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Volume 32 | Issue 3 | Autumn 2022

IPEM
Institute of Physics and Engineering in Medicine

SCOPE

FIGHTING TWO EVILS: CANCER AND WAR

OPINION
The big question: "How can collaboration drive innovation?"

SUSTAINABILITY
The findings of a survey on manufacturer packaging

STRATEGY
A look at the launch of IPEM's Science Leadership Strategy

BOOK PITCH
Brian Cox and Jeff Forshaw on why you should read their book

CHAIR OF IPEM SCOPE EDITORIAL ADVISORY BOARD

Providing insights

Usman Lula outlines the content in the latest issue, including collaboration and innovation, the Ukraine invasion and Clinical Scientist training.

Welcome all to our third issue of *Scope* magazine this year. As I type away in a humid room, an extraordinary heat wave is upon us, and a drought has been declared in more than half of England. With rationed water bottles in supermarkets and the rising cost of living, we really are living in uncertain times. Let's hope the worldwide efforts for peace, sustainable living and equality can save the day.

The "Big Debate" in this issue centres on how collaboration can drive innovation in healthcare. Here, the key areas that are discussed include funding, resourcing, collaboration through engagement with all stakeholders, culture, policies, leadership and partnerships. Of course, that is just the icing on the cake as there are a further four questions that have also been answered by our five experts.

If there was one thing on my mind that I wanted to cover in *Scope* magazine this year, it had to be something around Russia's protracted invasion of Ukraine and its impact on healthcare services. Paul Doolan was able to provide a fantastic piece on just this – the impact of the invasion, contributed by a group of 12 Ukrainian radiation oncology practitioners. They provide insights into the movement of patients and service levels, the varying needs of the medical services, the availability of limited diagnostic and therapy services and the Ukraine Cancer fundraiser. It is a very interesting and powerful read.

> Key areas are funding, resourcing, collaboration through engagement with all stakeholders, culture, policies, leadership and partnerships

Member profiles were something we used to frequently include in past issues of *Scope*. For those readers who enjoyed them, we have a member profile in this issue – John Boulter. He is a Medical Equipment Specialist working within Clinical Engineering (NHS) – a key role in any healthcare organisation. Moreover, he volunteers for IPEM working with the Communication and Engagement Committee to support them with outreach and to engage with other clinical engineers.

Clinical Scientist training is currently provided through two main routes – the Scientist Training Programme and IPEM's "Route 2" – via in-work training and assessment by the Association of Clinical Scientists. In this issue, Lauren Harrison, IPEM's Training Development Officer, talks about IPEM's new Clinical Scientist Guided Training Scheme. In a nutshell, the scheme is expected to offer all the benefits of Part 2 and even more. Interested? If so, turn to page 52.

Usman Lula

Usman Lula
Chair of IPEM *Scope* EAB

SUBMIT NOW

Open for contributions

We love contributions from professionals at all levels, including "trainees" (for example, apprentices, PTP, STP, HSST) working within any of the IPEM areas. If you would like to contribute to *Scope*, please get in touch with me (usman.lula@uhb.nhs.uk), our Editor Rob (rob.dabrowski@redactive.co.uk), any of the *Scope* Editorial Advisory Board members or the IPEM Office. We would be keen to support you to write your first feature and any requirements (if that is the case) or discuss your proposal for submission. Don't forget – your submission counts towards your CPD. If you need an incentive, your feature could be chosen for the annual Keith Boddy award – that's £250 in your pocket, plus a certificate!

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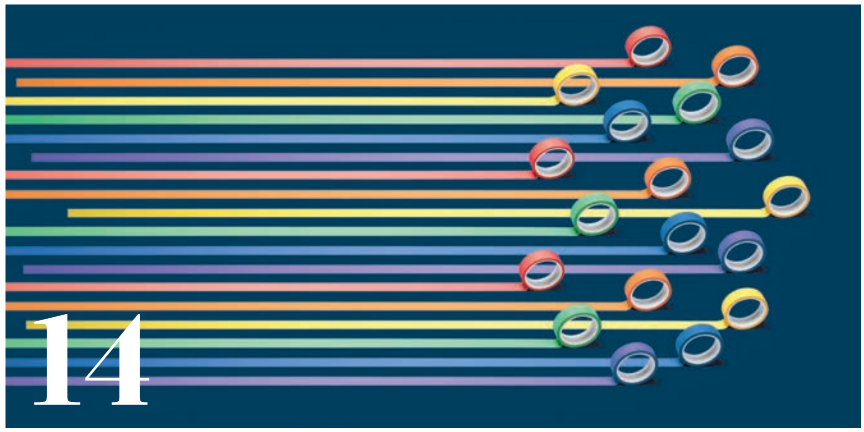

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THE BIG DEBATE

> We can influence fundamental or basic technology development by being a conduit to translate clinical needs to academia and industry.
>
> *– Dr Anna Barnes, Director, King's Technology Evaluation Centre* **page 14**

UPFRONT

Cover image by
ISTOCK

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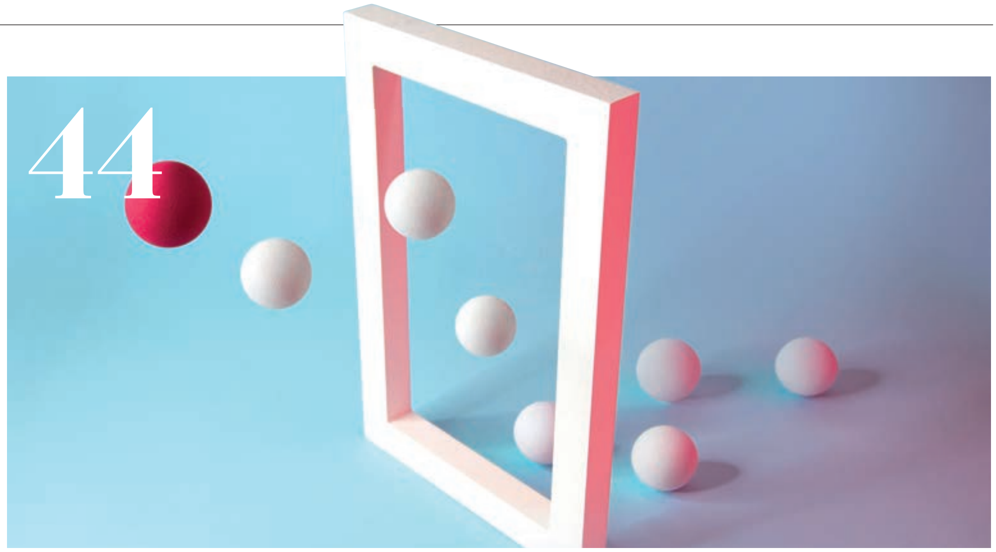
GENERAL



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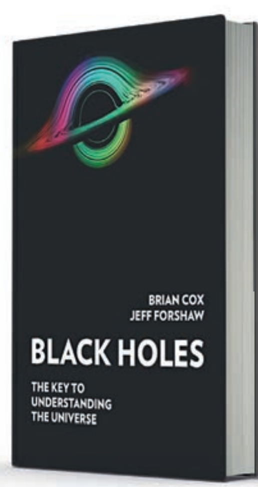


Imaging 1st

Imaging First Ltd, first opened in 2012 providing new and used ultrasound systems, probes, probe repairs and servicing options, we have continued to grow the business and are now on the NHSSC Framework for both equipment sales and servicing, with both new and used systems and probes in stock from a range of manufacturers.

Imaging First and Edan Medical

In 2019, we became the official UK distributors for Edan Medical ultrasound systems.

The Acclarix range starting with the AX3, with dual probe port and dual battery functionality, customisable touch screen interface in a 4.5kg lightweight body, produces great performance in a portable system, alongside its more powerful sibling, the AX8 with the addition of a tilt and swivel monitor and high clarity image quality, Edan have produced two portable systems that provide exceptional quality.

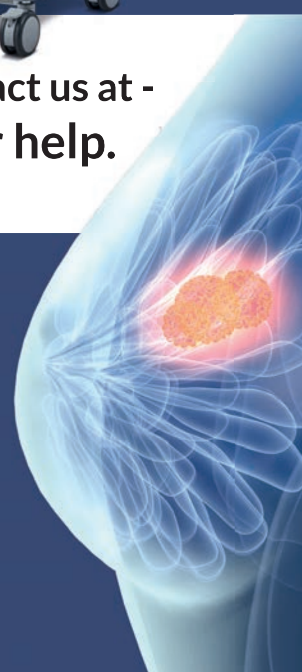
The new LX9 cart-based system, goes a step further in simplifying the experience for the user, it makes day-to-day operation an easy, fast and intuitive experience. With five probe ports, a customisable touch screen user panel and is available with additional options such as eLV, eOB, eVol.Flow and eFollical providing additional automated tools for stronger capabilities.

Imaging First and iCAD

In July this year, Imaging First became the official UK distributors for iCAD of their ProFound AI range of artificial intelligence for early breast cancer detection and diagnosis here in the UK. ProFound AI offers a solution that empowers radiologists to find breast cancer earlier and includes solutions for 2D mammography and tomosynthesis, ProFound AI also offers multi-vendor compatibility.

With two new options, ProFound AI Risk: The only clinical decision support tool that provides an accurate two-year breast cancer risk estimation that is personalised for each woman, based only on a screening mammogram and the age of the patient, and PowerLook Density Assessment: An automated solution to standardise the assessment of breast density to identify patients at higher risk of developing breast cancer.

All systems from Edan and iCAD are available to demo, please contact us at - info@imagingfirst.co.uk or on 0300 303 3600 for further help.



Precise. Powerful. Proven.

Discover the ProFound impact of artificial intelligence for digital breast tomosynthesis.

iCAD Imaging 1st

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UPFRONT

OBSERVATIONAL STUDY

COVID vaccines averted infection for patient-facing staff

IMAGE: ALAMY, NOUN PROJECT

The rapid COVID-19 vaccine rollout from December 2020 averted infection in a large proportion of NHS hospital workers in England during the second wave of the pandemic, suggests new research.

Without the vaccine rollout, which prioritised frontline healthcare workers, an extra 10% of all patient-facing hospital workers would have been infected. This could have led to staff absence due to COVID-19 being 69% higher, according to the paper.

It also reports that the odds of infection increased by 2% every day a healthcare worker went without vaccination.

Another study compared the effectiveness of the Pfizer-BioNTech and the Oxford-AstraZeneca COVID-19 vaccines against infection in 317,341 health and social care workers in England vaccinated between 4 January and 28 February 2021.

Using data from the OpenSAFELY research platform, the results show strong protection from both vaccines and no substantial differences between the two vaccines in rates of infection or COVID-19 related hospital attendance and admission.

Taken together, these findings provide essential insights into SARS-CoV-2 infection in health and social care workers that can be used to guide further infection prevention and control measures.

Healthcare workers were among the first groups eligible for COVID-19 vaccination. During rollout, coverage varied between healthcare worker groups, potentially leading to disparities in exposure and protection across the workforce.

The researchers therefore wanted to examine the rate of risk factors for, and impact of vaccines on, SARS-CoV-2 infection during England's second wave in susceptible hospital healthcare workers.

Using a combination of statistical and mathematical modelling, they analysed data from 18,284 clinical, support, and administrative staff with no evidence of previous infection who were recruited from 105 NHS hospital trusts in England as part of the SARS-CoV-2 Immunity and Reinfection Evaluation (SIREN) Study.

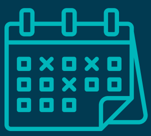
Participants completed a survey about their demographic, household and occupational characteristics, and fortnightly questionnaires that included whether they had been vaccinated. They also had PCR tests every fortnight and antibody tests every month throughout the study period (1 September 2020 to 30 April 2021).

After taking account of demographic, household, and occupational factors, 2353 (13%) of participants became infected during the second wave.

bit.ly/3J5ziBh

FAST FACTS

10% An extra 10% of patient-facing hospital workers could have been infected with COVID-19, were it not for the rapid roll-out.



69% This could have led to a 69% increase in staff absence due to COVID-19.

2% The odds of infection increased by 2% every day a healthcare worker went without vaccination.

BIODESIGN

Wireless neuro-stimulator

Many neurological disorders, such as Parkinson's, chronic depression and other psychiatric conditions, could be managed at home in the future, thanks to a collaborative project.

Researchers have developed a remote care platform that allows patients to access treatment from anywhere.

One of the research leads, Professor Peter Silburn, said: "By creating the world's first integrated and completely wireless remote care platform, we have removed the need for patients to see their doctor in person to have their device adjusted."

Electrodes are surgically inserted into the brain and electrical stimulation is delivered by a pacemaker that alters brain function - providing therapeutic relief and improving quality of life.

This digital platform allows clinicians to monitor patients remotely, as well as adjust the device to treat and alleviate symptoms in real time.

"We have shown that it is possible to minimise disruption to patients' and carers' lifestyles by increasing accessibility to the service, saving time and money," Professor Silburn said.

He said the system also fosters increasingly personalised treatment and data-driven clinical decisions that could improve patient care.

During the study the team established the platform safety, security, usability and effectiveness and optimised its features using patient feedback in a biodesign process.

In the initial weeks of a limited market release, they conducted 858 remote care sessions and "maintained a robust and high success rate".

The digital health platform for remote neuromodulation systems has regulatory approval and launched in Australia in October 2021.

go.nature.com/3RSrt5M

IMMUNOLOGY

NOVEL COVID-19 VACCINE USING MODIFIED BACTERIAL DNA

An international team of scientists has described a way to build a COVID-19 vaccine that would, in theory, remain effective against new and emerging variants and could be taken as a pill, by inhalation or other delivery methods.

The research involved building plasmids genetically altered to contain bits of genetic material specifically intended to target a vulnerability in the SARS-CoV-2 virus's spike protein – a portion of the virus critical to binding and infecting cells.

Plasmids are small, circular DNA molecules from bacteria that are physically separate from chromosomal DNA and can replicate independently.

They can be used by scientists to transfer genetic material from one cell to another, after which the introduced genetic material can replicate in the receiving cell.

The new approach narrows the focus to a part of the viral spike specifically involved in the virus's ability to infect that appears to be evolutionarily conserved, according to the team. This means the site doesn't change with new variants.

bit.ly/3z0OZqy

NEWS IN BRIEF

Remote programming CIEDs

More than 60 million magnetic resonance imaging (MRI) scans are performed worldwide each year, but imaging for the millions of patients with cardiac implantable electronic devices (CIEDs), such as pacemakers, is a logistical challenge, because of concerns with how the magnetic field affects the implants. Now a new study reveals safe and effective reprogramming of these devices is possible, even from a remote location. Researchers conducted an observational study of 209 patients who underwent remote programming of their device for MRI using Medtronic RM CareLink technology.

bit.ly/3on3FcT

Overlapping surgery

Overlapping surgery – in which a single senior surgeon operates across two parallel operating theatres and anaesthetists induce anaesthesia and junior surgeons commence and complete the operation – has been discussed as a potential route to reducing hospital waiting lists. Scientists, led by Professor Jaideep Pandit of Oxford University Hospitals NHS Foundation Trust, said there is potential for overlapping surgery to have some positive impact in situations where turnover times between cases are long. However, where operations are short (two hours or less), and "critical portions" of surgery constitute about half the operation time, advantages must be balanced against safety, ethical and training concerns.

bit.ly/3BcvVGU

COVID-19 biosensor

Researchers from Indiana University are developing a new biosensor with the potential to achieve the speed and efficiency required for the future of COVID-19 testing. It can currently analyse samples from 96 individuals in under three hours. In terms of efficiently, the system requires only 10 microlitres of blood. Researchers used 216 blood samples, including 141 samples from patients with COVID-19 and 75 healthy control samples. Based upon a blind analysis, the researchers found their biosensor's accuracy rate was 100% and its specificity rate was 90%.

