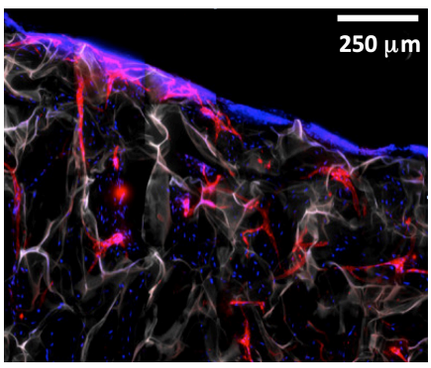
Cambridge
materialeyes

Spring 2021 Issue 36

Research for Regeneration

The Cambridge Centre for Medical Materials, with around 25 postgraduate students and postdocs, is jointly run by Ruth Cameron and Serena Best. Research encompasses Materials Science, Chemistry, Engineering, Physics, Biology and Biochemistry and focuses on the clinical application of materials that are either natural or mimic closely the tissues in the human body. Two major themes are: freeze-drying, to produce porous collagen sponges or scaffolds; and electrophoretic deposition (EPD) to produce layered membranes, or tubes.



Confocal micrograph of vascular structures in a cross-linked collagen scaffold. Image Credit: Nima Meyer.

In 2016 Ruth and Serena were awarded the first ever joint EPSRC Professorial Fellowship, with the aim to establish a "Design Toolkit" for tissue regeneration using freeze-dried collagen-based scaffolds. Drs Malavika Nair and David Barrett have been integral in establishing an online repository for the protocols and techniques used for scaffold fabrication. This includes a database, into which researchers upload their raw data on processing parameters and resultant structural and mechanical properties. An interactive interface (https://www.ccmm. msm.cam.ac.uk/Resources/Wiki) offers functionality for users to compare the influence of different parameters, and to predict scaffold properties.

David and co-workers have pioneered the development of EPD to create complex macromolecular membrane structures that can also incorporate live cells. This work has been patented, and David reached the final of the University-wide Postdoc Business Plan competition in November with plans for a potential spin-out company.

Malavika has recently been awarded a Junior Research Fellowship by Emmanuel College, and her plans include the discovery and optimisation of novel electrically active systems derived from biomaterials. This follows on from recent work demonstrating that biological materials, such as collagen, display piezoelectricity, which can be modified and enhanced through crosslinking procedures. Applications include regenerative implants, and mechano-biological lab-on-a-chip technology. The development and characterisation of promising materials systems is progressing through valuable collaborations, notably with Sohini Kar-Narayan's group in the Department.

Coronavirus Filter

James Elliot is one of the team of scientists and engineers from Cambridge and Ma'alot Tarshiha, Israel, who have developed a revolutionary new carbon-based material that captures and destroys an animal coronavirus, a close relative of the SARS-CoV-2 virus that causes COVID-19. The Active Virus Filter in the form of a thin carbon nanotube mat (TorStran™) has the filtration and air permeability properties that allow it to capture free virus molecules and those contained in airborne aerosolised droplets. Both filtration and virus disruption take place at the same time, allowing the filter to reduce the risk of infection by removing contamination from the air. It is envisaged being particularly useful in confined situations such as emergency vehicles, hospitals, transportation, waiting areas and wards.

Editorial

Welcome to this issue. Firstly, we offer our warm thanks to our predecessor, Paul Midgley, for the excellent stewardship of the Department from him and his team, not least through the difficult first months of the pandemic.

With a growing and successful Department, the role of the head has expanded greatly in recent years. In recognition of this, we have created a new 'Office of Head of Department' with three joint heads, sharing collective responsibility and collective leadership. While this model is new to Cambridge, we hope to allow time to be spent on critical strategic issues, in addition to day-to-day activities, while still balancing research and teaching roles.

