pharmaceutical industry, all spurred technological advances in cleanrooms and led to the modern cleanroom technology of the twenty-first century.

This article is in two parts. Part one looks at the concept of clean air and the development of cleanrooms up until the 1960s. Part 2 addresses the developments since the 1970s and the driver for a unified, international cleanroom standard.

Early history: surgical endeavours

Fixing a point in time, when it was commonly accepted that the surrounding environment had an effect on the level of cleanliness within a defined space, is not straightforward. Tracing the origin will provide a different answer depending upon the industry or technology surveyed. The complication arises because cleanrooms were developed through two dissimilar routes. One route was "industrial", for which the military, atomic, and space fields exerted the greatest influence on clean area development; the other route

Figure 1: Operator undertaking environmental monitoring in a cleanroom (image courtesy of Tim Sandle)

was "medicinal", of which the development of operating theatres was the most significant innovation.

One of the earliest recorded "industrial" concerns about environmental cleanliness was by a Swiss watchmaker, whose concerns with dust led him to cover his watches with a glass jar when they were not being worked on. Arguably this use of a bell jar was one of the first design attempts to create a "clean space".

Today modern cleanrooms continue to use the barrier concept. In addition to an enclosed space the most important mechanism for keeping an area clean is the use of air filtration. The history of air filters can be traced back to fire fighters. Until the early nineteenth century it was common for fire fighters to enter burning buildings with a wet cloth tied around their faces as a crude protection from smoke inhalation. This precarious activity was somewhat improved by the development of an air filter by John and Charles Dean in 1823, who devised a smoke protection filter which afforded some protection to fire fighters from the acrid smoke and dangerous chemicals in the air when fighting fires [1]. The air filter device was later adapted for use by underwater divers and for the gas masks invented by Cluny Macpherson which were used in World War I [2], as well as providing the design concept for the HEPA (high efficiency particulate air) filter.

When the medical strand is examined there are various times in the development of surgery where medical staff expressed concerns about environmental contamination contributing to patient harm. There

is, for example, documentary evidence indicating that surgeons in the American Civil War (1860-1865) acknowledged the environmental risks from field surgery. For instance, army physicians speculated that the spread of pus-formation from one patient to another was probably airborne [3]. Furthermore, in 1864 the American Medical Association campaigned for ventilation of the hospitals to be improved as a means to creating cleaner air [4]. Although of contamination from air, equipment, surfaces, and people were generally acknowledged as important risks during surgical procedures; little improvement was made to the cleanliness until the work of Lord Joseph Lister became accepted. One of Lister's concerns was with the spread of post-operative infections and in response he pioneered the use of aseptic methods in surgery. Inspired by the work of Louis Pasteur on ways to destroy microorganisms, Lister experimented with surgical dressings soaked with carbolic acid (phenol) to cover the wound; and with hand-washing, sterilising instruments and spraying carbolic in the operating theatre whilst surgery was performed, in order to limit infection [5]. In 1867, Lister described the first antiseptic:

"Carbolic or phenic acid, a volatile organic compound which appears to exercise a peculiarly destructive influence upon low forms of life, and hence is the most powerful antiseptic with which we are at present acquainted." [6]

Figure 2: Surgery, at the time of the American Civil War (image: Creative Commons)

From Lister's success in reducing post-operative infections, other medical developments in surgery followed. In 1878 Robert Koch discovered that bacteria in the blood caused septicaemia, a finding which led to greater support for the use of antiseptics [7]. The growing demand for antiseptics led to the American entrepreneurs James Wood Johnson and Edward Mead Johnson founding Johnson and Johnson for the first large scale production of anti-bacterial chemicals [8]. Scientists, following on from the work of Lister and Koch, reasoned that reducing bacteria present within the hospital environment would similarly reduce the dispersion of infectious diseases and promote patient recovery. For example in the late nineteenth century, Professor Neuber, and later, Ernst Bergmann, focused on the cleanliness of surgeons [9]. Improved hygiene was gradually adopted part of the operating theatre routine. Bandages, instruments and clothes were all steam-sterilised to remove dirt and microorganisms, which reduced the use of chemical disinfection. Greater discipline was also introduced to the practises of theatre staff by minimising infections via surgeons' hands and nails. Here the work of William Halsted, who introduced the use of rubber gloves, caps masks and gowns for surgery, was important [10]. Arguably it was improved post-operative survival rates which helped to advance surgical techniques in the early years of the twentieth century.

Post-war: industrial growth

Although the cleanliness of medical techniques continued to move forwards in the first part of the twentieth century, notably as a result of the field medicine of World War I, there was little advance with the concept of the "clean air space" in the first decades of the century. Consideration was given to controlled areas within factories which manufactured small bearings and gears used in aircraft, where attempts were made to eliminate the gross contamination associated with manufacturing areas (such as heavy dust-laden air which could cause seizure of gears mechanisms). Contamination control was attempted through good housekeeping practices and by segregating the work area from other manufacturing operations [11].

Figure 3: Production of gas filters for the Swiss Army (image courtesy of Schicht Hans H.: 40 years of cleanroom technology – some historical remarks. In: Proceedings of the 17th International Symposium on Contamination Control, Bonn/Germany, 6-9 Sept. 2004, p. 1-10. Edited by: Verein Deutscher Ingenieure (Association of German Engineers), Düsseldorf/Germany (2004))

Whilst methods of minimising air cleanliness were attempted (most notably with ultraviolet radiation in the 1930s) [12], the next significant step in the idea of a clean space was that century's second war and this was driven by industrial rather than medical applications. With World War II there was an escalation of military technological developments. The need to assemble small-sized critical components, from gun mechanisms to aircraft gyroscopes, in areas free from contamination led to the development of "white rooms". These were areas where the level of ventilation was increased and the air was filtered through air conditioning systems. These filters, part of the air handling unit, were initially described as called super impingement or super interception filters and were later referred to as absolute filters. Attempts were also made with room pressurization [13]. A further development took place with filtration, where the gas masks were designed as something akin to the HEPA filter whereby esparto grass and asbestos was used as the filtration medium [14].

The development during the war of atomic weapons was part of the driver for the design of more sophisticated air filters for creating clean working environments. This process led to the construction of the first "HEPA filters" as instructed by the Atomic Energy Commission (AEC), USA. The filters were termed "absolute filters" (the acronym HEPA was not used until the 1950s). Absolute filters were developed, as part of the atomic weapons Manhattan Project, in order to remove and to capture radioactive dust and particles from the air inside the laboratories. The development was undertaken by the research and development firm Arthur D. Little. The Little firm designed the first absolute filters to capture particles of a size of 0.3 µm and larger based in the design specification of the filter to effectively capture condensed radioactive iodine. These first air filters were very large compared to the HEPA air filters that are produced today [15].

Absolute filter technology was declassified after World War II and it became available for industrial use in the early 1950s, providing the primary part of heating, ventilation and air-conditioning systems (HVAC). The first filter mechanisms, based on grass, were replaced with glass fibres intertwined with paper. The use of HEPA filters formed part of the adoption in industry of many aspects of wartime technology. Many aspects of post-war industrial developments required clean working environments and the maintenance of cleanrooms increased in importance. Such industries includes the preparation of mechanical instruments, electronics (especially the use of semiconductors); and the nuclear and space industries. In the era of mass production, these sectors required larger cleanrooms with larger volumes of filtered air. This was part of the greater recognition of the need to control particulate levels, such as from dust, fibres and skin cells, particularly as dust could cause post-manufacture operational problems to precision instruments if sufficient quantities settled onto gears or bearings. The construction of these turbulent flow cleanroom areas was helped by the development of ventilation distributors which allowed greater volumes of air to be supplied in a more uniform manner [16].

As well as within industry, post-war developments in cleanroom applications continued within hospitals. In the 1950s there was extensive research undertaken into examining patterns of hospital acquired infections and the microbiological risks posed to patients during surgical operations [17]. This led to further attempts to improve the ventilation of operating areas, on the basis that addition of filtered air, in sufficient quantities, would considerably increase the level of air cleanliness (this was sometimes referred to as "positive ventilation") [18]. The most important technological development was the production of artificial ventilation whereby air speed and flow were subject to mechanical control. As this technology advanced artificially generated clean air became "cleaner" and was delivered through more reliable systems. This led to the USA, towards the late 1950s, to stipulate that the requirements for air circulatory systems employed in surgical suites were to be of a minimum of 12 changes per hour in existing facilities and a minimum of 25 changes per hour in new facilities [19].

1960s: the space race and the cleanroom first standards

A very significant innovation occurred in the nuclear industry which had become the receptacle of huge financial investment following the creation of the atomic bomb. This was the application of the HEPA filters to create laminar airflow. The concept of laminar airflow (now described today as "unidirectional airflow") is that air is introduced into the cleanroom at a high velocity which causes the air to travel along a unidirectional path over a required distance. In doing so, contamination is swept away from the critical area unlike the more random distribution and transition of contaminants in turbulent flow cleanrooms. The concept of laminar airflow led to the development of rooms and specialised airflow cabinets whereby greater levels of cleanliness could be achieved [20].