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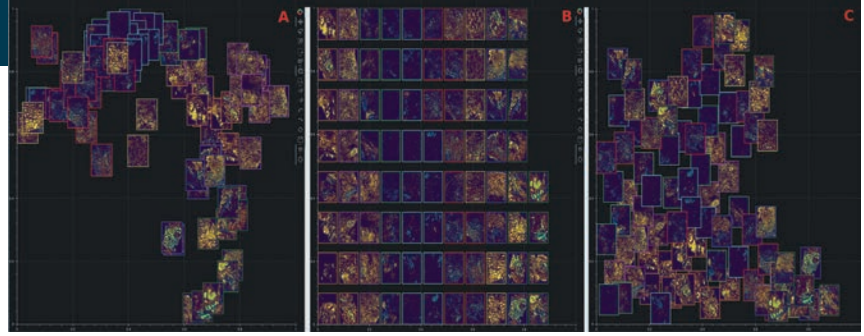


CLINICAL IMAGING

Open-source software for multiplexed image viewing

Researchers have developed an open-source software programme that allows users to view many multiplexed images simultaneously.

The team from the Moffitt Cancer Centre were working to understand the underlying spatial patterns between tumour and immune cells and how the tumours were organised.

This required the comparison of multiple images simultaneously and there was no software, free or commercial, enabling this.

They created a software programme that would enable them to view multiple images at the same time and extract data through additional analyses that could be used for a variety of purposes, including identifying biomarkers and understanding tissue architecture and the spatial organization of different cell types.

Their programme takes information from multidimensional images and uses dimensionality reduction methods called t-distributed stochastic neighbour embedding (t-SNE) to abstract each image to a point in reduced space. It can be used with images from Vectra, CyCIF, t-CyCIF and CODEX.

bit.ly/3b5YpHC

UP CLOSE

TRYPANOPHOBIA

WHAT IS TRYPANOPHOBIA?

The intense fear of needles. Specifically, people with trypanophobia fear needles in medical settings. They may avoid getting vaccines, blood draws or intravenous (IV) fluids.

WHAT IMPACT HAS THIS HAD IN THE PANDEMIC?

The pandemic enabled an evaluation of COVID-19 vaccine intention and uptake as well. Responses suggested that the combination of vaccine-related fears and feeling dizzy and lightheaded while getting a flu shot led some people to say they weren't likely to get the COVID vaccine – and then not get it.

WHAT CAN BE DONE?

A new study from Ohio State University calls for interventions to help people who want to get vaccinated, but have fears holding them back.

CAN YOU GIVE AN EXAMPLE?

There is a technique recommended by the World Health Organisation called "applied muscle tension", which involves crossing your legs and repeatedly tightening core and lower body muscles to raise blood pressure.

WHAT DO THE RESEARCHERS SAY?

Their paper says: "Intervention research to reduce fear and prevent vasovagal symptoms to support vaccine uptake is warranted."

WHERE CAN I READ MORE?

The study was published recently in the journal *Applied Psychology: Health and Well-Being*. To read the paper, visit **bit.ly/3OwsPjR**

BIOMEDICAL ENGINEERING

TOOL FOR MORE PERSONALISED CELL THERAPIES

A US team of scientists has, for the first time, developed a new tool to predict and customize the rate of a specific kind of DNA editing called "site-specific recombination."

It paves the way for more personalised, efficient genetic and cell therapies for diseases such as diabetes and cancer, they claim.

The process of site-specific recombination involves using enzymes that recognise and modify specific sequences of DNA in living cells. It has important applications for treating myriad diseases using cellular therapies.

University of Minnesota engineers have developed a method that combines high-throughput experiments with a machine learning model to make the site-specific recombination process more efficient and predictable. The model allows researchers to programme the rate at which the DNA is edited.

go.nature.com/3vgA88G

EXPERIMENTAL STUDY

SPRAY COATING TO SHIELD SURFACES FROM VIRUSES

A first-of-its-kind sprayable coating that can prevent the surface spread of infection from bacteria and viruses – including COVID-19 – over a sustained period has been developed by a team of researchers from Australia.

It works two ways: repelling viruses and bacteria through an air-filled barrier and killing pathogens through microscopic

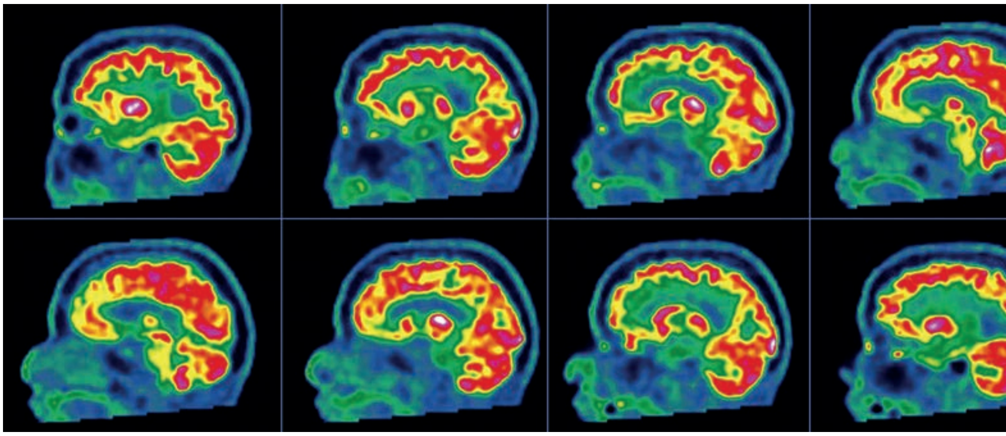
materials if the layer becomes damaged or submerged for extended periods.

The spray uses a combination of plastics strong enough to be considered an alternative to bullet-proof glass.

The coating provides a reliable alternative to standard disinfectants, which are becoming less effective and require regular reapplication, and is the only permanent surface layer proven to protect surfaces from contamination by viruses.

It is safer than existing alternatives to disinfectant, with no harmful side effects and more stable potency – unlike the next most promising non-disinfectant agent that kills bacteria, silver nanoparticles.

bit.ly/3aTeSip



MACHINE LEARNING

AI discover novel brain patterns linked to mental illness

A new development may lead to early diagnosis of devastating conditions, such as Alzheimer's disease, schizophrenia and also autism.

A team of US scientists has built a computer programme that is able to comb through massive amounts of brain imaging data and discover novel patterns linked to mental health conditions.

The data came from scans using functional magnetic resonance imaging (fMRI), which measures dynamic brain activity by detecting tiny changes in blood flow.

"We built artificial intelligence models to interpret the large amounts of information from fMRI," said Sergey Plis, Associate Professor of Computer Science and Neuroscience and lead author on the study.

He compared this kind of dynamic imaging to a film – as opposed to a snapshot, such as an X-ray or, the more common structural MRI – and noted "the available data is so much larger, so much richer than a blood test or a regular MRI. But that's the challenge—that huge amount of data is hard to interpret".

fMRI's on these specific conditions are expensive, and not easy to obtain. Using an artificial intelligence model, however, regular fMRI's can be data mined.

go.nature.com/3vcuynu

IMAGES: CESAR NICHOLAS, UNIVERSITY OF MELBOURNE / SCIENCE PHOTO LIBRARY / ISTOCK / GETTY IMAGES

BIOMARKERS

"SMART NECKLACE" BIOSENSOR

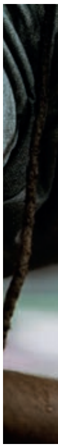
Researchers have successfully tested a device that may one day use the chemical biomarkers in sweat to detect changes in a person's health.

A team from Ohio State University demonstrated a battery-free, wireless biochemical sensor that detected the blood sugar – or glucose – humans excrete when they exercise.

The team fabricated a "smart necklace" complete with a functional clasp and pendant – which was used to monitor the glucose level of study participants as they exercised.

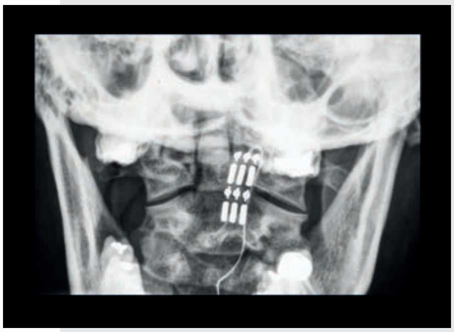
Instead of a battery, it works using a resonance circuit, which reflects radio frequency signals sent out by an external reader system. After engaging in indoor cycling for 30 minutes, participants took a 15-minute break, during which they drank sugar-sweetened beverages, before resuming cycling.

The researchers knew that glucose levels in the sweat should rise after drinking the sugary beverages – the



RESEARCH AWARD

Spinal stimulation through autonomic neuromodulation



The pioneering collaborative work being performed by Kessler Foundation scientists has been recognised with the Neuromod Prize – a new initiative from the National Institutes of Health in the US.

The prize aims to accelerate the development of neuromodulation therapies — targeted treatments that have the potential to treat a multitude of conditions through regulation of the nervous system.

The team's winning proposal outlines a pathway to greater independence for individuals paralysed by spinal cord injury.

While gaining voluntary control over paralysed or weakened limbs is a major focus of the research, spinal cord injury is complex, disrupting motor and sensory pathways, and the autonomic nervous system that regulates heart rate, blood pressure, breathing, balance and bowel and bladder control.

Building on their advances in restoring motor function through epidural stimulation, the team proposed the development of a novel tablet-type controller, which will help individuals with implanted epidural stimulators continuously stabilise their blood pressure and improve their respiratory and bladder function.

bit.ly/3cFHDPO

question was whether this new sensor would pick it up, said Jinghua Li, study co-author.

The results showed the sensor did track the glucose levels successfully, which suggests it will work to monitor other important chemicals in sweat.

"Sweat contains hundreds of biomarkers that can reveal important information about our health status," said Li. "The next generation of biosensors will be so bio-intuitive and non-invasive that we'll be able to detect key information contained in a person's body fluids."

bit.ly/3PPF3VE

MAGNETIC RESONANCE IMAGING

"Effective oxygen treatment for long COVID"

A new study has found a promising treatment for long-term COVID-19 symptoms, based on advanced hyperbaric oxygen therapy (HBOT).

Long COVID affects up to 30% of patients infected and, to date, no effective therapy has been found.

The researchers said their study is the first randomised controlled trial to demonstrate a solution for long COVID.

Patients exposed to an intensive protocol of HBOT treatments showed significant improvement compared to the control group.

The study – a prospective, randomised, double-blind, placebo-controlled clinical trial – included 73 patients with reported post-COVID-19 cognitive symptoms, such as inability to concentrate, brain fog, forgetfulness and difficulty recalling words or thoughts, persisting for more than three months following an RT-PCR test.

The results were highly encouraging: patients treated with HBOT showed significant improvement, while those in the control group with long COVID symptoms remained largely unchanged.

In HBOT-treated patients, the greatest improvements were in the global cognitive function, attention, and executive functions.

go.nature.com/3aZbwuh

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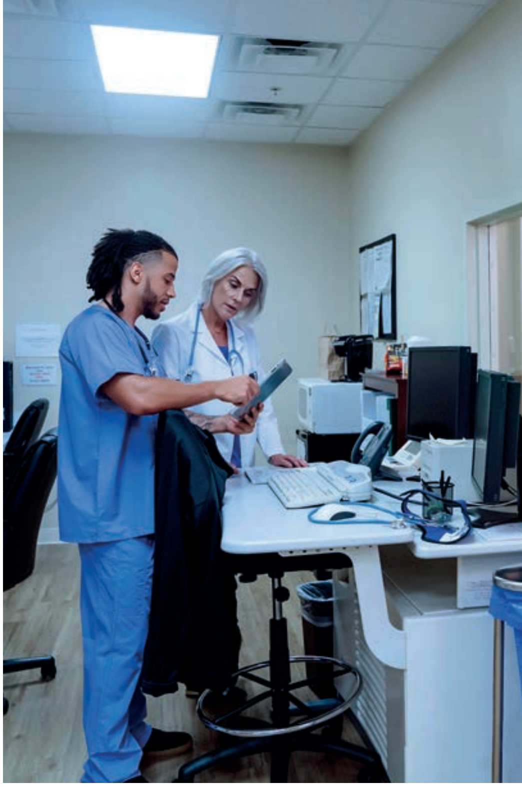
POLICY UPDATE

POLICY UPDATE

NHS staffing crisis

Sean Edmunds, the Institute's External Relations Manager, outlines the latest policy news and Institute updates.



A report about the understaffing crisis in the NHS released earlier this year overlooked the chronic shortages in the healthcare science workforce.

The House of Commons Health and Social Care Committee's report, published in the summer, suggested the NHS in England could be short of 12,000 hospital doctors and more than 50,000 nurses and midwives.

IPEM has repeatedly reported the shortages impacting the medical physics and clinical engineering workforce (MPCE) and called for urgent action to be taken.

The latest IPEM *Radiotherapy Workforce Census Summary Report*, published in June, said staffing of radiotherapy centres is barely "adequate" and there is little room for training new staff or implementing the latest treatment technologies to improve care.

The census also found there is a struggle to recruit clinical technologists and often difficulties in finding maternity and sick cover, leaving services strained, which has become even more critical due to staff absences caused by COVID-19.

IPEM research also highlighted the diagnostic radiology and radiation protection workforce to be at less than half the level recommended by established staffing models, with some services working at less than one-third of what is recommended, with almost 800 additional Clinical Scientists and technologists needed.

"Not just doctors and nurses"

Dr Robert Farley, IPEM's President, said: "Anyone working in the NHS knows

A CONFERENCE, A CONSULTATION AND A CAMPAIGN

As the world began to re-open this year, IPEM's Vice President International attended the World Congress on Medical Physics and Bioengineering in Singapore.

Dr Claire-Louise Chapple and Dr Catriona Inverarity, IPEM's Professional Knowledge and Innovation Manager, met international IPEM members.

Dr Chapple said: "We explored what they most value from membership and what areas they would like to see developed.

"For those unable to attend, I would still welcome your views, so please get in touch via office@ipem.ac.uk to help shape our future international strategy."

Earlier in the year, the government published its response to a consultation on medical device regulation, which IPEM had responded to.

The Medicines and Healthcare products Regulatory Agency (MHRA) launched the consultation in September 2021 and IPEM's Engineering Policy and Standards Panel led on the response.

IPEM Fellow Justin McCarthy, one of the many members who contributed their expertise to the response, said the government's report did not contradict anything contained in IPEM's current best practice guide on medical devices. You can read more here: ipem.ac.uk/news/government-response-to-medical-device-regulation-consultation.

A campaign by IPEM to update the guidelines on continuing professional development (CPD) for medical physics experts (MPE) has been successful.