The ongoing and changing lockdowns and quarantine conditions imposed by COVID-19 have provided exceptionally testing circumstances for our students and staff, but they have risen to the challenge with good humour, flexibility and creativity. A blend of online and in-person teaching has been provided over the past year with the balance responding to shifting circumstances. We have all learned many new skills, and there is no doubt that there will be much to capitalise on post pandemic to take advantage of these innovations.

This year we commemorate the 100th anniversary of the founding of our Department, dating back to the formation of a laboratory for "the study of metallurgy" on 5 October 1920. We are holding a number of virtual events and hope to be able to celebrate in person soon.

Finally, to mark our anniversary, we are launching our new Student Opportunity Fund, through which we will be able to offer our hardworking students additional research and professional development support. We are also grateful to AWE, for their commitment of a founding donation to this fund.

Ruth Cameron, Jason Robinson and James Elliott

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Support the Next Generation

In honour of our centenary, we are delighted to announce the launch of our Student Opportunity Fund, which will enable us to provide ongoing support to our talented students. Please consider making a donation today. To make a gift or for more information, visit: www.philanthropy.cam.ac.uk/give-to-cambridge/materials-science-metallurgy-student-opportunity-fund

Thank you! to our outgoing editor

John Leake will be familiar to many, with his long-term influence upon teaching and research in the Department, as well as key roles in St John's College, and on the University Council and General Board. Over the years, he has lectured to thousands, and supervised many hundreds! Throughout that time he was also in charge of the Department's X-ray facilities. And, following retirement in 2004, John maintained a very strong link with the Department through a long stint as editor of *Material Eyes*.

Image courtesy of Peter Dornan

Having been a Cambridge undergraduate and PhD student (in the Cavendish), John joined Metallurgy (as it then was) as a University Lecturer in January 1968, recruited specifically for his expertise in crystallography. This followed a postdoc at Brookhaven National Laboratory in the USA, working on crystals of inert gases, amongst other materials.

The Department had only recently joined with Mineralogy and Petrology (later forming part of Earth Sciences) to give the IA Crystalline State course, and John took on the Department's responsibility for 24 lectures on basic crystallography in the Michaelmas Term, alternating with Brian Ralph. With content including the stereographic projection, Brian, Trevor Page and John devised practical demonstrations that many of us remember. Another challenging topic which he introduced into IA was reciprocal space and its use in diffraction.

Besides many stints as an examiner (including practical exams in earlier days), John was closely involved in the development of the first assessed IA "artefact project", requiring the deconstruction and analysis of a simple piezo spark lighter. This project (currently based upon a cheap calculator) has become an important and much enjoyed component of IA.

John contributed much to teaching for all other years of the Tripos (and for postgraduate students), with lecture courses, examples classes and practicals. He was significantly involved in the establishment of the Part III course, as Senior Examiner in the first year of its existence, including liaising with the External Examiner, Trevor Page; and he brought valuable guidance to the inception of the DoITPoMS project through his membership of the Education Committee of the University General Board. He supervised for a range of Colleges, covering all Tripos years, as well as Physics and Engineering.

For many years John was a member of the Inter-Departmental Committee (with Earth Sciences) overseeing Part IA, and was also Secretary of the Departmental Teaching Committee, having proposed that the Department needed an academic in this role. He was the first-ever Deputy Head of Department following Prof. Colin Humphreys' appointment as Head in 1992.

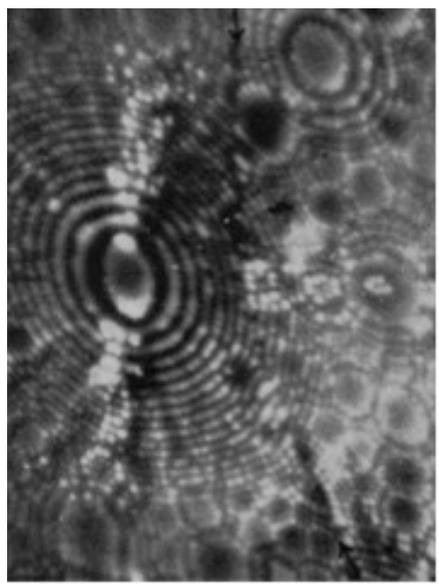
Since retirement John has found a little more time to enjoy travel and walking, but also continues advising on study skills at St John's, and assists the Institute of Physics in reviewing Fellowship applications. His very significant input to *Material Eyes* over many years is greatly appreciated.