The development of laminar flow technology was completed in 1961 by a team led by Willis Whitfield at the Sandia Corporation (later the Sandia National Laboratories) based at Albuquerque, New Mexico,

Figure 4: Cleanroom, circa 1960s. National Climatic Data Center, USA (image: Creative Commons)

USA, in partnership with the U.S. Atomic Energy Commission. The objective of Whitfield's work had been to devise an air control system which protected personnel from nuclear particles. The starting basis of the research was that current cleanroom designs were inefficient when measured against the pace of industrial developments, such as the problems of dust particles contaminating electronic components [21]. The primary way to create very clean environments was as equally reliant upon intensive manual cleaning as it was to ventilated air. Whitfield was able to achieve higher cleanliness standards by using fans to both push outside air through filters into a room whilst simultaneously using fans to remove the air from the room at an equal measure through exhaust pipes located in the cleanroom walls. A later development provided air from the ceiling and removed air ("air exhaustion") through grills in the floor, based on the principle that particles deposited into the air stream would, through gravitational affects, be more easily removed from the room by the airflow [22].

The applications of HEPA filtration which followed on from the Sandia developments were adopted by a number of other industries [23]. In some industries the technology was orientated towards protecting people from contamination against a range of hazards like radiation, chemicals. Whereas in other sectors like car production, the company General Motors was one of the first car manufacturers to use clean spaces to protect circuits from dust [24]. In

the 1960s a series of different patents pertaining to cleanrooms were issued, such as a patent for a vertical laminar flow room was issued by Charles Moll and William Andersen, based on work undertaken at the Westinghouse Electric Corporation. It was known as an "ultra clean room" [25].

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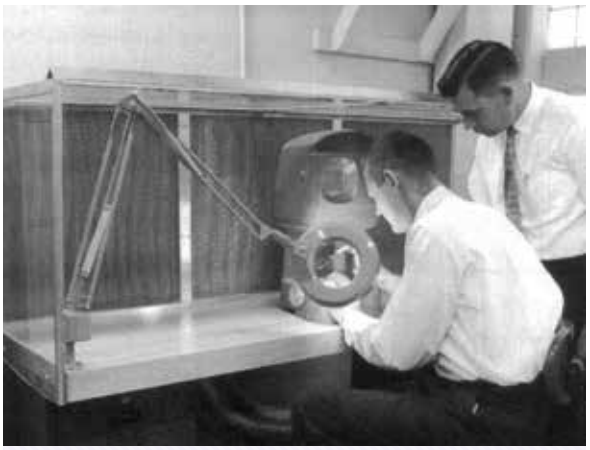

Figure 5: Whitfield working under a laminar airflow at Sandia Corporation, circa 1961 (image courtesy of Schicht Hans H.: 40 years of cleanroom technology - some historical remarks. In: Proceedings of the 17th International Symposium on Contamination Control, Bonn/Germany, 6-9 Sept. 2004, p. 1-10. Edited by: Verein Deutscher Ingenieure (Association of German Engineers), Düsseldorf/Germany (2004).)

The widespread use of cleanrooms across a range of industries and the improvements to building design technologies led to a requirement for a means by which cleanliness could be measured, standardised and compared. The standardisation of cleanroom cleanliness was first marked by the U.S. Air Force Technical Order 00-25-203 [26]. This was the first standard for a controlled area. The Technical Order adopted the classification system Class I to Class IV, with Class I established as the cleanest standard. The classification was based on, as with modern standards, the maximum quantity of particulate matter, of a specific size, which pertained to a particular room

class. In addition to a classification standard, the Technical Order also described the process for entering a clean area, clothing requirements and some rudimentary room design issues [27]. The Technical Order became the basis of the stricter requirements of the development of rockets and later of the U.S. Federal Standard 209.

A powerful driver for technologies designed to produce cleaner manufacturing areas was the space race [28]. The US National Aeronautics and Space Administration (NASA) centre utilized cleanrooms and laminar airflows to advance rocket technology [29]. NASA initially adopted the Air Force Technical Order and classification system, which was only based on particulate assessment, and added to this a requirement for microbiological monitoring due to the need to minimise microbial levels on critical components required for the assembly of spacecraft (through a series of handbooks such as NASA SP-5076 which was concerned with contamination control) [30]. For microbiological testing, the NASA guidelines recommended the use of Reyniers slit air-samplers, RODAC plates for surface sampling, and for the monitoring of the hands of personnel by requiring personnel to touch sterile stainless steel strips and then subsequently washing the strips with peptone water, with the peptone water subject to further dilution and transfer onto microbiological culture media. The culture medium used for all tests was Trypticase Soy Agar (with an incubation of 32oC for 72 hours). As an indicator of the level of contamination control of this time, research reports conducted in the mid-1960s indicated that where particle control was generally achieved microbiological control was often lacking [31,32].

The work on cleanroom standards by the US Army and NASA paved the way for the U.S. government to issue the first federal standard for cleanrooms, through approval by the General Services Administration, on 16th December 1963. This was Federal Standard 209 [33]. The FS 209 standard established classes for air cleanliness based on specified concentrations of airborne particles (of a size 0.5 µm of larger) suspended in one cubic foot of air. The classes were applicable to the types of industries in which cleanrooms were being used. For example, Class 1 was applicable to microelectronics, Class 10 to semiconductors, Class 100 to aseptic manufacturing, Class 1000 to optics, Class 10,000 to support areas for aseptic filling, and so on (albeit the pharmaceutical industry only utilised cleanroom concepts with any great seriousness in the 1970s). When the particles in a room were measured the class limit was set on the basis of which ever particle limit was not exceeded.

In addition, the standard outlined the method and monitoring plan required in order to determine particle concentrations. The standard contained both mandatory and non-mandatory (guidance) sections. The application of the standard was made easier by particle counting technology becoming more accurate and the use of particle counters became more widespread.

The influence of this standard was not confined to the USA and it a de facto global standard for cleanrooms. The first draft of Good Manufacturing Practice standards produced for medicinal dispensing and pharmaceutical manufacturing referred to the FS 209 standard for cleanroom particulate levels. The FS 209 standard was subsequently revised as 209a (1966), 209b (1973, with an additional amendment issued in 1976), 209c (1987), 209d (1988) and 209e (1992), after which it was withdrawn and replaced with an ISO standard. The primary changes with edition related to revisions of the air cleanliness classes in terms of classification by particulates, driven in part by improvements to particle measuring technology. The final revision, the 209e standard, adopted metric measurements.

As with industrial developments, the 1960s also saw cleanroom improvements in the medical field. These were advancements of the ventilated room concept. The most significant work was undertaken in 1961 by Professor Sir John Charnley, a U.K based orthopaedic surgeon, and Hugh Howorth, who used unidirectional airflow to create a downward flow of air from a much smaller area of the ceiling directly over the operating table [34]. This “clean air enclosure” recirculated a continuous flow of filtered air, which was under positive pressure, over the zone under which operations took place and also functioned to remove airborne contamination generated during surgery [35]. The innovation became known as the Charnley-Howorth system [36] and was adopted by many hospitals for operations where high-risk surgery (such as transplant surgery) was undertaken [37]. The role that personnel played in cleanroom, as sources of contamination, or as impediments to the airflow was given increased attention. For example the studies of Blowers and Crew on developing turbulent airflow examined how people disrupted the airflow over operating tables [38]. Such studies further promoted the requirement for laminar airflow for critical activities [39].

Aside from cleanroom design technology, another cleanroom development of the 1960s was with the use of specialist clothing in cleanrooms [40]. It had long been recognised that clothing served as an important particulate barrier.

Figure 6: Operating theatre for orthopaedic surgery with horizontal unidirectional airflow, circa 1973 (image courtesy of Schicht Hans H.: 40 years of cleanroom technology - some historical remarks. In: Proceedings of the 17th International Symposium on Contamination Control, Bonn/Germany, 6-9 Sept. 2004, p. 1-10. Edited by: Verein Deutscher Ingenieure (Association of German Engineers), Düsseldorf/ Germany (2004))

Summary

This article has considered the history of cleanrooms from the industrial and medical perspectives. The creation of clean air is necessary to protect sensitive instruments from dust; to protect patients from pathogens; and to ensure medicines are made safely. The pharmaceutical aspect is considered in more detail in part 2, together with the development of the first international standard for cleanrooms.

Author

Tim Sandle, MIScT, BSc (Hons), MA, PhD, CBiol, MIBiol

Tim is a chartered biologist and holds a first class honours degree in Applied Biology; a Masters degree in education; and has a doctorate from Keele University. He is a tutor with the School of Pharmacy and Pharmaceutical Sciences, University of Manchester for the university's pharmaceutical microbiology MSc course. In addition, Dr. Sandle serves on several national and international committees relating to pharmaceutical microbiology and cleanroom contamination control (including the ISO cleanroom standards). He is a committee member of the Pharmaceutical Microbiology Interest Group (Pharmig); and is a member of several editorials boards for scientific journals. He was a member of the National Blood Service advisory cleaning and disinfection committee.

Tim has over twenty-five years' experience of microbiological research and biopharmaceutical processing. This includes experience of designing, validating and operating a range of microbiological tests including sterility testing, bacterial endotoxin testing, bioburden and microbial enumeration, environmental monitoring, particle counting and water testing. In addition, Tim is experienced in pharmaceutical microbiological risk assessment and investigation.

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Modelling and scale-up of metal production

Charles Osarinmwian

The advent of solid state electro-deoxidation in rotationally symmetric electrochemical reactors has led to the discovery of sub-stoichiometric TiC on the surface of Ti cathodes[1] and the diversification, adaption and even reinvention of metal production to match evolving market conditions in high-tech sectors.[2,3] For well over a century Al has been produced by the electrochemical reduction of Al_2O_3 dissolved in ionic melt.[4] Herein the electrochemical reduction and electro-deoxidation of Al2O3 to Al in ionic melt is outlined. The physical design of the reactor and electrodes are discussed, and a numerical model of electro-deoxidation reported.