The Department of Health and Social Care accepted IPEM's proposal on CPD for MPEs, which was submitted more than a year ago. Professional bodies will have to write guidance as to what constitutes appropriate CPD, and IPEM aims for this to be done by the end of this year.

The future supply of radionuclides in the UK for use in cancer diagnostics and therapeutics was discussed at an event hosted by IPEM.

The roundtable event, convened by IPEM, together with the Royal College of Radiologists and the Society of Radiographers, brought together a host of like-minded organisations, charities, academics, and nuclear and cancer experts to discuss the growing issue of radionuclide supply in the UK. You can read more about this on pages 48–51.

Finally, IPEM's Nuclear Medicine Special Interest Group provided input into a review by the Welsh Health Specialised Services Committee of PET-CT imaging in the country.

IMAGE: ALAMY

An IPEM report says staffing of radiotherapy centres is barely "adequate"

there is a staffing crisis and that it is more than just shortages of doctors and nurses that are posing a serious risk to patient safety.

"IPEM has been reporting for several years about the acute shortages faced by healthcare scientists, such as medical physicists and clinical engineers, and has repeatedly called for action to be taken to address this.

"We need the government to address the workforce crisis being faced across the NHS in general and in our professional areas in particular.'

"WE NEED INVESTMENT IN BOTH PEOPLE AND EQUIPMENT AND WE REALLY NEED TO SEE ACTION TAKEN

Workforce reporting

Dr Jemimah Eve, IPEM's Head of Workforce Intelligence and Training added: "Every time we carry out a census of the MPCE workforce, we get the same response about shortages, lack of investment and inadequate numbers of training places.

"The MPCE provides a critical role within modern healthcare and we regularly survey our areas of practice to understand and report on what the current situation is.

"The same messages are coming back loud and clear – we need investment in both people and equipment and we really need to see action taken to address this."

THE BIG DEBATE

The healthcare science ecosystem

We ask a panel of five experts five questions around how collaboration can drive innovation.

Q What practical steps need to be taken to ensure innovation in healthcare can take place and thrive in the current climate?

DR CATRIONA INVERARITY

Against a backdrop of Brexit, climate change, massive NHS backlogs, chronic understaffing and the hangover from COVID, the Science Minister role is vacant. The next incumbent must be made aware of the critical importance and value of innovation in and delivery of physics and engineering services in the NHS and in British academic and research institutes.

Both funding and protected time are essential to allow people the opportunity to advance in their fields. Collaborative networks are key to bringing in the right skills and the right time to ensure projects don't stagnate and ideas can be brought to fruition.

While training must ensure competencies are fulfilled, we must not lose sight of the fundamental skills of research and inquisitive spirit in developing new scientists and engineers.

PROFESSOR WENDY TINDALE OBE

Collaboration is absolutely key to successful innovation. We need to ensure that we break out of any silos that we may be working within and engage with multi-disciplinary teams, patients and service users, and all of the many professionals who may be stakeholders in our areas of innovation. For me, innovation is about creating value from ideas and to create that value, or impact, you need all of those stakeholders to be on side. Perhaps most important of all is to ensure that the unmet need that you are aiming to address is fully understood – where and why does the need exist, by whom, in what context and is there a consensus of opinion about this? If everyone agrees that it is a problem worth solving and the proposed solution would be practical and impactful, you are much more likely to achieve sustained adoption of your innovation.

DR ANNA BARNES

The same mantra we always say – more time and more staff. I remember when I joined the NHS in 1993 not only was a research element written into all job descriptions, but you were rewarded for taking part. It was expected from your superiors, and everyone took part if they wanted too. It may have been a little haphazard, but it didn't seem quite as intimidating as it does now in part because it was part of what you did every day rather than something separate and additional.

PROFESSOR CHRIS HOPKINS

The NHS is an attractive target for many technology and innovation companies, but the processes, regulation and testing requirements can be a barrier – especially for start-ups and SMEs. Funding for research and grant applications can also be a barrier – again, especially for start-ups and SMEs.

When it comes to the larger corporate organisations, they are looking for partners and suppliers who can simplify the processes and react to their needs with

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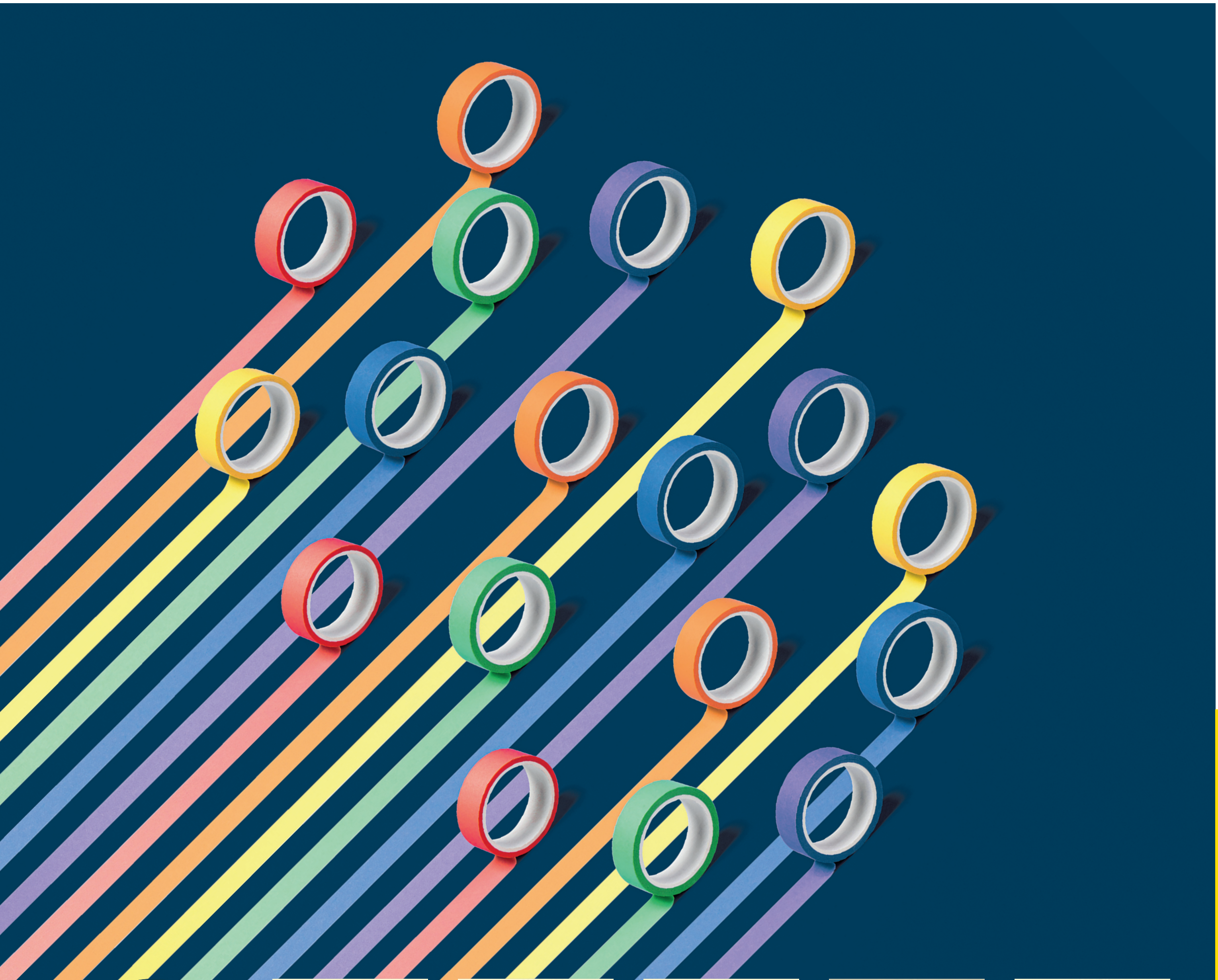


MEET THE EXPERTS

DR CATRIONA INVERARITY
Professional Knowledge and Innovation Manager
IPEM

PROFESSOR WENDY TINDALE OBE
Scientific and Innovation Director
Sheffield Teaching Hospitals NHS Foundation Trust, **Clinical Director,** NIHR Devices for Dignity MedTech and in Vitro Diagnostic Co-operative

DR ANNA BARNES
Director, King's Technology Evaluation Centre, (KiTEC), King's College London
Honorary Consultant Clinical Scientist
Healthcare Technology Assessment, Guy's and St Thomas' NHS foundation Trust, **Vice-President – Academic**, IPEM

PROFESSOR CHRIS HOPKINS
Consultant Clinical Scientist
Head of Innovation and the Tritech Institute Hywel Dda University Health Board
Fellow of the Academy for Healthcare Science, Honorary Professor of the Wales Institute for Science and Art (WISA)

GRACE KEANE
Junior Researcher
University Medical Centre Utrecht, **Consultant,** Boston Scientific, **Vice-President – Industry**, IPEM

a commercial and timely response.

While intellectual property (IP) is not a service or product, it is important to recognise the positive contribution that identifying, protecting, and exploiting IP can make. The IP rights should be determined at the point of entering a collaborative agreement or contract along with future revenue share to prevent conflict and commercialisation delays.

Not all health boards and trusts have a formal business planning process in place for the acquisition of medical technology, and while business cases are sometimes prepared, they are of variable quality. Often the variable quality relates to deficiencies in the evidence base.

We should enable clinical staff to innovate and support engagement with academia and industry to develop, test and adopt medical technologies that add value to the healthcare system.

GRACE KEANE

Successful innovation depends on so many pre-conditions – organisational culture and policies that create an environment for innovators to flourish; leadership that is committed to change and good communicators who build support and momentum; funding and access to resources (staff, infrastructure, time etc.) to get projects off the ground, especially for technological innovations, which often require upfront investment to bridge the period before the value is fully realised.

The two most important steps I would single out are: bringing together relevant stakeholders including patient groups, scientists, doctors, government bodies, industry, and policy parties that understand what it takes to bring an idea from inception to implementation. Through these partnerships you provide people with the tools to develop promising ideas faster and more effectively. Secondly, I think you need ongoing support and funding, the NHS has a large network of scientists with great skills to offer, but it's a chronically under resourced workforce. A practical step that can be taken is making sure support is in place to enable individuals to be innovative.

> **"MAKE SURE SUPPORT IS IN PLACE TO ENABLE INDIVIDUALS TO BE INNOVATIVE**

Q *How are technological developments influencing innovation in healthcare?*

DR CATRIONA INVERARITY

Digitisation in general should increase speed, efficiency and throughput – done well it also improves consistency and allows you handle massive amounts of data with precision, accuracy and speed to generate meaningful outputs.

"AI" is a term that is bandied around a lot as a sort of technological panacea but, when designed well and for a defined use-case, it does offer real potential. Prostheses is a really exciting application area. Advances in design (personalised 3D printing; finely tuned robotics) far exceed the level of control possible by users. The combination of advances in computing (allowing ever smaller devices and higher capability) and AI can combine to create prosthetic hands, for example, that can learn from patterns of behaviour and movement to allow fine motor control and naturalistic movement.

PROFESSOR WENDY TINDALE OBE

The advent of AI, data science, and digital health applications in their broadest form is driving much of the innovation we are now seeing in healthcare. Engineering and science in healthcare has never been more to the fore, and this is a definite growth area for our community. AI solutions are finding application in operational efficiency, workforce challenges, triage, as well as many areas of imaging and diagnostics. But we must not forget to also consider the service re-design that frequently needs to accompany technology innovation, nor the need for robust real-world clinical and economic evaluation.

DR ANNA BARNES

The technology that brought us smart phones is probably the biggest influence on healthcare right now. The number of health apps linked to "wearables" that are currently available has made it possible for us to monitor our own vital signs almost obsessively! Unfortunately, their integration into everyday care pathways has not kept up with the rate at which we have integrated them into our lives. The NHS of the 21st century is a risk-averse institution and while MRI, and PETCT revolutionised diagnostics in the 1990s and early noughties, introducing new technology into care pathways now seems riddled with caution. I think the next big technological developments that have the potential to influence healthcare are those aimed at minimising effects of said technology on our environment. Substitution of single-use plastics – which revolutionised infection control when they were invented – in all sterile procedures, renewable energy sources to run the huge amount of equipment we use or to design equipment that requires minimum energy to run. Humans are amazing at adapting and as the climate warms and the UK regularly has to cope with summers where the temperatures are above 30˚C we will be redesigning hospitals and healthcare facilities to make life more comfortable.

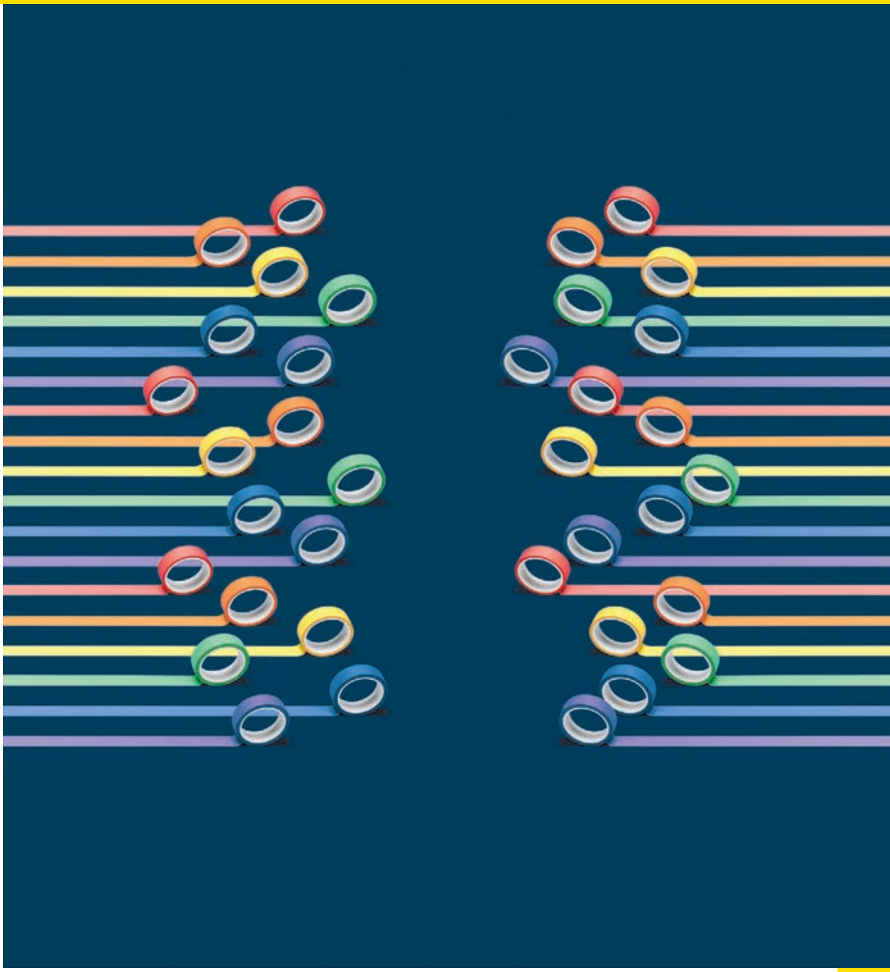
PROFESSOR CHRIS HOPKINS

Medical technologies represent a substantial asset for the NHS and are central to patient care and enablement. Ongoing increases in the sophistication of medical technologies provide benefits to patients in terms of new and advanced techniques, improved clinical outcomes, and less time in hospital. For the NHS and other healthcare systems there are additional benefits, including higher patient throughput and lower costs of diagnosis and treatment. A considered and planned approach to the acquisition of medical technology, taking into account the needs and preferences of professionals and end-users whilst retaining consistency and control, is needed if value for money is to be obtained. Beyond the NHS, these technologies support the net zero carbon emission targets outlined in Delivering a *"Net Zero" National Health Service Report.*

Real-world evaluations provide the opportunity to assess service and staff user experiences of technologies, the costs associated with their implementation and ongoing utilisation and whether operational and service improvements result. The TriTech Institute focuses on these bespoke evaluations to enable medical technology adoption and gain new insights on enhancing care pathways and supporting systems.