Smart Plastics

An initiative funded in November 2020 called *Smart Sustainable Plastic Packaging from Plants* (S2UPPlant) led by James Elliott, Prof Paul Dupree (Department of Biochemistry) and Dr Jonathan Cullen (Department of Engineering) will research the potential for components of packaging sourced from food or agricultural waste, or from genetically altered plants. New materials will show improved properties, such as strength or low permeability to water or oxygen, reducing the volume of plastic packaging needed to keep food fresh. The investment is part of the Enabling Research competition in the *Smart Sustainable Plastic Packaging Challenge*.

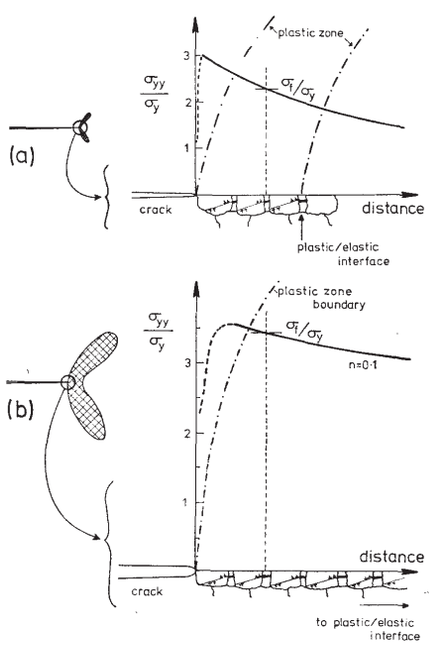
Centenary Research Highlights – 60s & 70s

Our Department website features 'Papers of the Month' but, of course, research landmarks have been generated throughout our 100 years. Here we note two classic papers, to celebrate the contributions of **Brian Ralph** and **John Knott,** both recently deceased. Brian and John were distinguished members of academic staff who moved on to head departments (at Cardiff then Brunel, and at Birmingham respectively). Brian was part of the team that established field-ion microscopy as a method to study crystal defects, and that laid the foundations for modern atom-probe tomography. John's group was a hub for research on fracture mechanics, his influence seen still through distinguished alumni across the globe. The two figures below are from the most cited papers of Brian and John, each written when they were in our Department, and each paper involving co-authors (now spread across continents) who are still flourishing.



Field-ion micrograph of a grain boundary in tungsten.

DG Brandon, B Ralph, S Ranganathan & MS Wald. A field ion microscope study of atomic configuration at grain boundaries. *Acta Metall.* **12** (1964) 813–821.



The critical fracture event at a sharp crack at (a) low, (b) high temperature.

RO Ritchie, JF Knott, JR Rice. On the relationship between critical tensile stress and fracture toughness in mild steel. *J. Mech, Phys. Solids* **21** (1973) 395–410.

The full range of length-scales in these studies remains centrally relevant in materials science today.

Making an Impact in Today's World

As an undergraduate Natural Scientist at Robinson College, Saul Nassé's initial plans were for Chemistry. However, having taken the IA Crystalline Materials option, he chose Physics with Materials Science & Metallurgy at IB and, part way through, decided that Materials was the Part II option for him. He found this 3rd year, back in 1986, the most enjoyable part of his education. The Department was relatively small and friendly: students got to know the teaching and technical staff and lectures took place in a very positive environment, with the opportunity for discussion and chat. He appreciated the cutting-edge science that he was learning from those at the forefront of their fields, and was also strongly influenced by the Department-organized external visits, for example to Lotus Cars in Norfolk. These encouraged in him an awareness of the intersection between science and engineering, as well as building on his earlier interests in the presentation and popularisation of science, which had first been prompted by watching *Tomorrow's World* on the BBC.