Industrial production

The reduction of dissolved Al_2O_3 to Al is performed in a Hall-Héroult reactor consisting of a steel shell (9-12 m long, 3-4 m wide and 1-1.5 m depth) lined with refractory Al_2O_3, carbon and a thermal insulator. The base of the reactor is lined with carbon blocks inlaid with steel and current distributor bars that are preferably inlaid horizontally in order to generate uniform current distributions. Electric current enters the reactor through the anode and flows through 3-6 cm of ionic melt, which contains additives, to the molten Al deposited at the base of the reactor. In industrial reactors the optimum current density is ~ 1 A cm^{-2} (60-500 kA total current capacity), that can produce > 450-4000 kg of Al per day with a current efficiency limited to 85-95 % and a reactor voltage of 4.0-4.5 V.[5] The two types of consumable carbon-based anode in Hall-Héroult reactors are monolithic self-baking (Soderberg), and prebaked. The latter is more efficient and differs only in fabrication and anode stub connection, [6] while being consumed at a rate of ~ 2 cm day^{-1} with anode changes that maintain a 4-5 cm anode-cathode gap. The gases released at the anode generate bubbles that lower the effective ionic melt conductivity and so an increase in electrical resistance:

$$Al_2O_2F_6^{2-} + 2F^- + C \rightarrow CO_2 + 2AlF_4^- + 4e^- \quad (1)$$

$$Al_2O_2F_4^{2-} + 4F^- + C \rightarrow CO_2 + 2AlF_4^- + 4e^- \quad (2)$$

The influence of concentration polarisation is minimised at the cathode since no gas bubbles are generated:

$$AlF_6^{3-} + 3e^- \rightarrow Al + 6F^- \quad (3)$$

$$AlF_4^- + 3e^- \rightarrow Al + 4F^- \quad (4)$$

It is important to note that the deposition of Al2O3 at the base of the reactor, caused by poor dissolution and diffusion, creates concentration gradients that generate non-uniform current distributions. At very low Al_2O_3 concentrations (< 2 wt.%) an anode effect occurs by the physical manifestation of large bubble growth on the horizontal underside of an anode leading to a decreased ability of the ionic melt to wet the anode.[7]

Electrode behavior

Incorporating dimensionally stable (inert), oxygen evolving anodes into rotationally symmetric electrochemical reactors in electro-deoxidation could lead to lower costs and a technological revolution in Al production. The development of inert anodes could facilitate the application of perforated, undulated and sloped anode undersides.[2] For sloped undersides, the gas bubble velocity tends to increase with inclination angle (1.5° to 10°) 8 where grouping anodes with 0.5-3° inclinations could allow the control and enhancement of circulation patterns in the ionic melt depending on slope direction 9:

- 4 sloped anodes orientated to generate a counter-clockwise circulation pattern;
- 6 sloped anodes orientated to generate a clockwise circulation pattern at the left side and right side of a reactor, with a counter-clockwise circulation pattern in the middle of a reactor;
- 18 sloped anodes orientated to generate a serpentine circulation pattern.

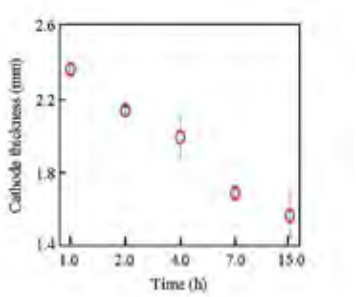

Fig. 1: Phase-induced cathode deformation. The thickness of the porous cathode was measured using SEM.

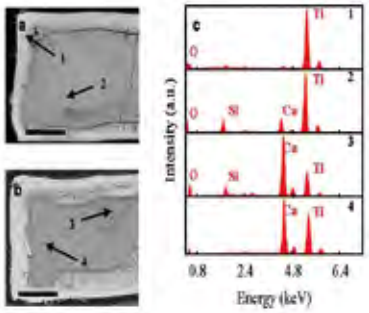

Fig. 2: SEM observation of a partially reduced cathode cross section using SEM at (a) 7 h, (b) 15 h. (c) Ti, Ca and O intensities, measured by EDX analysis, indicates changes in solid volume because of the formation of $CaTiO_3$ and Ti_2O_3 [2]. The relatively high Si concentration in as-received TiO_2 powder explains Si in partially reduced cathodes. Scale bar: 1 mm.

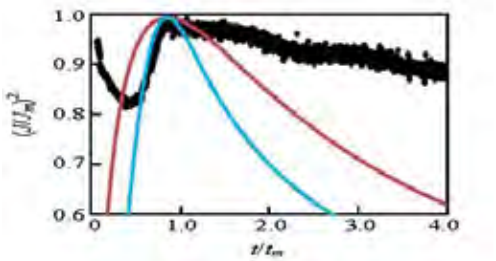

Fig. 3: Nucleation modelling. Current-time transients are fitted to the Scharifker-Hill model [3] where the experimental results (data points), instantaneous nucleation (red curve) and progressive nucleation (blue curve) are shown. Nomenclature: J and J_m is the current and maximum current respectively, t and t_m is time and time taken to reach maximum current.

In the case of porous cathodes, the thickness of a porous cathode during electro-deoxidation decreases due to atomic rearrangement, grain growth, and density changes (Fig. 1, [10]). Imbalances in diffusion-controlled transport in the cathode lead to changes in composition-dependent lattice parameters and local volume via diffusion-induced excess atoms and vacancies in metal nuclei and at grain boundaries. In the case of TiO_2, an annihilation mechanism of excess vacancies, originating from the formation of relatively dense, fcc crystal structure TiO by slow reconstruction of Ti_2O_3 and $CaTiO_3$ lattices (Fig. 2), leads to volumetric contractions, whereas incorporation of excess atoms contributes to dislocation climb and so local volumetric expansions in certain regions of the cathode. The uneven profile of the three-phase interline (3PI) (Fig. 2a) can be attributed to a Kirkendall-like effect [2] driven by stress and point defect chemical potential gradients generated when diffusion causes the local density and point defect concentrations to deviate from their equilibrium values. Thus, the faster diffusing O^{2-} ions relative to metal atoms and vacancies could render the potential necessary to drive plastic deformation negligible. Alternatively, plastic metal deformation could become rate limiting before metal cathode formation, [2] where plastic deformation proceeds by relaxation rather than diffusion. Further, increasing the cathode thickness prior to electro-deoxidation could lead to a breakdown in the Scharifker-Hill model (Fig. 3).

Numerical method

The governing equations in an electro-deoxidation model can be expressed as integral and partial differential equations that are readily represented and approximated by the finite element method.[11] Most partial differential equations encountered in science and engineering are second order because the principle of minimum Fisher information introduces a second order operator of a field quantity as the highest order term. The finite element method uses a weak formulation of field variable constraints in coupled systems of partial differential equations to make discontinuities integrable. The number of finite elements in an electro-deoxidation model is directly related to the accuracy of the numerical solution. Convergence to a solution is monitored by an implicit error criterion, which allows error distribution within a finite element mesh to be controlled by changing the size of elements. By applying local mesh refinement [12,13] in the cathode, each 2D triangular element in regions of highest error are subdivided into four equally shaped elements (i.e. regular split method) such that the solution is accurate to $\lesssim$ 5 %. Although a solution completely independent of element size is desirable, mesh independent solutions are unlikely due to large computational requirement and geometric singularities.

An improved approximation to a solution is found by iteration until an acceptably accurate solution is achieved. In more detail, COMSOL Multiphysics uses a DASPK version of a differential-algebraic equation solver to integrate over time steps such that the implicit time integration scheme accurately describes time-dependent 3PI movement. An initial approximated solution is developed by evaluating a predictor polynomial, this interpolates approximates at previous time steps. The solution is then computed in a corrector step by solving a nonlinear system of equations using Newton iteration at each time step.

Electro-deoxidation model

The electro-deoxidation model uses a Multi-physics approach with the finite element method assuming an electro-neutrality condition for the bulk melt and porous cathode in a rotationally symmetric electrochemical reactor.[2,3] This assumption is feasible because the strong short-range order of ionic melts lowers electrostatic repulsion energy.[14] Also, the charge separation at electrode surfaces is completely ionic since no solvent molecules are present to soften ionic interactions. Unlike the electrical double layer in aqueous solutions, the charge distribution of the electrical multilayer at the surface in ionic melts is characterised by a complex attenuation of oscillations

from the surface.[15] Despite this complexity, the structure and dynamics of ions close to the surface are very similar to those in the bulk melt.
The Multi-physics approach couples electric field effects, electron transfer kinetics and electrochemical effects using the COMSOL application modes: Conductive Media DC and arbitrary Lagrangian-Eulerian while interchanging current flow (Neumann) and fixed potential (Dirichlet) boundary conditions, and a Tafel kinetic equation at the 3PI. The model is assumed to have a thin layer of porous metal at the start, an insulating current collector/bulk melt interface and a grounded inert anode/melt interface. A mesh sensitivity test used to generate numerically accurate simulations is shown in Fig. 4.