GRACE KEANE

Emerging technologies, including AI, predictive analytics, and the internet of medical things, are all contributing towards a more personalised, integrated healthcare experience for patients. We have increasingly connected lifestyles, and there's a demand on healthcare services to follow suit, by offering greater availability, improved access and convenience – seamless technology integration and interoperability are key to delivering this. The digitisation of health and medical data allows for ever more sophisticated data analytics and greater opportunities for collective analysis to build "big data". Data sharing enabled through cloud technology and more sophisticated IT infrastructure has undeniably influenced this. In short, technological development are carving out a path to more data-driven, patient-centric and integrated approaches.



Q *Do you see more opportunity to collaborate on fundamental or translational work? Is this balance right? What does it mean for the future of your discipline?*

DR CATRIONA INVERARITY

In a recent panel discussion, some of our members raised an interesting point that funding for medical physics, particularly, is difficult to access in the UK. Where it is available, it is aimed at projects addressing short-term clinical need. There is less opportunity for developing fundamental research that might lead to major advances – something as impactful as the emergence of MRI in the 1970s and 1980s. On the one hand, funding projects with immediate benefit to patients might help with the perceived value of physics and engineering research. On the other, there is a risk that we are missing opportunities to support work that might have more transformative results longer term. I think there is a place for both, but this needs to be reflected in the funding and research ecosystems to ensure the long-term survival of, particularly, medical physics.

PROFESSOR WENDY TINDALE OBE

There are definitely greater opportunities in the translational space. From the perspective of an NHS leader in medical physics and clinical engineering, the NHS is in a unique position to translate novel developments into practice through both academic and industry collaborations. It is also easier to justify the use of NHS resources if we can see a clear clinical or patient benefit from our activities in short to medium term. That said, and whilst fundamental research is more the domain of academia, NHS scientific and engineering input in this space provides valuable direction and insight to ensure that there is a genuine downstream application. Grant partnerships are a useful way of encouraging both fundamental and translational work and can open up opportunities for more junior members of the profession to get involved and gain experience of cross-sector collaboration.

DR ANNA BARNES

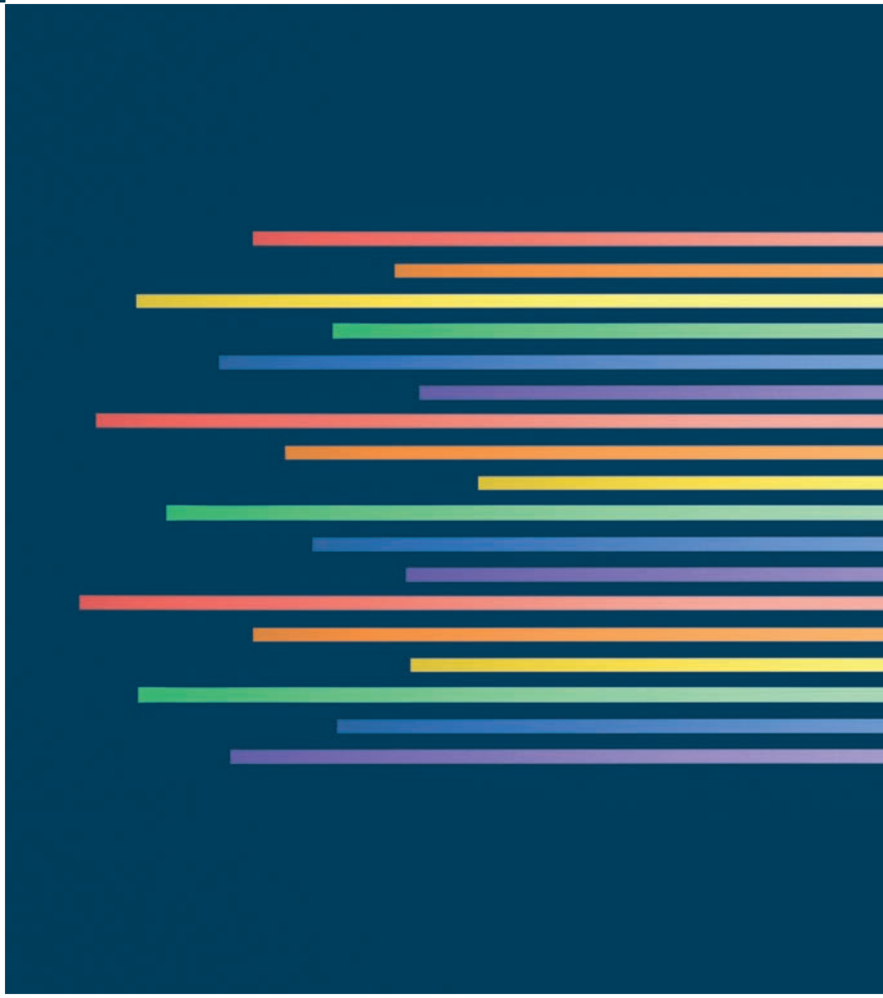
Surely it needs to be both? As scientists and engineers, we can influence fundamental or basic technology development by being a conduit to translate clinical needs to academia and industry and we can support and facilitate translational research by being the conduit to establish new technology in a clinical setting. On a personal level we can choose which we feel we can have more impact on. I've been fortunate enough to be on both sides of the technology flow but for myself I've always preferred the translation of technology into clinical practice.

PROFESSOR CHRIS HOPKINS

One thing that is vital for me is building partnerships and collaboration within the sector, academia and government. It is important to identify key clients, partners and collaborators to work with, along with the types of projects they would work on. Working together from an early stage is crucial and ensures clinical and patient engagement. It can also result in technologies with increased sustainability that better meet the needs of the population.

GRACE KEANE

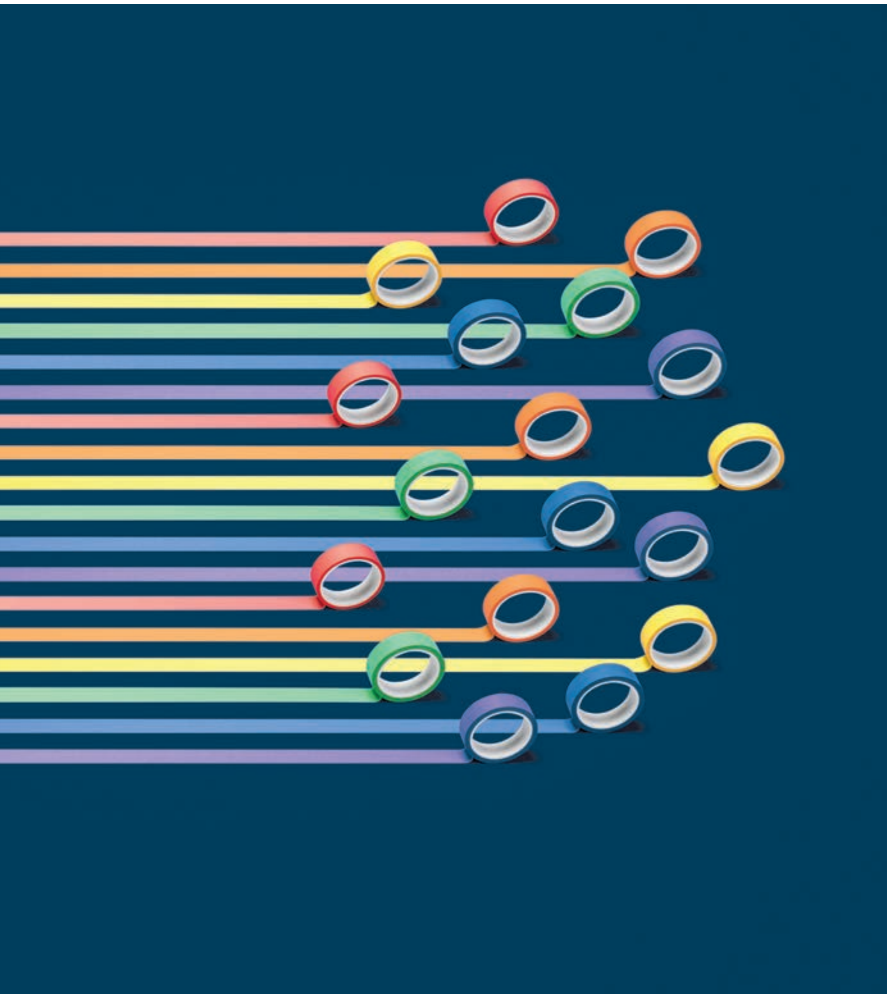
At the moment funding is still weighted towards translational work where there is immediate clinical benefit, and less priority is given to fundamentally developing services. Ensuring we find the right balance is something that IPEM can support with! However, I think we will see an increasingly collaborative landscape in both fundamental and translational research in the future. Speaking from an imaging research perspective (my discipline), the bar is being continually raised for academics; there are more regulatory demands than ever, more requirements to involve data management companies, compliance, and legal parties, and so a much larger input (budget, effort, personnel) is needed for the same output. It's inevitable public-private partnerships will increase, and collaboration will come earlier in the innovation process and not just for translational work. I've seen this first-hand in my roles in both academia and industry, and I think this trend will continue.



Q *How can IPEM support meaningful collaborations for our members and partners?*

DR CATRIONA INVERARITY

IPEM's member network contains a wealth of experience, skill, expertise and real passion in both healthcare service and in the underpinning science. We are unique in the breadth of disciplines in one



partnering externally to make sure we can bring in the best people to explore and translate initial ideas.

Our prizes and awards and range of grants are intended to support innovative work. We need to ensure these awards evolve to remain relevant to our members and the areas they operate in. I'm also keen to look at other ways we can support innovation – for example, helping develop skills to help people develop project proposals, win funding, assemble and lead projects. The practicality of securing time, particularly for those working in pressurised clinical environments, is of course a big challenge. I'm very keen to hear ideas and examples to ensure we can offer the best support and resources.

PROFESSOR WENDY TINDALE OBE

A useful area to explore would be how IPEM can support the development of more industry collaborations with its members – perhaps through some networking events in areas of mutual interest, with a specific aim of fostering new relationships exploring the application of novel science. I would also like to see a focus on entrepreneurship as part of development opportunities within the profession and potentially some mentoring of those interested to get into cross-sector collaborations by those who are more experienced in the enablers and barriers of this way of working.

" IPEM'S MEMBER NETWORK CONTAINS A WEALTH OF EXPERIENCE, SKILL AND EXPERTISE

professional body, so we're really well placed to make a difference, particularly in interdisciplinary and cross-modality work.

Strategic oversight of our Communities of Interest, Special Interest Groups by the Science, Technology and Engineering Research and Innovation Council, and the Professional and Standards Council will allow us to move to support innovation in key areas, but we will be dependent on the ideas coming from our members.

The member directory is a great way to find people. The trick is to play a more proactive role identifying the problems we want to solve, and assembling the best teams to achieve this. That might also involve

DR ANNA BARNES

I think IPEM as an organisation can provide a framework in which collaborations between the three pillars of our membership – NHS, industry and academia – can come together and share in the form of cross-discipline workshops, from which one or two ideas get taken forward to apply for the IPEM innovation funding and/or encourage members of the team to apply for the travel bursary to find out how other groups around the world are pushing forward ideas. Provide mixing events at the annual conference for early career members to mix with more experienced and senior career members of the three different pillars.

PROFESSOR CHRIS HOPKINS

The regulatory landscape in the UK is changing and in many cases the real and perceived "red tape" involved in bringing innovation to adoption in the NHS is a barrier to some smaller organisations and start-ups. The need for robust testing and regulation to ensure the safety and security of all concerned is essential, but it can be a barrier to innovation and entry. IPEM should continue to support adoption of innovation through a robust regulatory landscape whilst reducing inappropriate variation by supporting robust evaluations that can be used across the NHS to enable adoption of innovation.

GRACE KEANE

IPEM has a huge platform and is in a great position to get a temperature reading of the community, to understand both what is driving the shift towards greater collaboration, and where the community would benefit from better collaboration. I think the shift towards collaboration is down to a culture change – people no longer want healthcare/knowledge institutions setting their own scientific course and operating autonomously, but instead want research that incorporates the input of patient organisations and industry partners, where they can see the translation of scientific knowledge and innovations into economic and/or social value. Having an overriding strategy and direction for medical physics and clinical engineering services that encompasses these points is something IPEM should be involved in. I believe IPEM should also be involved in shaping policy to ensure innovation-friendly laws and regulations that do not stifle great ideas.

Whilst working at a medical device company I found that it was sometimes difficult to access scientists in the NHS, as relationships have historically been with clinical staff. IPEM – being the touchpoint for scientists and industry partners – is well placed to facilitate a "round table" service, bringing together all parties in one place. They can also help mediate in situations where there are competing interests – for example, securing a patent for a new technological innovation will likely take years and result from multiple studies, but industry will strive to bring innovations to market as quickly as possible, so managing expectations of all parties is essential. Finally, IPEM should continue to support innovation through supplying funding via the innovation grant.

Q *Do you have a great example of collaboration leading to innovation we can learn from?*

DR CATRIONA INVERARITY

This is more of an opportunity than an example – but I think there is a great opportunity to collaborate in taking practical steps to realising the NHS net zero plans. The strategy is ambition and wide-reaching, so it will necessarily spill into equipment, procurement and maintenance. Working alongside industry could help reduce the carbon footprint of existing services and pave the way for future equipment and technologies that are "green by design", without compromising performance or safety.

PROFESSOR WENDY TINDALE OBE

I have been fortunate to lead the NIHR Devices for Dignity MedTech Co-operative in recent years. This is part of the infrastructure of the National Institute for Health and Care Research and is hosted in Sheffield but has a national remit. It brings together clinicians, academics, the public, carers, charities and industry to develop new healthcare technologies in response to unmet needs. Through those collaborations we have developed 19 CE-marked products which are close to or in use, some worldwide, with another 10 in clinical trials. We have supported over 150 companies and have benefited from the input of hundreds of patients from diverse and sometimes marginalised groups. Our successes are a direct consequence of open innovation and teamwork. We now run the Healthcare Science Innovation Fellowship Programme in England and Wales which provides NHS scientists and engineers with direct experience of the innovation process and the value of partnerships.

DR ANNA BARNES

One of my oldest and dearest friends Dr John Krakauer, a Professor of Neurology at Johns Hopkins University, has always surrounded himself with a multi-disciplinary team of scientists, mathematicians, psychologists, and computing engineers to investigate the mechanisms of stroke rehabilitation. A decade ago he teamed up with a group of video gaming programmers to create Kata design studios. Their websites states: "We started Kata to bridge the gap between professional experiential production and neuroscience, clinical neurology, and medical hardware. We strive to build experiences and technology from the ground up, with a focus on mission, and at a level that is consistent with the best productions in the industry. We mirror the thousands of hours that go into a level design in a video game, but with the crucial difference that the focus is on the subtleties required for patient treatment or wellness."