As we know, there's not too much time for other activities during a Natural Sciences degree at Cambridge, but Saul joined the Cambridge Film Unit, and also enjoyed solo weekend photography trips to London, with a particular interest in trains, railways and tube stations.

Following his degree, and having previously worked in fluid engineering at Cranfield University on summer placements, Saul began PhD research there. But his real passion was television, not just in the sphere of science fact but also science fiction – he'd been a big fan of *Doctor Who* since primary school. Having been frustrated by needing to make the choice between science and the arts at A-level, he found himself drawn towards a role at the BBC. Taking advice, which came from the producer of *Doctor Who*, John Nathan-Turner, he gained further experience writing, e.g. for Marvel Comics, and working with actors through amateur theatre. And then the break came: in a letter to the editor of *Tomorrow's World*, Saul pitched story ideas based upon some of his interests: science fiction and railways. It worked, and an initial 3-month contract with the show led on to him becoming editor, at the unprecedented early age of 31. It is significant that, not only was this the TV programme which had first piqued his interest in science and its presentation, but it was during his link with *Tomorrow's World* that Saul met his wife, the presenter Carmen Pryce. They held their wedding at the Institute of Materials in London.

With family roots in India, Saul was then very happy to take an opportunity to join the BBC World Service Trust, an international charity. Based in Delhi, he worked on reality TV programming directed at the promotion of knowledge and understanding of HIV and AIDS. Massive audiences tuned in, and he took great satisfaction in the huge impact this had on the control of the disease: a TV show which actually saved lives!

This experience unlocked a strong desire to use his skills and available opportunities for positive societal impact. For example, he was later to become Controller of BBC Learning, based in Salford, where he influenced education through the provision of free online support for school-children. He also took on the role of a governor at the University of Sunderland, and in the North East he was very grateful to reconnect with Trevor Page, who'd supervised him and had been 'the best teacher ever'.

There are many other broadcasting highlights: Saul introduced *Strictly Come Dancing* to the Indian subcontinent, through BBC Worldwide, again achieving huge viewing figures. And he stood in for a year as head of religious broadcasting at the BBC, which included the production of *Thought for the Day* and coverage of the funeral of a Pope.

He was eventually tempted away from broadcasting and back to Cambridge to manage the English Division at Cambridge Assessment, the University's international exams group. Subsequently promoted to Chief Executive of the entire organisation, his work includes setting strategy and also draws upon his presentational skills at conferences and in the press, with (in normal times) much international travel, including visits which vary from schools to government ministries.

At the opening of Cambridge Assessment's new HQ Triangle, with Zimbabwean student Kundai Nyakpoto.

His daughter (now 11) was born in India, and is currently enjoying school in Cambridge, with the family appreciating the proximity of everything here. Though, as travel lovers, trips to exotic locations had been important, a recent lockdown discovery has been the value of holidays in sunny Norfolk. As his career shifted more to the creative side, Saul has enjoyed keeping up his engineering skills through DIY projects. He describes himself as a foodie, and loves cooking, for example with his own tandoor.

Through his professional links with the BBC and with *Doctor Who Magazine*, Saul Nassé had been thrilled to find himself on the set of the show on more than one occasion. How impressed would that earlier 8-year-old *Doctor Who* fan have been if he'd been able to take a TARDIS trip forward in time?