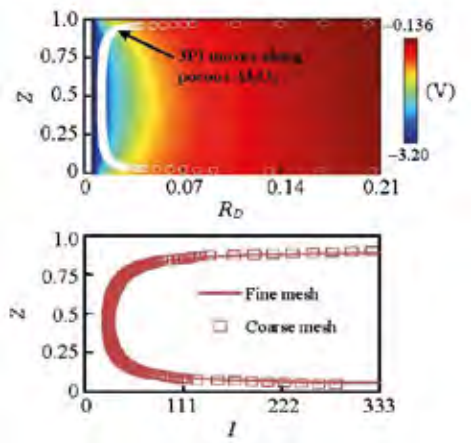

Fig. 4: Potential distribution and mesh sensitivity test in an electrochemical reactor containing an annulus anode. The curved plots show 3PI movement after 30 s. Nomenclature: I is the dimensionless current, RD and Z is the dimensionless radial and vertical length. [3]

The current and potential distribution is an essential step in the rational design and scale-up of electrochemical reactors.[16] Electro-deoxidation modelling of $MO_x + 2xe^- \rightarrow M + xO^{2-}$ on the 3PI in porous cathodes by either bandwidth-controlled transition driven by the broadening of electron bands or band-filling controlled transition induced by the doping of charge carriers in the cathode would preclude reasonable understanding of electro-deoxidation. Therefore, the effective interaction that describes the length (or energy) scales of fluctuations at each 1D interline connecting metal, metal oxide, and ionic melt is assumed similar according to the statistical continuum limit [3]; the number of independent variables at each 1D interline is fixed and finite. The renormalisation of 1D interlines into a 3PI (or quasi-2D interface) introduced by Osarinmwian et al. describes electro-deoxidation.

During electro-deoxidation the porous metal propagates along the upper and lower surface of a porous cathode because the intensity of electric field lines maximizes the predicted potential on the 3PI (Fig. 4, 2). Changing the surface area of the anode would change the electro-deoxidation rate because the electric flux density D on the 3PI and electric field intensity E increases by hD and hE respectively (where h is a factor > 1) and so the total energy of the electric field 0.5D·E, derived from the differential form of Gauss' law, changes. Also, accounting for the degeneracy of excess electrons, the equilibrium constant 4x for $e_2 \leftrightarrow 2e$ is equivalent to the renormalized length of the 3PI.[3]

Author

Charles Osarinmwian MIScT, RSci, is in the School of Chemical Engineering and Analytical Science, The University of Manchester, Oxford Road, Manchester M13 9PL, United Kingdom.
Email: charles.osarinmwian@manchester.ac.uk

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Harnessing potentials of aquaponics towards sustainable aquaculture

Olumide A Odeyemi

Aquaculture - workers harvest catfish from the Delta Pride Catfish farms in Mississippi.Credit: United States Department of Agriculture

Aquaculture and its benefits

Aquaculture is defined as farming or culturing of seafood, marine plants and marine animals in either natural or artificial environment for the purpose of increase in production.[1,2] Seafood plays significant roles in human diet as sources of animal protein, micronutrients, and fatty acid omega 3.[1,3] Seafood production can be artisan also known as wild catch, industrial fisheries or aquaculture (Figure 1). Decline in wild fish catch, high demands of aquaculture products, demand for new food, and increase in human population has resulted in an increased demand for, and patronage of, aquaculture in recent years.[4,5] In 2009, the Food and Agricultural Organisation (FAO) of the United Nations reported the production of over 50 million tonnes of aquaculture products, while in 2012 over 90 million tonnes were reportedly produced, making it the fastest growing food production sector in the world[6-9] leading to generation of income, jobs and profits.4 Aquaculture currently contributes to 50% of global fish consumption [10] and it has been projected that in the next 15 years it will contribute more than 60%, with the major production coming from low income countries in Asia, however, sustainability of aquaculture is required.[11]

Negative environmental and social impacts of aquaculture

Despite the huge advantages of aquaculture its negative environmental and social impacts cannot be overemphasised. Among which are indiscriminate destruction of mangrove natural habitats, overexploitation of wild fish stocks, use of chemical for disease control [3], waste water (effluent) pollution as a result of deposition of aquaculture waste, pathogen transfer [12], ocean acidification, occupational hazards.[13]

Figure 1: Types of seafood production

Harnessing the potentials of aquaponics

In recent years aquaponics, which is a combination of aquaculture and hydroponics for the sole purpose of food production, has come to the fore as a viable means of food security. Aquaponics involves the deliberate integration of hydroponics into aquaculture for the purpose of producing vegetables or edible crops,

together with fish without using soil.[14,15] Over the years, there has been an increased interest in the use of aquaponics for crop production and aquaculture. This is due to the fact that the materials and equipment required can easily be set up within human reach and that the technique does not involve use of any antibiotics, chemical or pesticide for production. [14] Aquaponics involves fish farming within an enclosed system. The waste generated from fish farming serve as raw nutrients for the growth of crops, with the plants grown in this system purifying the waste water generated from the fish. This cleaner water is then recirculated back into the fish water. Due to this process, aquaponics can therefore help to reduce environmental impact of conventional aquaculture. [16] Wastes generated by conventional aquaculture pose challenges to the environment because these waste are suspended solid particles or dissolved nitrogen and phosphorus in water.[17] It is fairly easy to remove the solid suspended particles through sedimentation and filtration, however, it is rather difficult to remove the dissolved particles.[17,18] Both dissolved nitrogen and phosphorus in water can be removed from waste water generated from conventional aquaculture using aquaponics. [17,19] According to Diver S, Rinehart L [20], aquaponics has the advantage of producing crops and fish together using the same operational costs thereby increasing profits and minimising discharge of fish waste water into the environment. In a recent review of commercialisation of aquaponics by Goddek S, Delaide B, Mankasingh U, Ragnarsdottir KV, Jijakli H, Thorarinsdottir R [21], it was stated that aquaponics could be a key potential driver for integrated food production systems.

Benefits- Economic, Social, Political, Environmental

Industrialisation, urbanisation and globalisation have significantly affected people's diet. According to Damman S, Eide WB, Kuhnlein HV [22], this change in diet has caused nutritional changes. Due to this, various alternative forms of food production have been proposed to help provide more healthy food. Increases in population have also resulted in food insecurity. It is therefore important that more varied and sustainable means of providing food for all are adopted. The various benefits of aquaponics have been highlighted in a number of key research literatures. It helps in conserving water resources, plant nutrients,

The raft tank at the CDC South Aquaponics greenhouse in Brooks, Alberta. Credit: Bryghtknyght (wikipedia)

production of fish protein, and reduces relative costs of operation.[23] Damman S, Eide WB, Kuhnlein HV [22] reported that the lack or reduction in consumption of locally produced and prepared food among indigenous people can easily lead to obesity and related chronic diseases, due to consumption of modern and often unhealthy junk food. The economic significance of aquaponics can also help low income families to have access to a sustainable farmed food production. Enough vegetables and fish protein can be produced that can feed the family and also generate an income. Additionally, the practise of aquaponics can help reduce the environmental pollution resulting from the waste water generated from conventional aquaculture because the waste water generated in aquaculture is recycled and filtered within the system without further discharge into the environment.

Author

Olumide A Odeyemi FIScT, RSci, Ecology and Biodiversity Centre, Institute for Marine and Antarctic Studies (IMAS), University of Tasmania, Launceston campus, Australia; Springforth Scientific Resource Centre, Lagos, Nigeria
oluodeyemi@gmail.com;
olumide.odeyemi@utas.edu.au

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Changing phase of mobile telecommunications – can it be visible light technology?

Arnesh Vijay

Overview

There has been a rapid growth in the demand for bandwidth in mobile telecommunications, with an increase in the number of users requiring "anytime, anywhere" services. Forthcoming wireless technology must be capable of offering high capacity channels to support various broadband services such as high definition television, video conferencing, and high-speed internet access and so on. The traditional access networks deploy coaxial, copper cables and optical fibres, in combination with radio frequency and microwave transmission links and equipment. The continuous proliferation in traditional communication systems has given rise to newer forms and types such as radio over fibre and optical-wireless technologies. Although radio based systems have excellent performance and services, they are challenged with issues such as congested spectrum, security, health safety, exorbitant licensing fees, and high cost for installation and accessibility. When compared to these conventional technologies, optical-wireless has the potential to serve as a dynamic research and development sphere in rendering a number of

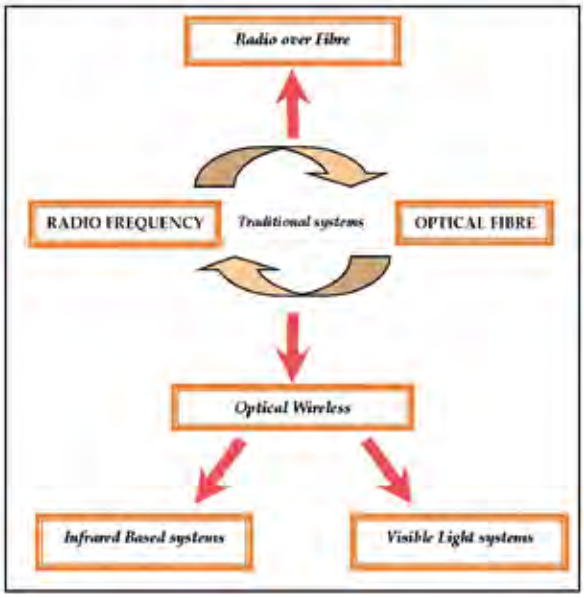


Figure 1. Interrelation between the various communication technologies

significant solutions to complicated communication challenges. The reason for this can partly be attributed to the benefits it offers in terms of unregulated and unlimited license free spectrum, with high data rate, and simplicity in the cost and implementation of the optical wireless equipment.