Together, John and his team are revolutionising stroke rehab by recognising that video games can motivate and enable rapid physical recovery at very early stage post-event. The website continues: "What has been discovered in the last decade is that experiential technology (interactive games, virtual and augmented reality, haptic interfaces, etc.) can exploit and augment brain plasticity. Hundreds of studies published over the past decade show that specific types of commercially available digital games that require visual spatial navigation, rapid decision making and focus, etc., have remarkable 'transfer' effects (...) Although experiences can have deep effects upon the brain, scientists are only scratching the surface by analysing off-the-shelf games that were intended as commercial entertainment. Building therapeutic interventions requires building experiences ground up. [Kata does this by] incorporating art, design, production, and technology at the highest levels of professional excellence."

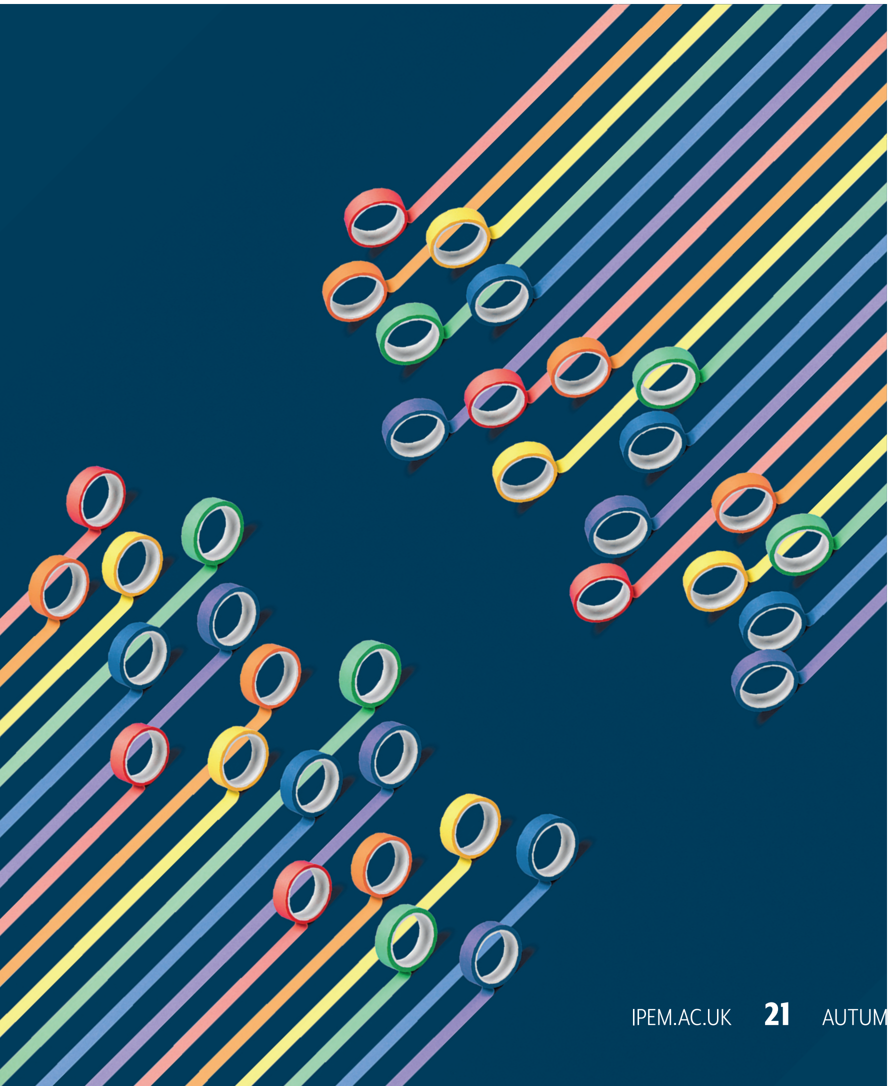
PROFESSOR CHRIS HOPKINS

Through the Tritech Institute and funded by Moondance Cancer Initiative, Prof Chris Hopkins, Mr Sohail Moosa (Consultant Urologist), Dr Rachel Gemine and Jiva.ai (a commercial partner) demonstrated the first innovative deployments of JivaRDX within Hywel Dda University Health Board. Retrospective data from patients who underwent MRI for suspected Prostate Cancer was secured by analysis of the patient records and anonymised. The urology expert and the JivaRDX software independently assessed whether or not the MRI shows clinically significant prostate cancer. The clinical diagnosis data was then used to define whether each patient received a correct diagnosis of prostate cancer. Uniquely, we extracted existing data from our source radiology systems to create a feasibility demonstration of a multimodal predictor that included PSA analysis, patient age and MRI data.

> **"WORKING WITH INDUSTRY COULD HELP REDUCE THE CARBON FOOTPRINT OF EXISTING SERVICES**

This collaborative study to test for non-inferiority of a machine learning platform against independent urology experts showed that JivaRDX is not worse than the expert in terms of sensitivity and specificity. This means that the platform can aid clinical decision making leading to reduced diagnostic delays and potentially improve patient outcomes.

Our intention now is to prototype these demonstrators to clinical pilot readiness within Hywel Dda University Health Board to quantify early diagnostic and value-based healthcare benefits. This project highlights the impact of working with companies to improve healthcare.



GRACE KEANE

Interventional X-ray and scintigraphy imaging (IXSI) is an innovative medical imaging modality that combines a classical X-ray C-arm with a SPECT/CT system. The combination of X-ray and nuclear detection capability in a compact device that may be implemented in the interventional radiology suite is a unique concept. By combining these modalities in one piece of equipment, clinicians can obtain more imaging information in a single step, improving efficiency and making procedures more tolerable for patients. This device could offer clinical benefit for several workflows involving image guided intervention with radionuclides.

The concept for IXSI, formulated in the nuclear medicine department of UMC Utrecht, demonstrated there was a clear benefit that could be offered to patients through this technology but developing the idea and bringing it to life would not be possible in isolation. The department partnered with Philips to build the patented dual layer detector and mobile gantry, together with the Agency for Applied and Engineering Sciences within Dutch government for funding, and the medical technology and clinical physics team for support with navigating the regulatory requirements. The system is now being used in a phase I clinical study.

FIGHTING ON TWO FRONTS

War and cancer in Ukraine

A group of 12 Ukrainian radiation oncology practitioners describe the devastation wrought by Russian forces on the country, its people and its cancer centres.

Can you imagine, as a radiation oncologist, you have to shelter your patients in a Co-60 vault to protect them from missiles, provide them with water by melting snow, feed them, keep them warm by using a back-up power generator and evacuate them just two hours before the missile destroys the radiation oncology department?

What if, as a radiation therapist, you volunteer to live in the radiation oncology department 24/7 to scan wounded patients using a computed tomography (CT) simulator?

Imagine, as a medical physicist, working long shifts to treat twice the usual patient volume on a 15-year-old linear accelerator (linac) that frequently breaks down.

IMAGE: ISTOCK, ALAMYW

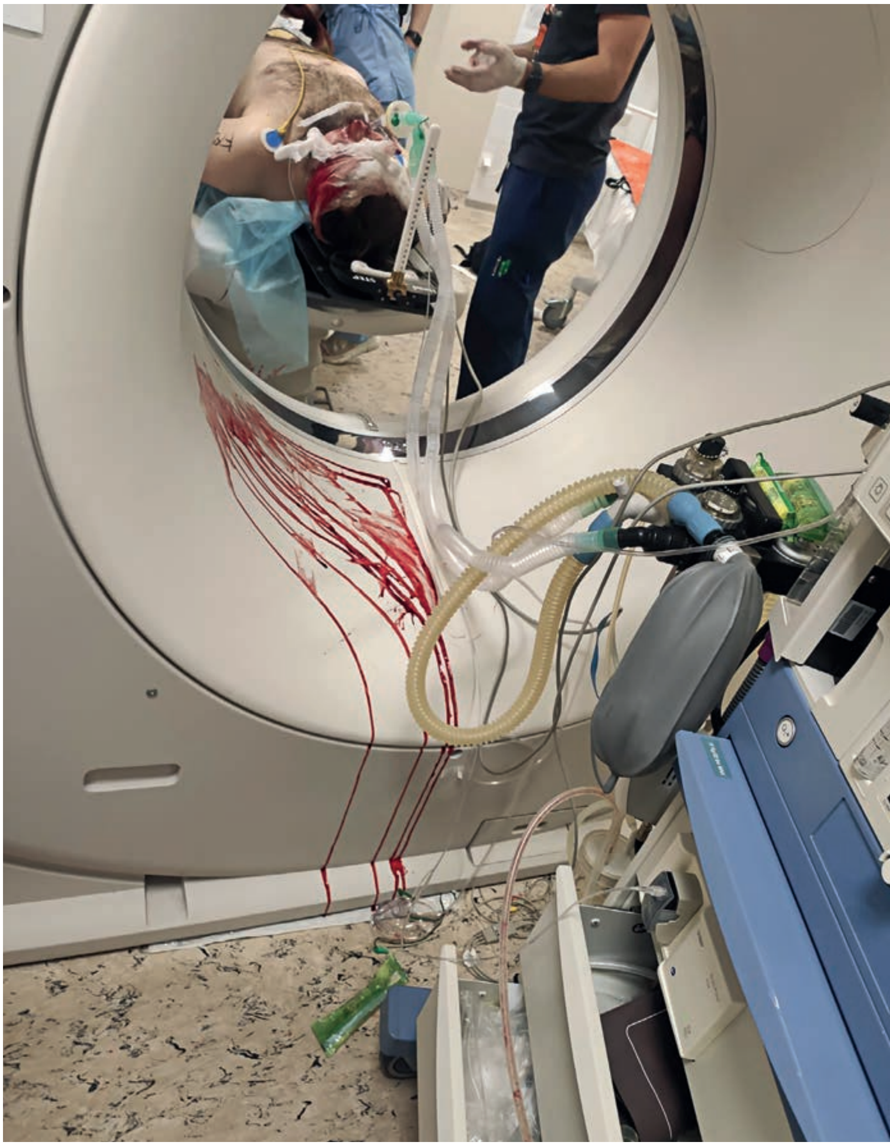
Can you imagine, as a nurse caring for cancer patients, worrying about your mother, with whom you could not connect for three weeks, knowing she is living in a basement, without water, heat, electricity and in an area that is constantly shelled?

Imagine evaluating a radiotherapy treatment plan while worrying about your son and husband who are fighting against the Russian invaders.

This is not some dystopian novel – it's the horrifying reality Ukrainian cancer practitioners are living through right now. And it is happening because in the 21st century Russia decided to start an imperialistic full-scale invasion of Ukraine.

Destroying hospitals

The Russian invasion of Ukraine on 24 February 2022 started an absolute horror of destruction and chaos for everyone in its path. Thousands of civilians were killed. Many were innocent children. Many more have been wounded. Approximately a quarter of the population of Ukraine was displaced as of 8 July – 5.5 million as refugees in Europe and 6.3 million internally displaced due to the war. The Russian army is obliterating Ukrainian cities, targeting civilian infrastructure with missiles, deliberately damaging and destroying hospitals and clinics in violation of Article IV of Geneva Convention. According to Ukraine's Minister of Health, Viktor Liashko, during the 100 days of war more than 600 healthcare facilities sustained damage, 105 of which were rendered beyond repair. In addition, the Russian army deliberately targeted and damaged around 450 pharmacies and 200 ambulances, the Ukrainian Ministry of Health reported. Even if the war stopped today, the inflicted damage to the healthcare infrastructure would last for years to come without the world's continuing support.



❶ OKHMATDYT's simulation CT is used for diagnostic purposes. CT scan of a wounded man, who unfortunately died of his wounds.

Treating cancer

Before the full-scale Russian invasion, according to unpublished Ukrainian NCI (Tumour Registry) data, in Ukraine, which has a population of 44 million, there are an estimated 139,000 people living with newly diagnosed cancer, and between 1000 and 1200 children receiving active cancer treatment. As for radiotherapy, Ukraine is classified by the Directory of Radiotherapy Centres International Atomic Energy Agency DIRAC IAEA as a low-middle income country with a level of availability of 2.6 external beam radiation therapy (EBRT) machines per one million of the population. Prior to the Russian annexation of Crimea and parts of Donbas in 2014, Ukraine had 52 radiation therapy centres with 86 Co-60 machines (81%) and 20 linacs (19%).

Since 2014, Ukraine has lost control of 10 cancer centres and over 13 EBRT machines in the occupied part of Donbas and five machines in Crimea (totally 17% of Ukrainian EBRT machines). To remedy the growing need, 16 linacs were installed by 2022, and the ratio of Co-60 to linacs became 54% to 46% (excluding EBRT machines in the occupied territories since 2014) ❸. The Ministry of Health of Ukraine planned to purchase an additional 20 linear accelerators, but this plan did not materialise as the Russian full-scale invasion shattered Ukraine in the early hours of 24 February.

Radiotherapy during war

In the first weeks of war, most radiotherapy centres suspended treatments. Bone marrow transplants were conducted in the basements under air raids, and palliative care continued due to the difficulties evacuating fragile patients. Paediatric cancer patients from OKHMATDYT – the biggest children's hospital in Ukraine – and the National Cancer Institute were evacuated in the first weeks of the war through the St Jude's Global Critical Care SAFER Ukraine programme and transferred to healthcare facilities across Europe, Israel, and the United States.

At the beginning of March, most radiation oncology centres in Kyiv (containing 20 EBRT machines) stopped operation. OKHMATDYT children's hospital was an exception –staff decided to live in the hospital to provide 24/7 diagnostic services for the wounded using the CT simulator ❶. The situation in the south of Ukraine became critical, with cancer centres in Kherson and Melitopol occupied, and Mariupol Onco Dispensary without electricity, water, gas, or communication and the city of Mariupol under constant shelling.

Dr Hanych, the Chair of Radiation Oncology in Mariupol Onco Dispensary, recounted a horrifying story of saving his 12 patients by sheltering them in the Co-60 vault and evacuating them just two hours before a missile destroyed the building. He evacuated on foot with his wounded friend by walking 15-18 km along the Sea of Azov. The fate of the Co-60 source in

"TWELVE PATIENTS WERE SHELTERED IN A CO-60 VAULT AND EVACUATED JUST TWO HOURS BEFORE A MISSILE DESTROYED THE BUILDING

the occupied Mariupol is unknown. The Kharkiv Radiation Oncology Department ❷ sustained severe damage as well.

Resuming work?