Sir John Meurig Thomas (1932–2020)

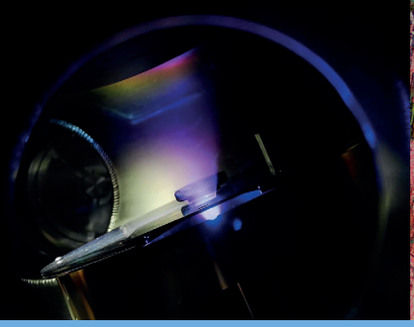
Image: Science History Institute (CC BY-SA 3.0)

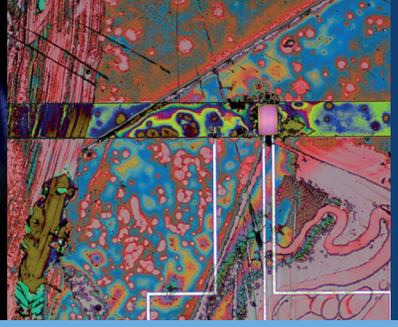
Sir John (or JMT as he was often known) was a remarkable scientist whose research and interests spanned many areas of chemistry and materials science, and he was particularly recognised for his work on catalysts and solid-state chemistry. During a long and distinguished career he received many awards, including around 50 medals, over 20 honorary degrees, and numerous honorary memberships of learned societies. He became a Fellow of the Royal Society in 1977.

An outstanding speaker and populariser of science, JMT was knighted "for services to chemistry and the popularisation of science" in 1991. In 2016 the Royal Society awarded him the Royal Medal for his pioneering work on catalytic chemistry. In further recognition, the mineral meurigite is named in his honour. Sir John was Head of Physical Chemistry here in the University, Master of Peterhouse, and succeeded George Porter as Director of the Royal Institution from 1986 to 1991. He co-presented the annual televised Christmas Lectures on 'Crystals and Lasers' in 1987.

His passion for science, and for communicating science, continued during Sir John's long association with our Department as Emeritus Professor and Distinguished Research Fellow. He published numerous papers with members of the Department, particularly the Electron Microscopy Group, and with many others in Cambridge. A publication on the use of microwaves to turn (unwanted) plastics into (useful) carbon nanotubes and hydrogen came out just days before he died. Sir John was always happy to speak with all members of the Department – whether to discuss the latest research, a recent scientific breakthrough, or just the state of Welsh rugby!

He was inspiring and generous, an extraordinary and brilliant scientist who will be greatly missed. Memorial events will be held both in Cambridge and in Wales later this year, Covid-permitting.





ABC Forum 2021

23 June 2021 online event

The Armourers & Brasiers' Cambridge Forum includes talks, the presentation of the Armourers & Brasiers' Materials Science Venture Prize, displays of current research and the 22nd Kelly Lecture, on 'Sustainable Metals', given by Professor Dierk Raabe (MPI für Eisenforschung, Düsseldorf).

www.msm.cam.ac.uk/forum

From 3D, to 2D, to Zero-carbon

The current Goldsmiths' Professor of Materials Science is Manish Chhowalla, who hails from New Jersey in the USA He gained his first degree from Rutgers University, and later studied hard-carbon coatings at the Engineering Department here in Cambridge for his PhD. These films (which were produced by cathodic arc deposition) have many applications, for example, as low friction coatings for machining tools, and as overcoats for hard-disc drives, requiring absolute (sub-nanometre) smoothness and continuity. Having previously gained some commercial experience in the USA immediately following his first degree, Manish was in an excellent position to exploit this research with the development of a spin-out company. He also became interested in the potential of hydrogenated amorphous carbon for semiconductor applications. Although this was not realised, a great deal was learnt from the science behind reaching this conclusion.

After a brief postdoc in Cambridge supported with a Royal Academy of Engineering Fellowship, Manish was tempted back to Rutgers in 2002, where he developed a very successful research group, working on many forms of carbon, including diamond, amorphous carbon, and nanotubes. His return to Cambridge in 2018 presented the challenge of moving this research, and some significant infrastructure, across the Atlantic. He praises, in particular, two very talented members of his team, Dr Jieun Yang and Ms Yan Wang, as being instrumental in this, and in enabling the group to re-start within a year.

Research is currently focused on two-dimensional materials. Manish credits another former member of his team, Goki Eda (then a PhD student), with initiating work in this field through the development of a method for the exfoliation of graphite to produce very thin flakes of graphene oxide. In 2006 his group at Rutgers was one of the first producing chemically exfoliated material and their 2008 paper, reporting large-area ultra-thin reduced graphene oxide as a flexible, transparent electronic material, has been cited nearly 3500 times.