The evolution of telecommunications has seen the very basic prehistoric forms of human communication start with fire and smoke, with its gradual progression over the course of time into the optical heliographs and Sumerian signally towers, and it's more recent advancement into the modern optical wireless forms. Undoubtedly, the data rate quality of service and the transceiver technologies employed have expanded and matured in comparison to its earlier counterparts. In its many applications the conventional optical and radio frequency based wireless services have become an indispensable part our daily lives, with the gradual supplement with optical-wireless entities in homes and offices. Optical-wireless based systems have already been deployed in personal computers, embedded systems, sensor networks etc. Despite its prominent applications, there are abundant benefits the optical-wireless technologies have yet to offer in terms of rendering instant, easy and sophisticated services to mankind.

Problem

One of the diverse applications of RF (Radio Frequency) technology is in voice/mobile telephony signal transmission. The introduction of cellular/mobile phones has revolutionised the concept of communication in terms of providing easy and instant connectivity to 95% of human population, forming a vital backbone to the telecommunication industry.

Despite offering innumerable benefits the RF technology, specifically in cell phone applications, comes with some paucity in terms of regional coverage and power consumption. It is evident that, due to signal deterioration, the mobile phone connectivity deep inside buildings is often difficult or poor. This can be demonstrated by the RF signal attenuation through walls, window panes, and ceilings, building structures or materials. The severity of this issue can be seen in densely populated areas such as markets, tunnels, underground shopping malls, car parks and airports. It is apparent that besides the issue of regional coverage there is also the concern of security risk with its apparent vulnerability to unauthorised RF interception. In parallel, due to its susceptibility for interference with other RF equipment, it is faced with the delimited application in RF restricted areas such as hospitals, scientific/research labs and military centres. Although considerable contributions have been made in terms of favourable applications by optical-wireless systems, with its innovative extension into the visible light spectrum, there still remain some unexplored areas in terms of its pertinence for cellular applications. The RoVL project intends to answer some of the above cited problems, including concerns in security, health safety, and spectrum regulation faced by the RF technology, by exercising ***visible light systems*** for mobile signal transmission in an indoor environment.

Significance of RoVL

RoVL technology is concerned with using visible light to convey information normally carried via radio waves, from one point to another. In effect the radio frequency signals are not carried via a radiated signal from an antenna in the usual manner but as a modulation of the light's brightness in accordance with the strength of the radio wave itself. The reason why this apparent added complexity is useful is that the information can be carried by the room lighting wherever it is, and does not require any additional technology other than those used to inject the radio frequency information into the lighting electrical supply. This in-turn allows local and private distribution of this radio information, because the optical lighting signal is contained within the room, unlike a radio signal, which is broadcast widely and passes through walls, windows, floors and ceilings. The ***RoVL*** technique also allows a better quality of service than would be the case if only radio signals were to be used in the conventional manner indoors.

The reason why quality-of-service (QoS) is important in radio (and also optical) communications is that on many occasions the signal from say mobile radio masts, do not penetrate sufficiently into an indoor location. Internal walls can certainly attenuate radio signals quite significantly. Many people have noticed in reality how mobile phone signals can disappear within a building. The strategic advantage of ***RoVL*** is that lighting is almost always present, even if at a low level, indoors and therefore is available for the dual purpose of illumination and communication. Thus, the possibility of evenly distributed optical "Wi-Fi" can be considered when using ***RoVL*** technology. Interestingly, many people have used optical-wireless without even noticing it. The remote controls frequently used for TV and video equipment almost always use infrared-optical-wireless for which the same principles apply as that of ***RoVL***. One of the main types of radio signal currently used extensively is the GSM (Group Special Mobile) or 2G signal, and there are others such as the 3G (or UMTS), or 4G signals. In any of these cases it is characteristic of these radio signals to propagate well in the open air but be relatively poor indoors, unless the user is near to a mobile radio base station. Frequently in situations such as shopping malls an

indoor booster is required to form a "macro cell", or even a "Pico cell"', which provides extra coverage but also which exposes nearby users to radio signals of some strength. Bearing in mind the public sensitivity to such a situation (and also the unknowns about the long term exposure, especially brain and eye tissue to these signals) it is therefore highly desirable to achieve a benign equivalent technology that can still provide the same quality of service or at least performance results to sustain mobile telecommunication. Figure 2 is a simple illustration of the applicability of ***RoVL*** technology, whilst Figure 3 shows a simple hardware prototype of optical-wireless mobile phone.

Figure 2. Applicability of RoVL

Figure 3. Hardware prototype of Optical-Wireless Mobile phone

Acknowledging the complexity in mobile technology and the challenges involved in its practical implementation, the RoVL project has investigated and proposed techniques and methods for the transmission of mobile signals through optical-wireless channels. Five major research challenges were identified and addressed in this project through mathematical modelling, simulation, and hardware implementation. Although the mobile industry is growing at a rapid pace, with research being conducted for the inception of next generation mobile radio, the possibility to consider new and higher frequency bands remains open. The methods and techniques proposed by this research, which has immense scope to be further improved, has laid foundation to explore other technologies to make 5G, a more integrated telecommunication system.

Arnesh Vijay is a former researcher from Warwick University and currently works as Radio Research Engineer at Nokia Bell Labs. He can be contacted by emailing **Arnesh.Vijay@Nokia-bell-labs.com**

“Winter Is Coming!”

New sensors could cut millions from gritting costs

“Winter is Coming”, the motto of the House of Stark, from the hit TV series Game of Thrones®, warns of the inevitable onset of bad weather and bad times, and implies the need to prepare.
Researchers, funded by the Engineering and Physical Sciences Research Council (EPSRC) at the University of Birmingham have clearly taken note. They have been developing sensors that could cut millions from road-gritting costs and help local authorities be ready for the darker days ahead.

Unnecessary gritting of roads and car parks could be avoided and road safety in cold weather boosted, thanks to these new internet-connected, temperature sensors that have already been successfully trialled in Birmingham, London and elsewhere across the country. Fitted to lampposts, for example, the low-cost devices collect and transmit a non-stop stream of data on road-surface temperatures that local authorities, highways agencies and other organisations can use to target precisely where gritting is needed - and where it isn’t.

The sensors have been developed by meteorologists at Birmingham in conjunction with Amey plc, the Oxford-based engineering consultancy and infrastructure support specialists.
Each of the hand-sized sensors costs only around £200, compared with the £10,000 or so needed to maintain a weather forecasting station like those currently relied on by local authorities to help them make tough decisions on when and where to grit.

“Generally, a local authority may have just two or three of these weather stations, which means the decisions they make are based more on forecasts than actual information. But because our new sensors are so inexpensive, local authorities could afford to deploy scores or even hundreds of them and make very localised decisions about the need to grit on a route by route basis. That’s extremely useful in view of the fact that there can be a 10°c to 15°c difference in road temperatures across a county, say, on a given winter’s night.” – Dr Chapman who led the project

The sensors are inspired by the fast-developing Internet of Things[1] by utilising increasingly pervasive WiFi networks to transmit a single number indicating the local road surface temperature every ten minutes. No cabling is necessary, deployment is rapid and the sensor boxes are fitted unobtrusively near ground level on the street side of the lamppost or whatever else they are attached to.

“The UK typically uses 2 million tonnes of salt in an average winter. Our estimates demonstrate that, by eliminating unnecessary gritting, this new technology could easily enable savings of between 20 per cent and 50 per cent, which would be equivalent to over £100 million per year in salt taken across the country as a whole.
“This cost-effective, real-time decision-making approach also has potential to be extended even further, with individual gritting lorries switching their gritters on and off as they go in response to the data generated by the sensor networks.” - Dr Chapman

The next step for the Birmingham team is to continue to work with key industrial partners towards full commercialisation and eventual mass production of the sensors. The team are also now looking to secure further support to enable them to continue their work to other infrastructure sectors, including solving the infamous leaves on the line problem on the railway network.
We could see networks of these new sensors becoming a valuable part of local infrastructure in almost every corner of the country within the next two to three years, Lee Chapman comments.

1.The Internet of Things involves connecting up all kinds of objects and devices to the internet, enabling them to transmit and receive data, and using this information (eg about level of usage, energy consumption etc) to improve their efficiency or to help inform the decision-making of individuals or organisations.

Controlling ADAM33 gene could stop asthma

Scientists at the University of Southampton have discovered a potential and novel way of preventing asthma at the origin of the disease, a finding that could challenge the current understanding of the condition.

The research, published in the *Journal of Clinical Investigation Insight*, analysed the impact of the gene ADAM33, which is associated with the development of asthma. ADAM33 makes an enzyme, which is attached to cells in the airway muscles. When the enzyme loses its anchor to the cell surface, it is prone to going rogue around the lung causing poorer lung function in people who have asthma.

The studies in human tissue samples and mice, led by Hans Michel Haitchi, an MRC Clinical Scientist Fellow and Associate Professor in Respiratory Medicine at the University of Southampton, suggests that if you switch off ADAM33 or prevent it from going rouge, the features of asthma - airway remodelling (more muscle and blood vessels around the airways), twitchiness and inflammation - will be reduced.