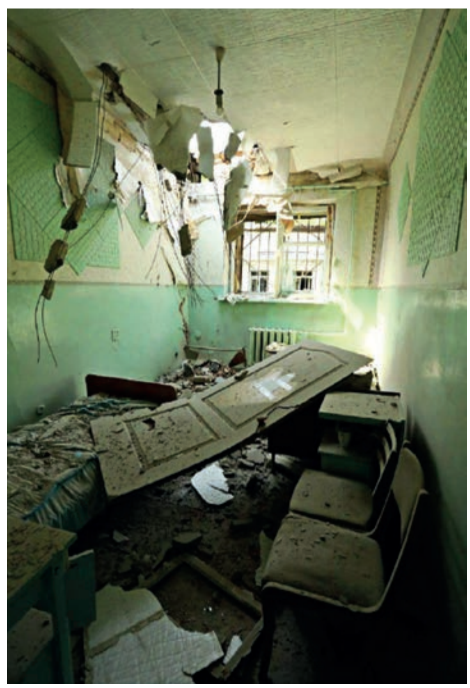
In mid-April, when the Russian army retreated from the north of Ukraine, the radiotherapy centres in Kyiv, Chernihiv and Sumy resumed work. In Chernihiv, the CT simulator sustained damage and the linac has not resumed operation due to cooling system issues. In the fourth month of the war, as of 12 July 2022, in addition to 10 cancer centres occupied since 2014, three other cancer centres were under occupation, three cancer centres suspended operation, and two cancer centres were under constant shelling. In some centres in the west and centre of Ukraine, the patient volume increased due to patients fleeing the war. Lviv Regional Cancer Centre is treating patients whose houses were shelled, and who have no belongings. Having fled from their home towns they arrive at train stations requesting appointments to resume their cancer treatment.

Where we need help

A group of oncology practitioners organised the Help Ukraine Group (HUG) to connect with cancer providers in Ukraine and establish a feedback loop of determining the need and providing support. We interviewed D. Beznosenko, Chief Medical Officer of National cancer Institute in Kyiv and the President of Ukrainian Society of Medical Oncology. "There is an acute need for chemotherapy medications and disposable medical devices. The supply chains became disrupted by the war, and the hospital is running out of medication," he said.

Many medical warehouses were destroyed or are unavailable due to logistical issues, airports are not operational, many bridges and highways damaged. There are also procurement challenges for tender agreements.

Disposable devices are in need in almost every radiotherapy centre. The HUG members collected the data on this and asked CIVCO and Orfit for donations. For items that were not donated, HUG members applied for Union for International Cancer Control (UICC) Solidarity Fund and obtained the funding. The first shipments of immobilisation devices are on the way to Ukraine. More sustained support needs to be established to provide the medical supplies, devices and chemotherapy medications. We call on the professional organisations to run a Support Ukraine fundraising drives with members and the industry to provide help for Ukraine.



❷ Damage to Kharkiv Regional Oncology Centre

3 Map of the cancer centres providing external beam radiotherapy in Ukraine, as of June 2022. Orange radiation symbols denote Co-60 machines, and black symbols denote linear accelerators. Yellow arrows show the radiotherapy centres under Russian occupation since 2014, green arrows show the radiotherapy centres under Russian occupation after full-scale invasion in 2022, black arrows show the centres working under constant shelling as of July 2022, and orange arrows show the centres that suspended operation as of July 2022. Source: https://dirac.iaea.org/ supplemented by the data from Ruslan Zelinskyi

Calling for donations

Ukraine, a country of 44 million population, has only three PET/CT scanners, all in Kyiv, and only two are functioning after the war broke out. Patients from all over Ukraine have to risk their lives and travel to Kyiv for a diagnostic or follow-up CT scan, with many patients abandoning the scan altogether. According to the European Association of Nuclear Medicine, there should be at least one PET/CT scanner per 1.5-2 million people, which would translate into 22 scanners for Ukraine. In an effort to reduce oncologic morbidity and mortality as the result of war, HUG members are calling on PET/CT scanner and cyclotron vendors to donate at least one PET/CT and cyclotron to Lviv Oncology Regional Therapeutic and Diagnostic Centre to overcome disparities for Ukrainian cancer patients during the war.

Upon Dr Beznosenko's request, HUG members are organizing a training programme in US/Canada/Australia for the Ukrainian female physicians of various specialties (radiation oncologists, medical oncologists, surgeons, anesthesiologists, pathologists) and medical physicists. Please contact the authors if your institution is willing to provide funding for a visiting scholarship for Ukrainian female doctors or medical physicists. HUG members created a fundraiser to help collect funds to cover the travel and initial expenses for Ukrainian female physicians and physicists. Ukraine needs help in modernising the training for radiation oncologists and medical physicists, as the training in Ukraine is based on Co-60 technology. HUG members are also creating educational materials for transitioning from 3D to IMRT/VMAT. We thank Rayos Contra Cancer for donating training videos for us to translate.

A team of Stanford medical and computer science students led by Solomiia Savchuk created a TeleHelp Ukraine initiative to provide remote medical advice and mental health support for Ukrainians, with the help of American doctor-volunteers and a team of interpreters. HUG members are grateful to MIM Software for proving a free software license to host a MIM cloud DICOM repository for medical images from Ukrainian patients that further informs the video consultations. This effort urgently needs physicians of various specialties.

We call on all radiation oncology vendors to provide their support, donate equipment and software, enhance support for equipment maintenance and service, and to provide training. Ukrainians are grateful to Varian and Elekta for organizing the free training courses for Ukrainian radiation oncologists and physicists. We are also grateful to Limbus AI Inc for providing free licenses for automatic contouring software and RADformation for donating automatic 3D-planning, automatic contouring, secondary plan check, secondary MU calculation to Ukrainian cancer centres which will facilitate streamlining the treatment planning workflow.

Start with individuals

Even if the war were to stop today, the long-lasting effect of the decimated healthcare system in Ukraine will last for years to come. It's imperative that the effective cancer recovery plan in Ukraine should have radiotherapy at its heart with precise coordination between governing bodies, professional organisation, patient organisations, multidisciplinary professionals and industry. But all these efforts start with individuals, and individual power and the will of Ukrainians to fight for their cancer patients is truly inspiring. Let's help these Ukrainian doctor-heroes to win against two evils: cancer and war. If you are interested in helping us provide support for Ukrainian cancer centres, please consider contributing to this fundraiser, or share the link with your colleagues: bit.ly/UkraineCancerFundraiser

Kovalchuk N, *Clinical Associate Professor, Stanford University,* ***Zelinsky R***, *President of Ukrainian Association of Medical Physicists,* ***Beznosenko A***, *Medical Chief Officer at NCI and President of Ukrainian Society of Medical Oncology,* ***Melnitchouk N***, *Assistant Professor, Brigham and Women's Hospital, US,* ***Iakovenko V,*** *Assistant Professor, University of Texas Southwestern Medical Centre, US,* ***Kowalchuk R***, *Medical Doctor, Mayo Clinic, Rochester, US,* ***Hanych A***, *Chair of Mariupol Oncological Dispensary, Ukraine,* ***Severyn Y***, *Assistant Professor, National Specialised Children's Hospital OKHMATDYT, Kyiv, Ukraine,* ***Bachynska B***, *Radiation Therapist, National Specialised Children's Hospital OKHMATDYT, Kyiv, Ukraine,* ***Duda O***, *Deputy Head of Surgery, Lviv Regional Cancer Centre, Lviv, Ukraine,* ***Brovchuk S***, *Medical Physicist, Kyiv Regional Cancer Center, Kyiv, Ukraine,* ***Suchowerska N***, *Associate Professor, University of Sydney, Australia.*

SUSTAINABLE PACKAGING a survey

Catherine Stanford-Edwards, a Clinical Scientist from Swansea Bay University Health Board, reports the findings of a packaging survey.

As a member of the newly formed IPEM Environmental Sustainability Group (ESG), I have been inspired to look for ways to improve sustainability in my department. Several members of the group have had deliveries of very small items in large boxes, surrounded by a lot of packaging which is often plastic ❶. To engage suppliers and manufacturers on this issue, I sent a survey to companies delivering to my radiotherapy department to determine what actions they are planning to take towards sustainable packaging, and whether the IPEM ESG could help facilitate changes.

A total of 13 companies were identified who regularly delivered to the department, considering physics radiotherapy equipment, engineering parts, IT equipment, planning software, and linear accelerator suppliers. The companies who responded to the survey were those with direct contacts in the organisation, those that did not respond tended to be those where a general inquiry address was used.

Survey results

Specific questions were asked to indicate the company's engagement on improving environmental sustainability, and where responses were not given their websites were searched for further information. Less than half of the companies had any online information on their sustainability views. However, the majority acknowledged in responses or online that they either had policies, strategies or targets to improve sustainability. Five companies were certified for the ISO 14001:2005 standard for Environmental Management Systems and one other respected this, but did not have certification. General comments in responses acknowledged that sustainability was something they were considering, however, there was a wide range in the level of action being taken to address this.

Actions that could be taken to improve delivered items were questioned, such as using packaging that can be recycled, carbon offsetting deliveries, optimising the size of packaging, eliminating plastic, and reusing packaging.

❶ Examples of deliveries where packaging could be improved.
Top: very large box for small item. Bottom: excessive plastic packaging

The six responders stated that they ensure packaging can be recycled (cardboard was the main focus in answers) and that the size of their packaging was being optimised. Carbon offsetting deliveries is performed by half of responders, and all companies stated they had eliminated plastic packaging or were working towards this. Reusing of packaging had a mixed response – half already did, where possible, and one was seeking to. However, two companies stated there were practical challenges around this and was not something they planned to do.

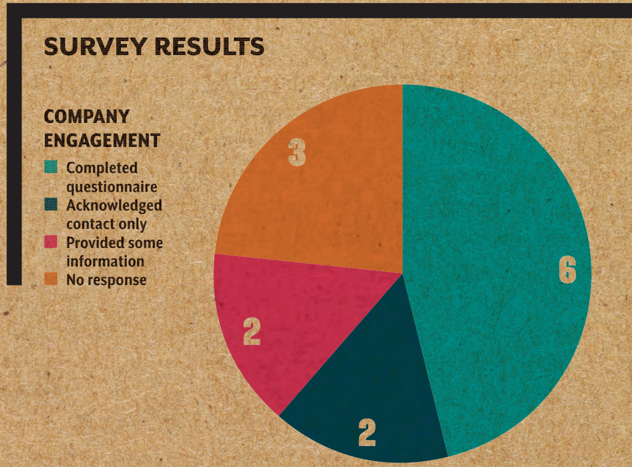
What next?

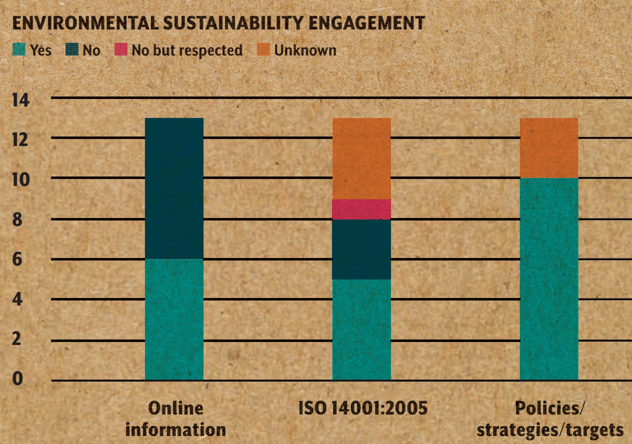
The responses overall highlight that sustainability is considered by most companies used by the department. However, only a few of the larger companies evidenced significant changes in practice to reduce their carbon footprint and improve sustainability of packaging. As many companies worldwide are now making pledges towards "net zero", this is an area that is more likely to be improved in the future. However, smaller companies with fewer resources to allocate for investigating ways of improving will inevitably lag behind. Therefore sharing ideas to improve packaging, could assist companies in reducing their carbon footprint and, most likely, the costs of delivery as well.

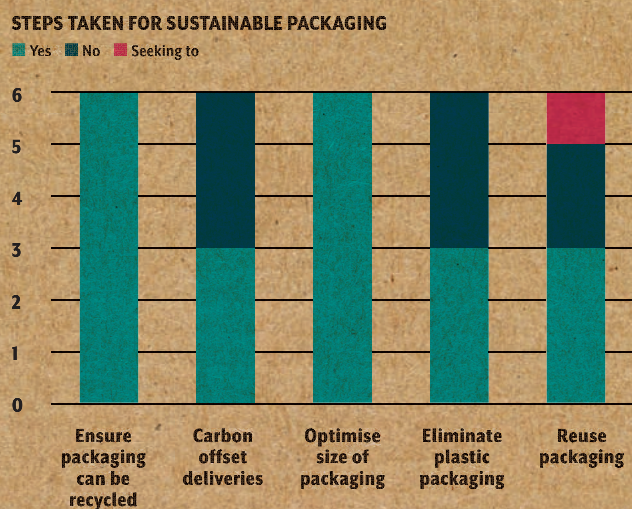
What about plastics?

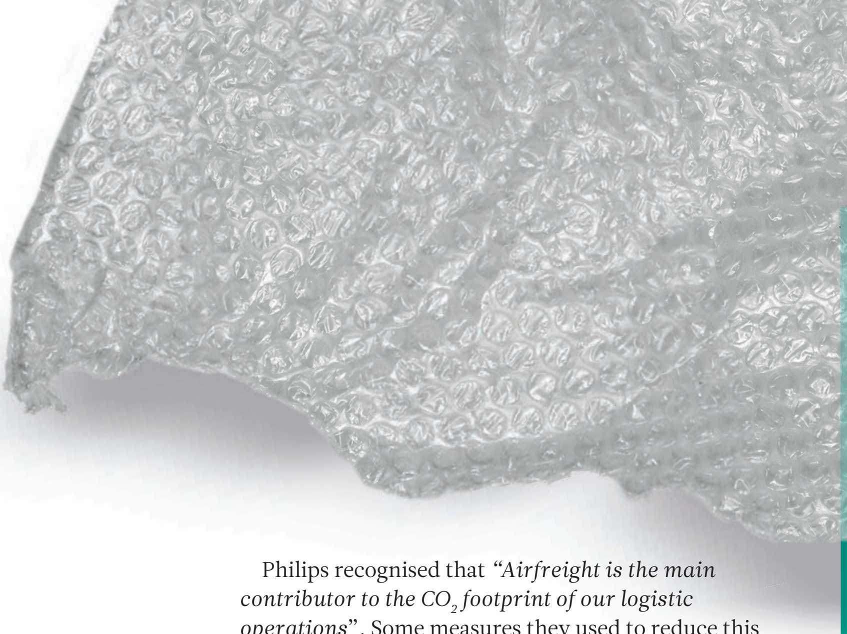
Cardboard and paper are commonly used in packaging and can be easily recycled, which appears to be routinely happening. But the use of plastics in packaging is still common, and this is a more challenging area to improve. One company pledged to use packaging that is 100% reusable, recyclable or compostable by 2025, and several stated they use no plastic packaging, so there are ways around this. Some ideas from comments from the survey

❷ Example of packaging that could be improved









include reusing plastic packaging, considering the type of plastic and whether it is bio-based, using easily available supplies, such as recyclable tape and eco packing, and to encourage the companies supply chain to reduce plastics as well.

One company stated their focus was on ensuring the packaging is suitable for the protection and storage of products, but acknowledged they recycled some cardboard packaging. The use of alternative packaging does need careful consideration to ensure the products are suitable protected. However, there are alternatives to virgin plastics that can be used effectively as well. Philips particularly engaged with the survey and shared some examples of good practice. They routinely optimise packaging for equipment and shared examples of "Eco Passports" for deliveries, covering the packaging of the item, along with the equipment's energy use, weight, substances and circularity. They summarised that they make use of sustainable materials where possible, and have requirements to minimise packaging weight and volume, and ensure suitability for reuse and recycling.