Image courtesy of Manish Chhowalla

Bringing his earlier interests in defects and disorder in 3-dimensional carbon to the 2-dimensional form has led Manish and his group to significant advances in the materials science and applications of 2D carbon. Research has also broadened into the study of other ultra-thin materials: e.g. the transition metal dichalcogenides, WS_2 and MoS_2, which show a band gap and can therefore be used for electronic devices. Besides these electronic aspects, ground-breaking progress is being made on the electrochemical and catalytic properties of the materials, offering great potential, for example for hydrogen evolution and in batteries.

Manish now has a Fellowship at his former College (Churchill), and his wife and two young sons are enjoying Cambridge and everything it has to offer. He has an impressive number of major international collaborations and holds visiting professorships in Singapore, Korea and Hong Kong, which have allowed for much-enjoyed family holidays and travel in Asia. However, pastimes of walking, running and tennis have most recently been confined more locally.

He has been appointed as the Royce Institute Core Area Champion for Cambridge. The Royce UK National Institute for Advanced Materials has headquarters in Manchester, and Cambridge is one of seven 'spokes' with a theme of *Materials for the Energy Transition*. This, in addition to his link with the University's new climate control initiative, *Cambridge Zero*, is very close to Manish's heart, bringing materials expertise to solve critical scientific questions facing climate control.

Porotech

When Rachel Oliver's group set out to develop a novel quantum light source, they weren't expecting to end up spinning out a company. However, the need for new materials to enable light extraction from quantum light sources led them to develop a novel process for creating porous nitride semiconductors, materials which have a wide range of applications in electronics and optoelectronics. Trials combining mirrors made from porous nitrides with standard structures for light emitting diodes (LEDs) showed that the mirrors could increase the efficiency of such devices by as much as 25%. Based on this achievement, Rachel and her colleagues in the Department, Tongtong Zhu and Yingjun Liu, founded spinout company, Poro Technologies Ltd, and have set up an R&D facility and pilot plant in Sawston. The company is focusing on porous nitrides for microLEDs, a technology that will enable new augmented reality and virtual reality concepts.

Congratulations

David Barrett, finalist of University-wide Postdoc Business Plan competition
Thomas Bennett, 2020 Harrison-Meldola Memorial Prize, Royal Society of Chemistry
Eleanor Brug, Full Blue in Archery, University of Cambridge
Megan Hill, Herchel Smith Postdoctoral Fellow
Nick Jones, Promoted to Reader
Malavika Nair, Junior Research Fellow, Emmanuel College
Rachel Oliver, Women's Engineering Society, Top 50 Women in Engineering: Sustainability
Chris Pickard and **Bartomeu Monserrat**, Physics World Top 10 Breakthroughs of 2020
Tom Southern, Postgraduate Teaching Prize, Fitzwilliam College

Upcoming Centenary Event

A Hundred Years of Books

CAMBRIDGE MATERIALS
1920 – 2020

Thursday, 15 April at 2 pm GMT

Join Professor Sir Harry Bhadeshia, Professor Zoe Barber and Joe Smith as they explore the past, present, and future of materials research through seminal books associated with the Department. For more details or to RSVP, email jasmine.aslan@admin.cam.ac.uk. Registration: ahundredyearsofbooks.eventbrite.co.uk

Editorial team: Zoe Barber, James Elliott, Lindsay Greer, Nalin Patel and Lianne Sallows **Comments to:** alumni@msm.cam.ac.uk
The Department is also on Linkedin, Twitter and Facebook
If you would prefer to receive your copy of *Material Eyes* electronically please email alumni@msm.cam.ac.uk.
Images, top from left to right: Pulsed Laser Deposition of Lithium for solid state batteries, Adam Lovett. Dried solvent deposits on an in situ TEM chip, Jedrzej Morzy.