"This finding radically alters our understanding of the field, to say the least. For years we have thought that airway remodelling is the result of the inflammation caused by an allergic reaction, but our research tells us otherwise." - Professor Haitchi

The first study showed that rogue human ADAM33 causes airway remodelling resulting in more muscle and blood vessels around the airways of developing lungs but it did not cause inflammation. When a house dust mite allergen was introduced, which is a common human allergen, both, airway remodelling and allergic airway inflammation were more significantly enhanced.

In another study, remodelling of the airway was shown in mice that had ADAM33 switched on from in utero. The gene was then switched off and the airway remodelling was completely reversed.

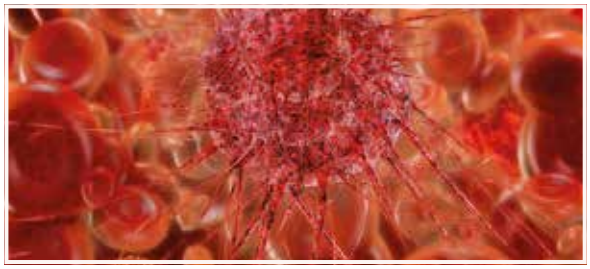
Furthermore, they studied the impact of house dust mite allergen on asthma features in mice that had the ADAM33 gene removed. Airway remodelling and twitchiness as well as airway inflammation rates were significantly reduced by 50 per cent and respectively 35 per cent in mice that did not have the rogue gene.

These findings identify ADAM33 as a novel target for disease modifying therapy in asthma.

"Our studies have challenged the common paradigm that airway remodelling in asthma is a consequence of inflammation. Instead, we have shown that rogue human ADAM33 initiates airway remodelling that promotes allergic inflammation and twitchiness of the airways in the presence of allergen.

"More importantly, we believe that if you block ADAM33 from going rogue or you stop its activity if it does go rogue, asthma could be prevented. ADAM33 initiated airway remodelling reduces the ability of the lungs to function normally, which is not prevented by current anti-inflammatory steroid therapy. Therefore, stopping this ADAM33 induced process would prevent a harmful effect that promotes the development of allergic asthma for many of the 5.4 million people in the UK with the condition." - Professor Haitchi

New insights into blood cancer that develops before birth



Researchers from the Medical Research Council (MRC) Centre for Regenerative Medicine at the University of Edinburgh have identified the cells responsible for a form of leukaemia that can develop while a baby is in the womb. The research, published in Cell Reports, adds to our knowledge of how this aggressive type of cancer advances, and will help identify future therapies. One form of leukaemia is caused by a type of DNA damage called "chromosomal translocation". This is where parts of two different chromosomes fuse together. The resultant fusion gene – in this instance MLL-AF4 – acts in a very different way from when the two genes are separate. The expression of the MLL4-AF4 fusion gene can occur at very early stages of the embryo's development while in the womb and can result in infants being born with a very aggressive form of leukaemia. The earlier the onset of this form of blood cancer, the worse is the prognosis.

Survival rates for the most common form of childhood leukaemia, acute lymphoblastic leukaemia (ALL) have improved dramatically, with around nine in 10 children surviving for longer than five years. Infant ALL, which develops when the child is under 12 months of age, accounts for less than five percent of cases of childhood ALL and is a biologically distinct cancer – often involving just a few genetic faults. It has a much poorer outlook, with only around half of patients surviving for longer than five years. A MLL gene fault is involved in 80% of cases of infant acute lymphoblastic leukaemia. Because this cancer begins to develop "in utero" and prior studies have studied the effect of MLL-AF4 in blood cells of adult mice only, the key question of how MLL-AF4 might affect an unborn baby's unique blood cells remained unanswered. This is the first study to investigate how MLL-AF4 effects developing blood forming cells in mouse embryos in a bid to understand how this aggressive leukaemia emerges.

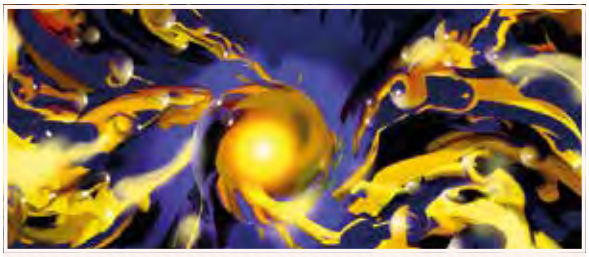
To investigate the disease process, scientists bred mice where one parent carries an inactive form of the fusion gene and the other parent expresses a gene for an enzyme that activates the fusion gene. The embryos from this pairing were found to have a development window where a pre-leukaemic state took hold with increased production of pro-B cells – precursor to a type of white blood cell.

"One of the most common and aggressive types of infant blood cancer is associated with the MLL-AF4 fusion gene, which arises during pregnancy. One of the main impediments to improving the survival rates in infants is the lack of knowledge on where and when during development this mutation arises and how it affects the developing blood system of the baby.

"Our findings reveal the first changes that take place in blood development caused by the MLL-AF4 mutation during a pre-cancerous state. This has increased our knowledge on how this aggressive disease develops and will help identify early signs of disease and points for therapeutic intervention." - Lead researcher, Dr Katrin Ottersbach

"Long term survival rates for childhood leukaemia have improved significantly overall, but the outlook for infants who develop leukaemia soon after birth remains comparatively poor. The intensive chemotherapy used can itself be fatal for babies and many survivors will develop health problems in later life. This more detailed understanding of how a key genetic fault drives the majority of infant leukaemia cases could lead to more effective and kinder treatments in the future." – Dr Alasdair Rankin, Director of Research at blood cancer charity Bloodwise, which funded the study along with the MRC and the Wellcome Trust.

Researchers build the world's tiniest engine from particles of gold



Expanding polymer-coated gold nanoparticles (credit Yu Ji / University of Cambridge NanoPhotonics)

Researchers have developed the world's tiniest engine – just a few billionths of a metre in size – which uses light to power itself. The nanoscale engine, developed by researchers at the University of Cambridge, could form the basis of future nano-machines that can navigate in water, sense the environment around them, or even enter living cells to fight disease.

The prototype device is made of tiny charged particles of gold, bound together with temperature-responsive polymers in the form of a gel. When the "nano-engine"'is heated to a certain temperature with a laser, it stores large amounts of elastic energy in a fraction of a second, as the polymer coatings expel all the water from the gel and collapse. This has the effect of forcing the gold nanoparticles to bind together into tight clusters. But when the device is cooled, the polymers take on water and expand, and the gold nanoparticles are strongly and quickly pushed apart, like a spring.

Nano-machines have long been a dream of scientists and public alike, but since ways to actually make them move have yet to be developed, they have remained in the realm of science fiction. The new method developed by the Cambridge researchers is incredibly simple, but can be extremely fast and exert large forces. The forces exerted by these tiny devices are several orders of magnitude larger than those for any other previously produced device, with a force per unit weight nearly a hundred times better than any motor or muscle. According to the researchers, the devices are also bio-compatible, cost-effective to manufacture, fast to respond, and energy efficient.

Professor Jeremy Baumberg from the Cavendish Laboratory, who led the research, has named the devices "ANTs", or actuating nano-transducers. Like real ants, they produce large forces for their weight. The challenge we now face is how to control that force for nano-machinery applications.

The team is currently working with Cambridge Enterprise, the University's commercialisation arm, and several other companies with the aim of commercialising this technology for microfluidics bio-applications. The research is funded as part of a UK Engineering and Physical Sciences Research Council (EPSRC) investment in the Cambridge NanoPhotonics Centre, as well as the European Research Council (ERC).

Naturally occurring protein discovered which boosts rice yield by 50%

In collaboration with researchers at Nanjing Agricultural University, Dr Tony Miller from the John Innes Centre has developed rice crops with an improved ability to manage their own pH levels, enabling them to take up significantly more nitrogen, iron and phosphorous from soil and increase yield by up to 54%.

Rice is a major crop, feeding almost 50% of the world's population and has retained the ability to survive in changing environmental conditions. The crop is able to thrive in flooded paddy fields – where the soggy, anaerobic conditions favour the availability of ammonium – as well as in much drier, drained soil, where increased oxygen means more nitrate is available. nitrogen fertilizer is a major cost in growing many cereal crops and its overuse has a negative environmental impact.

The nitrogen that all plants need to grow is typically available in the form of nitrate or ammonium ions in the soil, which are taken up by the plant roots. For the plant, getting the right balance of nitrate and ammonium is very important: too much ammonium and plant cells become alkaline; too much nitrate and they become acidic. Either way, upsetting the pH balance means the plant's enzymes do not work as well, affecting plant health and crop yield.

Together with the partners in Nanjing, China, Dr Miller's team has been working out how rice plants can maintain pH under these changing environments. Rice contains a gene called OsNRT2.3, which creates a protein involved in nitrate transport. This one gene makes two slightly different versions of the protein: OsNRT2.3a and OsNRT2.3b. Following tests to determine the role of both versions of the protein, Dr Miller's team found that OsNRT2.3b is able to switch nitrate transport on or off, depending on the internal pH of the plant cell.

When this 'b' protein was overexpressed in rice plants they were better able to buffer themselves against pH changes in their environment. This enabled them to take up much more nitrogen, as well as more iron and phosphorus. These rice plants gave a much higher yield of rice grain (up to 54% more yield), and their nitrogen use efficiency increased by up to 40%.