Elekta also highlighted an ongoing project aiming to re-design packaging cases for Linacs and Patient Support Systems. They summarised that by reducing the size and weight of packaging materials, and in some cases reuse packaging, they would be able to decrease the material used and also cut the carbon emissions of transport.

Delivery services

The courier or method used for transport is an area some companies have considered to reduce their carbon footprint. One company offset delivery activities using the UPS Carbon Neutral Scheme, but there are several eco delivery companies who aim to be carbon neutral by reducing their footprint and offsetting emissions through planting trees. Within the UK this is an easier problem to solve, however, many deliveries are from abroad and may be needed urgently and will, therefore, use airfreight.

IMAGES: ISTOCK, GERRY LOWE

" I WILL BE CONSIDERING ALTERNATIVE RE-USABLE SOLUTIONS IN MY DEPARTMENT

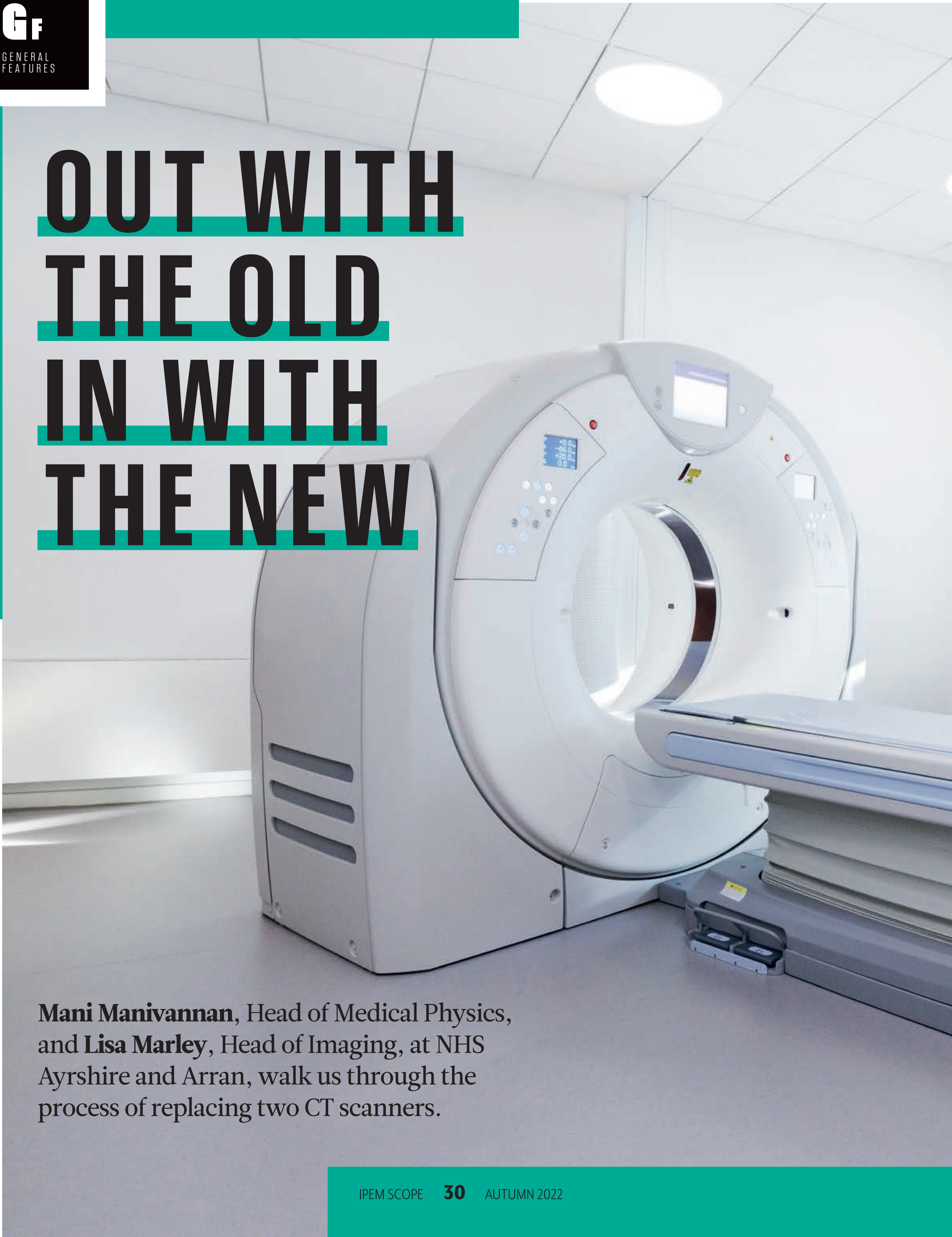
Philips recognised that *"Airfreight is the main contributor to the CO_2 footprint of our logistic operations*". Some measures they used to reduce this were multimodal shipments, transition from air to ocean freight, stricter air freight policies and optimisation of warehouse locations. Transportation by ship is still an issue, and the Clean Cargo Working Group (CCWG) was recognised as a business-to-business leadership initiative involving major brands, cargo carriers and freight, aiming to reduce the impact of shipping.

It was highlighted, however, that companies do have limited options for delivery services, particularly from abroad. Steps such as reducing packaging and electronic documentation to avoid printing were identified as useful to minimise the carbon footprint of deliveries and one company aims to encourage end-users to purchase in multiples to reduce the amount of packaging required and the impact on the environment.

Actions we can take

Next time a delivery arrives in an unnecessarily large box, or is filled with plastic packaging, I will be contacting the company to ask if this can be improved, and highlighting some of the good practices identified in this survey. Most responders did not think it would be possible for customers to return packaging for re-use at the moment, due to low numbers of shipments, different packages being used for items and limited storage in departments to store packaging. But one company did state it always looks to partner with customers to provide innovative solutions and welcome input from end-users, so I will also be considering alternative re-usable solutions in my department.

Work is also currently underway in the IPEM ESG to engage suppliers to consider alternative or reusable packaging for radioactive materials. If this is an area of interest, please contact the group through IPEM Communities of Interest. Additionally, the IPEM ESG is contacting the AXREM UK trade association (Association of Healthcare Technology Providers for Imaging, Radiotherapy and Care), which has recently launched a sustainability special focus group. Finally, I will be feeding this information back to the companies who responded to the survey, two of which expressed an interest in further engagement with the IPEM ESG.



OUT WITH THE OLD IN WITH THE NEW

Mani Manivannan, Head of Medical Physics, and **Lisa Marley**, Head of Imaging, at NHS Ayrshire and Arran, walk us through the process of replacing two CT scanners.

NHS Ayrshire & Arran (NHS A&A) covers a population of 368,000. In Ayrshire there are two acute hospitals (one at Crosshouse and one at Ayr). Arran is served by a smaller hospital providing minor emergency treatments. Any patients from Arran needing further treatment are transported by helicopter to Crosshouse.

University Hospital Crosshouse (UHC) had two Philips CT scanners that were eight years old. In September 2021, NHS A&A received funding of £1.4 million from the Scottish Government to replace the CT scanners.

Procurement of major medical equipment in Scotland requires meeting NHS Scotland procurement regulations. All capital equipment (costing over £5000) must be procured using a tender process. Fortunately, National Services Scotland (NSS) has set up a Framework for multi-modality imaging equipment that includes CT scanners and MRI scanners. This framework also includes injectors.

A project team was put together, led by the Head of Medical Physics, consisting of members from medical physics, radiology, estates, IT and infection control. Support was also provided by members from fire, health and safety and capital planning. Members from building contractor and equipment suppliers were invited to project meetings when needed and a product evaluation team was set up in the selection process.

Selection of a CT scanner make and model

The NSS framework allows either a direct selection of an appropriate make and model (within budget) or a "mini-tender" process. The mini-tender process invites tenders from all vendors (there are four in the framework) based on specifications provided by the NHS A&A selection team. As the price of equipment is fixed in the framework, suppliers are encouraged to offer anything additional that would add benefits to the patient care. See ❶ for scoring methodology used. The evaluation team consisted of two consultant radiologists and two senior radiographers with experience in using CT scanners. The evaluation team was unaware of all costs submitted through the tender. The clinical evaluation team used the scoring methodology ❷ for evaluating the products. NSS scored the service and support based on tender response. Scores

Table ❶ Scoring methodology used

Total cost of ownership	
Cost = cost of core specification equipment + cost of 10 years fully comprehensive maintenance (including tubes / detectors) + cost of turnkey work	400
Clinical and technical requirements	400
Service and support	200
Total	**1000**

IMAGE: GETTY IMAGES

were checked by the project lead. Scoring methodology for the service and support can be seen in ❸.

Evaluation process

All members of the evaluation team signed the "procurement declaration of interest form", as required by NHS Scotland procurement regulations. The CT project group reviewed various CT scanners offered by four manufacturers. Each company gave a presentation of their choice of products. The group selected four models that were expected to be suitable for our clinical needs. Site visits were arranged when needed.

The CT scanners at University Hospital Crosshouse are required to fulfil a broad variety of clinical applications, including imaging of acute stroke, poly trauma, paediatrics, cancer staging and CT fluoroscopy examinations. It is important that the chosen scanner is able to meet the needs of all these patient groups and, to some extent, be able to fulfil our aspirations for the next decade. We want to establish a cardiac CT service in the not too distant future, so it was essential that the chosen product was capable of cardiac CT imaging.

The evaluation team found that product C ❹ was best suited to fulfil our current and anticipated future needs. Although product C did not have the lowest lifetime cost it was the preferred option as the clinical scores and the service and support score were both greater than all of the other products reviewed.

Image quality is a key consideration when selecting a CT scanner, the scanner must be capable of producing high-quality diagnostic images while keeping the radiation dose to the patient as low as reasonably practicable. Product C was also capable of delivering some examinations with a reduced volume of intravenous contrast media, whilst maintaining image quality, this represents a small cost-saving in the long term. Acquisition time is also an important factor to consider, as we are frequently asked to undertake CT scanners on agitated patients or paediatric studies. Product C was also able to offer a metal artefact reduction algorithm, this is particularly useful in reducing the impact of beam hardening on image quality in the pelvic region of patients with hip prosthesis. Products B & C were able to offer a balance of all of the image quality factors and both achieved the maximum score for this aspect.

When selecting a product we also need to consider the physical aspects of the hardware and how these factors could impact on the service we deliver to our patients. Factors that directly impact patients include minimum table height and width of the scanner bore, both of these factors could potentially limit the range of patients we are able to image. The evaluation team noted the size of the scanner bore of product D was the smallest of all products assessed, this could potentially limit the imaging we are able to offer some patients. Product C was capable of adjusting the height of the patient table once the scanogram has been completed, this is a very useful tool in assisting Radiographers to ensure the patient is in the isocentre. Accurate positioning of patients in the isocentre can

Table ❷ The evaluation team consisted of two consultant radiologists and two senior radiographers with experience in using CT scanners. The evaluation team was unaware of all costs submitted through the tender. The clinical evaluation team used the following scoring methodology for evaluating a product:

Image quality – clinical	Max Score	Possible Scores			
Small liver lesion detection, small renal/ureteric calculus detection at low dose, conspicuity of sub-segmental pulmonary emboli, image quality with reduced intravenous contrast volume, image quality in obese patients, quality of iterative reconstruction images, metal artefact reduction.	**90**	0	18	54	90
Ease of use of interventional package including CT fluoroscopy.	**10**	0	2	6	10
Image quality – technical					
Low contrast resolution, body phantom scan for lesion detection, MTF, noise, artefact removal software – availability and functionality, motion correction options.	**40**	0	8	24	40
CT colonography and advanced detection software					
CT Colon software, RECIST software, co-registration and image fusion software, other software.	**30**	0	6	18	30
Gantry, tube and table					
Min. table height for patient access? Speed of table movements, Design for ease of cleaning and to reduce chance of bodily fluid ingress? Functionality and position of buttons on the gantry, size of bore, time taken for tube warm-up and detector calibrations.	**30**	0	6	18	30
Pitch options available for detectors.	**10**				
Dose minimization for staff and patients (dosimetry)					
CTDIs and DLPs for standard examinations, are all dosimetry packages available on all scan sequences such as body perfusion, CT fluoroscopy etc? Modulated exposure control? (type of system offered, ease of use, intuitive function, number of alterable parameters), iterative reconstruction (type of system offered, ease of use, intuitive function).	**80**	0	16	48	80
Image acquisition and display					
Ease of scanner console operation. Responsiveness of system when loading patient protocols. Wide choice of algorithms with fast reconstruction to maximise diagnosis, Choice of pre-programmed protocols set in an intuitive format? Ease of creating / modifying / saving new protocols. Fast multi-planar and 3D reconstructions, real time display, adaptable FOV, post-processing options including oncology perfusion in protocols.	**90**	0	18	54	90
User-friendly QA package, integration with existing systems HIS/RIS, PACs. Ease of data transfer/management, hard disc capacity, safety features – emergency stops etc.	**20**	0	4	12	20
Total Score	**400**				

Table 3 NSS scored the service and support based on tender response. Scores were checked by the project lead. Scoring methodology for service and support is as followed:

Heading	Score	
Remote servicing and updates	**20**	Yes = 20, No = 0
Servicing out of hours	**25**	Option 1: 7 days per week 8am to 8pm - 25 points. Option 2: 7 days per week but less than 8am to 8pm - 15 points. Option 3: 5 days per week excluding weekends or similar - 5 points.
Per annum downtime due to maintenance visits	**25**	8 hours or less - 25, >8 to 12 hours - 15, above 12 hours - 5.
On site response times	**30**	On site - 4hours = 30, >4h to 8h = 18, >8h-12h = 6, >12h = 0.
Applications training	**30**	Option 1: Free apps support and training while under fully comp service contract = 30, Option 2: Other = 0.
Applications training	**10**	Please provide detail of remote and telephone applications support. Remote apps available beyond 9am-5pm = 10. Remote apps available 9am - 5pm = 6 remote apps available <9am - 5 pm = 2
Number and duration of maintenance visits	**10**	Is applications support available during initial radiation physics testing Yes = 10, No = 0
Value adding proposition	**50**	Value adding proposition - based on the participating authority's requirement please present a proposal that you believe will offer additional value to the solution offered. There are two pre-requisites for any proposition to be considered by the participating authority as added value: 1. The proposition must be unique with no similar offer by any other bidder as part of their submission. 2. Evaluators must consider that the proposition does indeed provide additional value. A score of 0 points will be awarded if proposition has been deemed not to pass the aforementioned pre-requisites. If proposition passes the pre-requisites, scores will be awarded by monetary value based on price bandings as follows: £0-£29999, 10 pts, £30000 to £49999, 30 pts, £50K and above, 50 pts. Bidders should present the monetary value of the proposition that would have been payable under normal circumstances, this value must be verifiable by the authority either through framework pricing, previous quotes or standard available list prices. If no monetary value is presented by a bidder a score of 0 pts will be awarded.
Total	**200**	

Table 4 Cost and scoring analysis

CT Scanner	Total Lifetime cost	Total life-time cost score	Clinical Score	Service and Support	Overall Score	Overall score choice
Product A	£1,698,370	389	232	140	761	4
Product B	£1,850,979	357	344	135	836	3
Product C	£1,707,331	387	364	200	**951**	**1**
Product D	£1,653,420	400	292	155	847	2

help minimise radiation dose, inaccurate positioning can result in an increased tube current to ensure the resultant image noise is of an acceptable level.