"Now that we know this particular protein found in rice plants can greatly increase nitrogen efficiency and yields, we can begin to produce new varieties of rice and other crops. These findings bring us a significant step closer to being able to produce more of the world's food with a lower environmental impact." - Dr Miller

This new technology has been patented by PBL, the John Innes Centre's innovation management company, and has already been licensed to three different companies to develop new varieties of six different crop species.

This study, which will be published in the Proceedings of the National Academy of Sciences USA, was funded by the Biotechnology and Biological Sciences

Research Council (BBSRC) and grants from the Chinese Government.

John Innes Centre

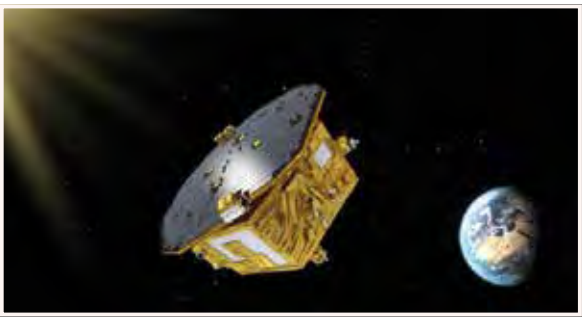
The John Innes Centre is an independent, international centre of excellence in plant science and microbiology. Their mission is to generate knowledge of plants and microbes through innovative research, to train scientists for the future, to apply our knowledge of nature's diversity to benefit agriculture, the environment, human health and wellbeing, and engage with policy makers and the public.
To achieve these goals they establish pioneering long-term research objectives in plant and microbial science, with a focus on genetics. These objectives include promoting the translation of research through partnerships to develop improved crops and to make new products from microbes and plants for human health and other applications. They also create new approaches, technologies and resources that enable research advances and help industry to make new products. The knowledge, resources and trained researchers they generate help global societies address important challenges including providing sufficient and affordable food, making new products for human health and industrial applications, and developing sustainable bio-based manufacturing.

This provides a fertile environment for training the next generation of plant and microbial scientists, many of whom go on to careers in industry and academia, around the world.

LISA Pathfinder exceeds expectations, partly thanks to UK researchers and RAL Space

A powerful space-based gravitational wave observatory is one step closer as a test of the technology shows that it performs well.

The European Space Agency's LISA Pathfinder mission has successfully demonstrated the technology needed to build a space-based gravitational wave observatory, partly thanks to substantial research and engineering support from UK researchers, including a team from STFC's RAL Space.



Artist's impression of LISA Pathfinder, ESA's mission to test technology for future gravitational-wave observatories in space. (Credit: ESA-C.Carreau)

Results based on just two months of science operations show that the two test masses at the heart of the spacecraft are falling freely through space under the influence of gravity alone, unperturbed by other external forces, to a precision more than five times better than originally required.

In a paper published in Physical Review Letters, the LISA Pathfinder team showed that the test masses are almost motionless with respect to each other, with a relative acceleration lower than 1 part in ten millionths of a billionth of Earth's gravitational acceleration, g.

The University of Glasgow provided the optical system for LISA Pathfinder; Imperial College London provided a system to ensure that the mirrors, as they float around, do not get unacceptably charged with particles from the Sun; and the University of Birmingham provided the electronic system that reads out the optical signals from the interferometer. STFC RAL Space were involved in several technology development projects in the early stages of the mission in 2001 - the sub-systems of the Optical Bench, test-mass caging mechanism and charge neutralisers.

For the Optical Bench this involved the build at RAL Space in Oxfordshire of the Engineering Model, in

collaboration with the University of Glasgow. Upon delivery it was integrated by Airbus with other LISA Pathfinder sub-systems, (these included laser, readout electronics and high-stability test facility) to prove one of the key "technical readiness" points for the LISA-Pathfinder development; by demonstrating interferometry to pico-metre level stability. This was achieved in 2003.

The successful demonstration of the mission's key technologies opens the door to the development of a large space observatory capable of detecting gravitational waves emanating from a wide range of exotic objects in the Universe.

Dr Harry Ward, Reader in Physics and Astronomy and a member of the Institute for Gravitational Research at the University of Glasgow, described the results as "a spectacular success" which effectively gave the green light to embarking on the next stage – "to fly a spaceborne gravitational wave detector".

"We want to detect super-massive black hole coalescences when galaxies collide but to do that we had first to prove you can make the super-sensitive measurements – and we have now done exactly that." – Dr Harry Ward

A team of scientists from the University of Glasgow's Institute for Gravitational Research developed, built, and tested the incredibly sensitive optical bench interferometer that lies at the heart of the LISA Pathfinder. This instrument is capable of detecting changes in distance between the test masses as small as 10 picometres, or one hundred millionth of a millimetre.
The IGR also led on the conception, development, construction and installation of sensitive mirror suspensions at the heart of the ground-based LIGO detectors, which were crucial to the first detection of gravitational waves, announced to the world in February.

"The team at the University of Birmingham who designed and built the phasemeter electronics have made a central contribution to the great success of the LISA Pathfinder mission. The Birmingham Phasemeter, which is the electronic heart of the instrument, is performing perfectly and the European Space Agency is planning to extend the mission by a further six months to make the maximum use of this extraordinary mission." - Professor Mike Cruise, from the School of Physics and Astronomy at the University of Birmingham

"We had requirements for what level of interference would be acceptable, and then we had best estimates of how isolated the masses could be. Our first results are even better than that. Space really is the perfect place to do these kinds of experiments. Nothing is as quiet as space." - Dr Peter Wass, a scientist from Imperial College London's Department of Physics was part of the team who built one of the isolation mechanisms for LISA Pathfinder

The team of Imperial College London physicists not only designed and built one of the isolation mechanisms for LISA Pathfinder they have also helped analyse the data during this first test run.

Oscillations in the fabric of spacetime

Hypothesised by Albert Einstein a hundred years ago, gravitational waves are oscillations in the fabric of space-time, moving at the speed of light and caused by the acceleration of massive objects.

They can be generated by astronomical phenomena such as supernova explosions, neutron star binaries spiralling around each other, or pairs of merging black holes. Even from these powerful objects, however, the fluctuations in spacetime are tiny by the time they arrive at Earth, smaller than 1 part in 10^{20}.
Sophisticated technologies are needed to register such minuscule changes, and gravitational waves were only directly detected for the first time in September 2015 by the ground-based Laser Interferometer Gravitational-Wave Observatory (LIGO).
This experiment saw the characteristic signal of two black holes, each with approximately thirty times the mass of the Sun, spiralling towards one another in the final 0.3 seconds before they coalesced to form a single, more massive one.

A broader spectrum

The signals seen by LIGO have a frequency of around 100 Hz, but gravitational waves span a much broader spectrum. In particular, lower frequency oscillations are produced by even more exotic events such as the mergers of supermassive black holes.
With masses millions to billions of times larger than the Sun's mass, these black holes sit at the centres of massive galaxies. When two galaxies collide, the black holes at their centres eventually coalesce, releasing vast amounts of energy in the form of gravitational waves throughout the merger process, and peaking in the last few minutes before their final coalescence.
To detect these events and fully exploit the newly inaugurated field of gravitational astronomy, it is crucial to open access to gravitational waves at low frequencies between 0.1 mHz and 1 Hz. This requires measuring tiny fluctuations in distance

between objects placed millions of kilometres apart – something that can only be achieved in space, where an observatory would also be free of the seismic, thermal, and terrestrial gravity noises that limit ground-based detectors.
LISA Pathfinder was designed to demonstrate key technologies needed to build such an observatory.
A crucial aspect is placing two test masses in freefall, monitoring their relative positions as they move under the effect of gravity alone. Even in space this is very difficult, as several forces – including the solar wind and pressure from sunlight – continually disturb the test masses and the spacecraft.

Thus, in LISA Pathfinder, a pair of identical, 2-kg, 46-mm gold-platinum cubes, separated by only 38 cm, fly, surrounded, but untouched, by a spacecraft whose job is to shield the cubes from external influences, adjusting its position constantly to avoid hitting them.

"Exceeded our most optimistic expectations"
LISA Pathfinder was launched on 3 December 2015, reaching its operational orbit roughly 1.5 million km from Earth towards the Sun in late January 2016. The mission started operations on 1 March 2016, with scientists performing a series of experiments on the test masses to measure and control all of the different aspects at play, and determine how still the masses really are.

"The measurements have exceeded our most optimistic expectations. We reached the level of precision originally required for LISA Pathfinder within the first day, and so we spent the following weeks improving the results a factor of five better." - Paul McNamara, LISA Pathfinder Project Scientist.

These extraordinary results show that the control achieved over the test masses is essentially at the level required to implement a gravitational wave observatory in space.

These results demonstrate that LISA Pathfinder has proven the key technologies and paved the way for such an observatory, to be implemented as the third "Large-class" (L3) mission in ESA's Cosmic Vision programme.

IST Organisation

IST Executive Board Members

President: Helen Sharman OBE, FRSC, FIScT

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

Chairman: Terry Croft MBE, FIScT

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

E: t.croft@istonline.org.uk

Honorary Secretary: Natalie Kennerley FIScT, CSci

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

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

Treasurer: Joan Ward FIScT

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

E: joanward@istonline.org.uk

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

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

E: education@istonline.org.uk

Marketing Officer: Ian Moulson FIScT

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

E: i.moulson@istonline.org.uk

Membership Development Officer: Kevin Oxley FIScT, CSci

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

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

Registrar: Michelle Jackson BSc, PhD, FIScT, CSci

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

E: michellejackson@istonline.org.uk

Fellowship & Overseas Secretary: Derek Sayers FIScT

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

E: dereksayers@istonline.org.uk

Executive support/advisors

IST administrator: Wendy Mason

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

E: office@istonline.org.uk

China Advisor/Representative: Geoffrey Howell MIScT, RSci

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

E: g.howell@istonline.org.uk

Co-ordinator for HE Regional Champions: John Dwyer FIScT

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

E: j.dwyer@lancaster.ac.uk

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

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

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

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

Industry Liaison/Advisor: James Trout MIScT CMgr

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

E: j.trout@istonline.org.uk

The Institute of Science & Technology

Leading Your Technical Team

Leading Your Technical Team Programme set

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

LYTT – Leading Your Technical Team
BYLS – Building on Your Leadership Skills

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

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

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

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

Leading Your Technical Team has a long and well respected history. It has been running for 30 years with more than 1,200 people having been through the programme over this time. The programme content has continued to adapt and develop in line with changes in HE and it continues to be held in very high regard by HE senior managers and staff developers. Its high reputation is maintained through delivering a very high standard of technical management training via experienced HE managers, in a practical context with the reality of managing in a university technical environment.

How the programme works

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

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

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.
- Gained information on key issues, changes in higher education and current initiatives and developments which affect technical staff.
- Reflected upon the practices and processes affecting management and leadership in technical units, sections and departments.
- Practised a number of leadership and management skills and identified ways to develop these skills further.
- Had an opportunity to share with presenters and fellow participants from a wide number of universities and higher education colleges, their views, experiences, expertise etc.

Content

The programme will cover topics including:

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

Who should attend

This programme is intended for chief/ principal/senior technicians, laboratory/ workshop/unit managers, recently appointed departmental superintendents or senior colleagues from UK universities and colleges, who might now or in the future, have managerial or supervisory responsibilities and are interested in developing their fundamental management/leadership skills. The programme content will be delivered within the context of working in an 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.

Building on Your Leadership Skills

Specific programme goals

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

By the end of the programme participants will know 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/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.

Previous course 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 taught 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."

Pogramme Dates and Cost

Leading Your Technical Team
Date: 9th & 10th February 2017
Times: Start 09.30 close at 16.00 Day Two
Venue: Loughborough
wendymason@istonline.org.uk

Building on Your Leadership Skills
Date: 9th & 10th March 2017
Times: Start 09.30 close at 16.00 Day Two
Venue: Loughborough
wendymason@istonline.org.uk

Cost:

£500 IST Members – Residential fees are inclusive of all meals and one night's en suite accommodation

£570 (Non IST members) – Residential fees are inclusive of all meals and one night's en suite accommodation

Extra night accommodation £89

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.

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 Resources & Operations manager of the Department of Infection, Immunity & Cardiovascular Disease within the Medical School at the University of Sheffield. He began his career at Sheffield as a trainee Medical Laboratory Scientific Officer over 35 years ago and has subsequently experienced a series of diverse technical roles within the School. Over the last 10 years he has undertaken a range of senior managerial positions, leading technical and support staff teams, under various administrations and has been involved with small and large project teams across the University. As well as helping to redesign and co-deliver the LYTT & BYLS programmes from 2010 Kevin is also actively involved in both promoting and delivering staff development and training at Sheffield.

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 role as Head of Campus Services.

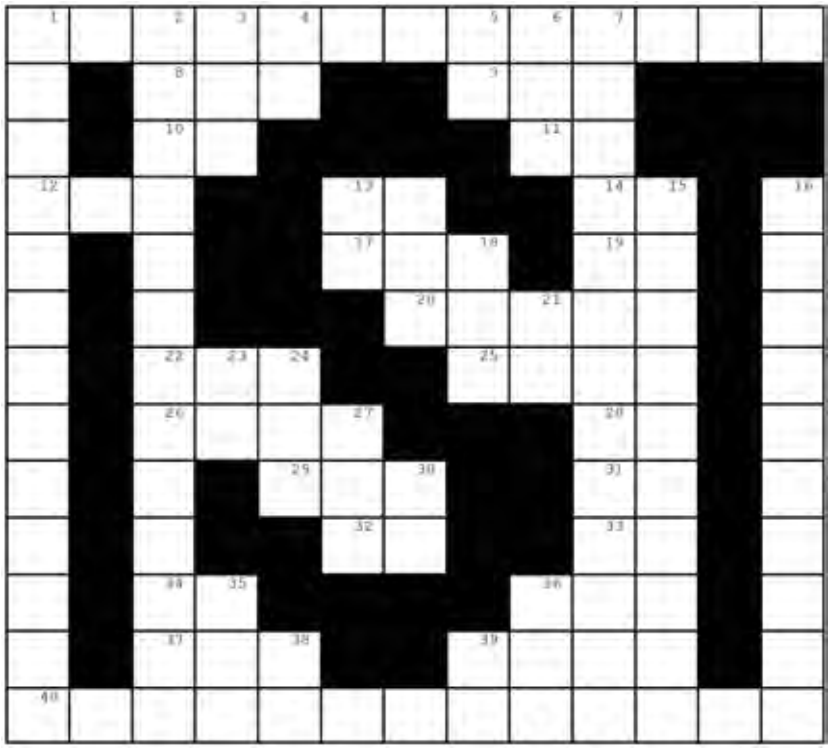
Ian Moulson

Before his retirement in December 2013 Ian was the departmental manager of the Department of Electronic and Electrical Engineering at the University of Sheffield. He was at Sheffield for 40 years, beginning his career there as an electronics technician following a number of years in the electronics industry and an electrical engineering apprenticeship in the steel industry. Throughout his career Ian built up a wealth of experience in managing a diverse range of support staff teams. He has managed technical teams ranging in size from 2 to 40 people as well as small to medium sized administrative and managerial teams. For many years Ian has been actively involved in both promoting and delivering technical training at Sheffield and also more widely since 2002 through the Leading Your Technical Team programmes.

To book a place on either of these programmes please contact:

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

The IST Journal's Quick Crossword



Across

1 A zoologist who studies fishes (13)
8 Chew and swallow food (3)
9 Whichever (3)
10 Abbreviation for a representative of the voters in the House of Commons (2)
11 Physically in contact with and supported by a surface (2)
12 French yes (3)
13 Antimony (element symbol) (2)
14 Arsenic (element symbol) (2)
17 Female grandparent (informal) (3)
19 Negative reply (2)
22 Covering for the head (3)
25 Fortified wine (4)
26 Organs of hearing (4)
28 Exclamation used to express a range of emotions including surprise (2)
29 But nevertheless (3)
31 Marital status neutral title (2)
32 Title of film about a lost young alien (2)
33 Used to attract someone's attention (informal) (2)
34 Calcium (element symbol) (2)
36 Vase with a stem and base used for storing the ashes of a cremated person (3)
37 A white vestment reaching to the feet (3)
39 Intermediate between larva and adult (4)
40 Person who writes beautifully (13)

Down

1 Behaviour or way of thought peculiar to an individual (13)
2 Describes a half of the earth (13)
3 An instrument for cutting a threaded hole in a material (3)
4 Abbreviation used for large electrical voltage (2)
5 Lanthanum (element symbol) (2)
6 Yoko ___ (3)
7 Abnormal insect having some male and some female characteristics (13)
13 Tin (element symbol) (2)
15 Least populated governorate of Egypt located in its eastern peninsula (10)
16 A person who is guided more by practical considerations than by ideals (10)
18 Pinch sharply (3)
21 Opposite of yes (2)
23 Abbreviation for a self-help organisation for people fighting alcoholism (2)
24 An effort to accomplish something (3)
27 Discern visually (3)
30 Motorcycle-racing competition held annually on roads in the Isle of Man (2)
35 The whole quantity (3)
36 Ununpentium (element symbol) (3)
38 Bismuth (element symbol) (2)
39 Abbreviation for a secretary working for one particular person (2)

Answers are on our website; **www.istonline.org.uk**

The Institute of Science & Technology

Professional status for people who work in technical roles

There are three schemes available for people who work in technical and science roles, awarded by the Institute of Science & Technology, under licence from the Science Council:

- **Chartered Scientist CSci** - for staff in senior scientific and leadership roles
- **Registered Scientist RSci -** for staff in scientific and senior technical roles
- **Registered Science Technician RSciTech - for staff in technical roles**

The IST believes that people who work in technical roles deserve formal recognition for the work that they do, the experience they've gained and the expertise they have to share. We know that our members are skilled professionals, and now we can give them official accreditation as a Chartered Scientist (CSci), Registered Scientist (RSci) or Registered Science Technician (RSciTech).

By registering, people who work in technical roles are helping to promote the professional standing of themselves and their colleagues. They are showing that they are making a vital contribution in their fields and achieving a status that makes them a key asset for the long-term.

The University Of Sheffield.

Science Council

GATSBY

The Institute of Science and Technology one day Technical Conference 2017

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

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

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The Institute of Science & Technology

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Tel: **0114 276 3197**

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Kingfisher House, 90 Rockingham Street
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T: 0114 276 3197 office@istonline.org.uk
F: 0114 272 6354 www.istonline.org.uk