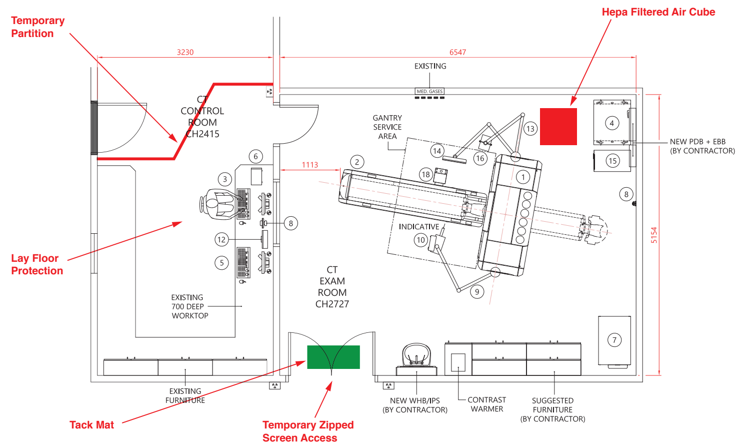
Factors that impact on staff using the scanner also need to be considered, such as how easy the equipment is to clean and how likely body fluid ingress may be. Positioning of controls and usability is important to staff who will be moving many patients in and out of the scanner each day, a low score here could have a significant impact on workflow. Product C offered a variety of essential controls on both sides of the gantry and foot pedals at both sides of the table to raise / lower. Other factors which may impact on workflow and should be considered are time taken for tube warm up and detector calibrations. Product C was the only product to score a maximum score for these aspects.

Workflow can also be impacted by the user interface, it is important the scanner console is easy to navigate with intuitive menus and layout of protocols. The review group felt some of the products contained too many steps before the scanning could be initiated, Product C offered the most user-friendly operator experience in setting up a scan acquisition.

The supplier of Product C offered free full range of consumable accessories for the life of the scanners to a value of £80,000.

Planning and installation

The CT section in Crosshouse had two Philips scanners located next to each other with a shared control area. As Crosshouse hospital is an acute hospital, we would not be able to manage with one CT scanner during the replacement of the other scanner. It is a common practice to rent a mobile CT van during the replacement period. Factors that determine this are cost and a suitable location to locate the van –reasonably close with relatively flat access. As Crosshouse hospital didn't have any CT pad area, creating a new pad area worked out to be very expensive. In addition, as the radiology department is centrally located in the hospital, close to the emergency department, a potentially suitable area for the van would be a considerable distance from the radiology department. Potential locations for the CT van were also very exposed in the likely event of inclement Scottish winter weather (please note: it is a requirement that a radiology department should have easy access to an outside area where a new CT or MRI scanner can be brought in). One of the rooms in radiology had an eight-year-old Konica Minolta static X-Ray system that was not working efficiently. It was decided to decommission this system and use this room as a temporary location for the new Canon CT scanner.



❺ HAI-SCRIBE measures

Three stages of projects	
Stage 1:	Install the new CT scanner Canon in the temporary room.
Stage 2:	Remove the old Philips CT scanner from CT room 2 and install a new Canon CT scanner in room 2.
Stage 3:	Remove old Philips CT scanner from CT room 1 and move the Canon CT scanner from temporary room to CT room 1

Preparation work before project start

In Scotland, all capital projects requiring any refurbishment work requires an HAI-Scribe process to make sure the health and safety is fully compliant. Prior to the commencement of the project, contractors provided a project plan and RAMS (risk assessment and method statement) for their work at site. In addition, the building contractor provided an HAI-Scribe room layout showing arrangements for the management of dust control for all three rooms ❺.

Due to COVID, the project team met online using MS Teams to discuss various issues, such as approval of layouts, colour schemes , furniture, radiation protection requirements, skip location, egress routes for removal of old CT scanners and delivery of new CT scanners. In addition, under health, safety and environmental requirements, CDM regulations, contractor management and induction, site rules and regulation for contractors, asbestos survey were discussed.

Management of patient data

CT images and angiography video sequences are stored in PACS. As the system is managed nationally, NHS A&A digital services require that any new system that transmits data over the network is required to meet their strict requirements for the management of data with the use of CT scanner. Staff from medical physics, radiology and Canon filled in a "compliance checklist – IT security assessment" document, which collects information on "who and how" patient data are extracted from RIS (radiology information system). These are used to combine data acquired by the Canon CT scanner and then transmitted to PACS. The Konica Minolta fixed X-ray system in the room was removed by a third party contractor free of charge. Extra radiation protection work was needed for the installation of the new CT scanner. As the current rating required for a CT scanner (160A) is higher than a fixed X-ray system (125A), a power distribution board (PDB) and an earth reference bar (ERB) were needed. Minimum room refurbishment was carried out to reduce the cost. Canon then installed the new CT scanner. Our RPA performed safety checks and a critical exam was also carried out. The room had a clinical clean. The equipment was then signed off after we accepted the electrical installation certificate from the building contractor. Application training was provided by Canon for some radiographers who were deemed as "superusers" and cascaded training to other radiographers. The new CT scanner went "live" on 21 January 2022. The cost of this part of the programme was £74,015. Hiring a CT scanner van with staffing and power generator would be £80,000-£130,000.

As part of the mini-tender process, we invited all suppliers of new CT scanners to make an offer to buy our current Philips CT scanners. A Netherlands-based company, Agito, offered to buy the two CT scanners for £58,000 and £47,000. Value of CT scanners depends on "tube count" and service records. The Philips CT scanners were in good working condition and NHS A&A had a fully comprehensive maintenance contract and maintained good records of all repairs done. Agito

"THE CT SCANNERS HAVE BEEN OPERATIONAL FOR EIGHT WEEKS, WITH NO SIGNIFICANT PROBLEMS

engineers dismantled the first CT scanner, which was transported to their store in the Netherlands.

After the building contractors spent a few weeks upgrading the room, the new CT scanner was installed. After RPA testing and accepting the room as safe for use, application training started and trained various radiographers for 10 days.

Clinical use of the equipment started on 21 February 2022. The overall cost of this part of the programme was £103,000. CT room 2 downtime during the replacement of the CT scanner was 44 days.

At this stage, we had two new Canon CT scanners working, one in the temporary room and another in room 1. The old Philips CT scanner from room 1 was uninstalled and taken away on 6 March 2022.

Once the old CT scanner was gone, building contractors took over the place for three weeks to refurbish and install new electrical switch boards and ERB. The new Canon CT scanner was then moved carefully from the temporary room to room 1. The move was planned over a weekend to minimise the disruption of very busy radiology department with waiting area in the path of the move. Once the CT scanner was moved, Canon engineers needed eight working days for the reinstallation, calibration and testing of the system. After RPA checks and a clinical clean of the room, a shorter four day application training followed.

The equipment was accepted for clinical use on 3 May 2022. The cost of this part of the project was £120,000. Downtime of CT room 1 during the replacement was 59 days.

Discussion and conclusion

Replacement of CT scanners in the busy radiology department of an acute district hospital requires a well-designed plan with full support from estates, IT and infection control. Programme duration depends of availability of building contractors who specialise in the installation of high-end imaging equipment. Location of skip should be carefully selected to minimise the access issues for contractors and disruption to patient, staff and visitors movement. Both the removal of old equipment and the delivery of new equipment should be planned over the weekend so that the loading bay is available uninterrupted for the contractors for both equipment and heavy tools. Delivery routes should be planned and agreed and on the day of delivery, NHS staff should be on site to both induct and guide the delivery personnel. Unavailability of the CT facility should be communicated to clinical staff so that any emergency scans are carried out elsewhere. Application training and certification of staff should be carefully planned and executed to comply with both IR(ME)R and IRR regulations. Remote access to the CT system by Canon engineers should be agreed and accepted by local IT department. Access to new CT data for both storing and reporting using PACS should be agreed and accepted by PACS managers. Major projects such as this will not be a smooth ride, so allowance should be made for any delays. Manager who are heading up the project should also have access to further funding, if needed, to allow for any unknown expenditures.

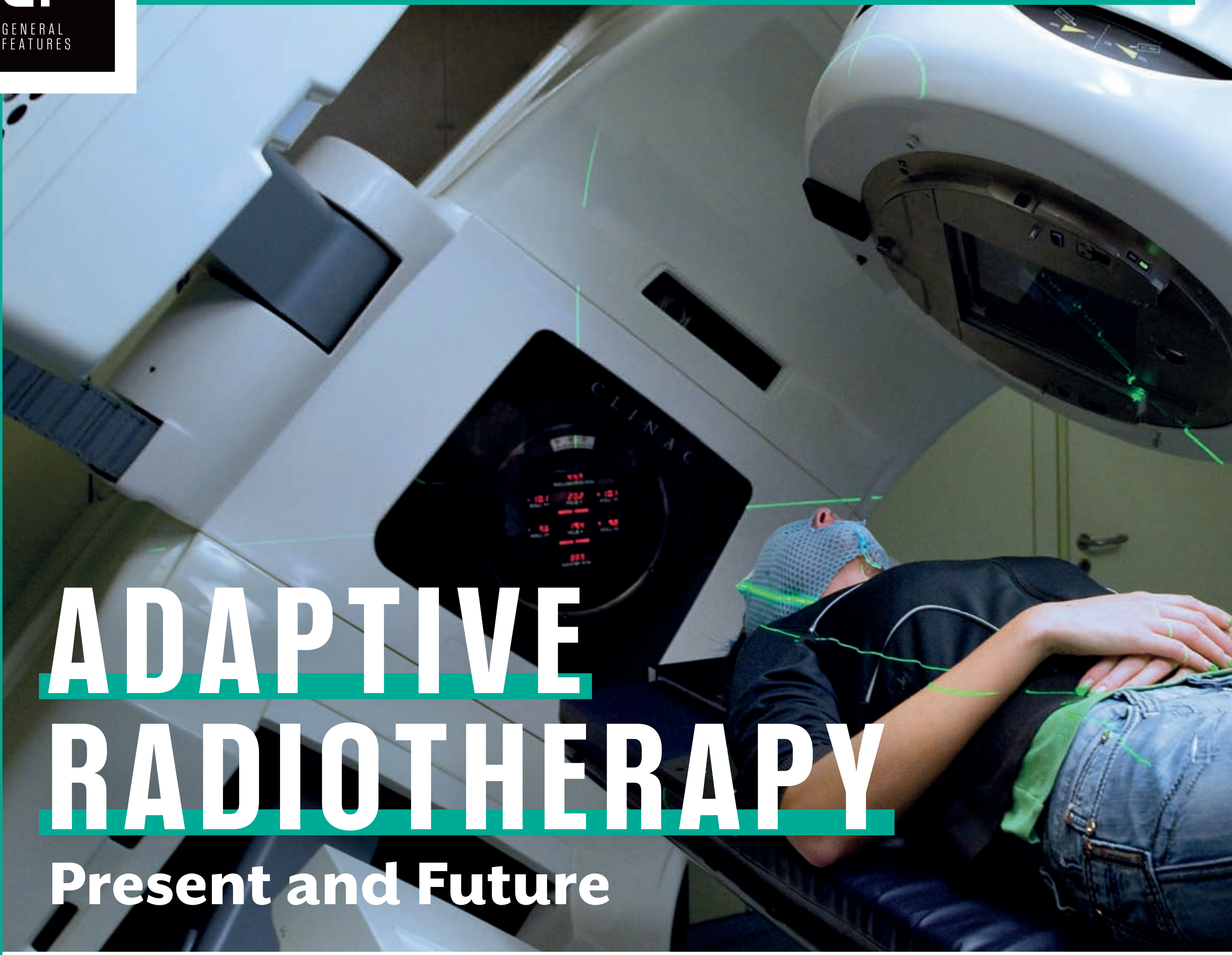
The two new CT scanners have been operational in their final locations for a period of eight weeks, with no significant problems. Staff training for some complex procedures is ongoing, but all staff working out of hours are able to deliver the wide range of examinations we require to support unscheduled care. Patients are benefiting from faster image acquisition times, which is particularly beneficial in paediatrics and trauma cases when patients may struggle to remain still.

A New scanner gantry turning a tight corner. Magnetic locks to the radiology dept were temporarily removed for the scanner on wheels to enter the dept.

B The scanner gantry is in position. Now how do we get the table in position?

C The old scanner is mounted and ready to roll.

D The new CT scanner during installation.



ADAPTIVE RADIOTHERAPY

Present and Future

Lead Research Radiographer **Helen A McNair** on the potential to further improve the delivery of radiotherapy.

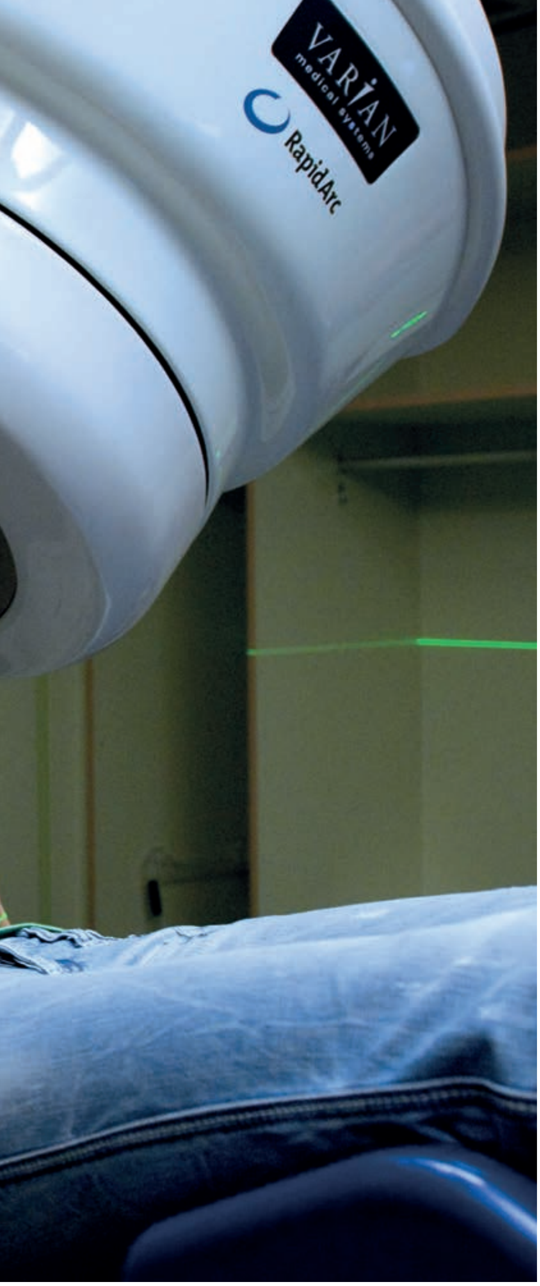
Cancer incidence is rising with around 375,000 new cases diagnosed each year in the UK. Radiotherapy will be part of a patient's treatment in ~40% of these cases. With 50% of patients diagnosed with cancer surviving, the reduction of any potential side effects is crucial. Radiotherapy is delivered usually once daily and recent trials have shown that reducing the number of treatments and increasing the daily dose (cGy) results in similar outcome and toxicity. With the reduction in number of treatments, precision and accuracy become increasingly important.

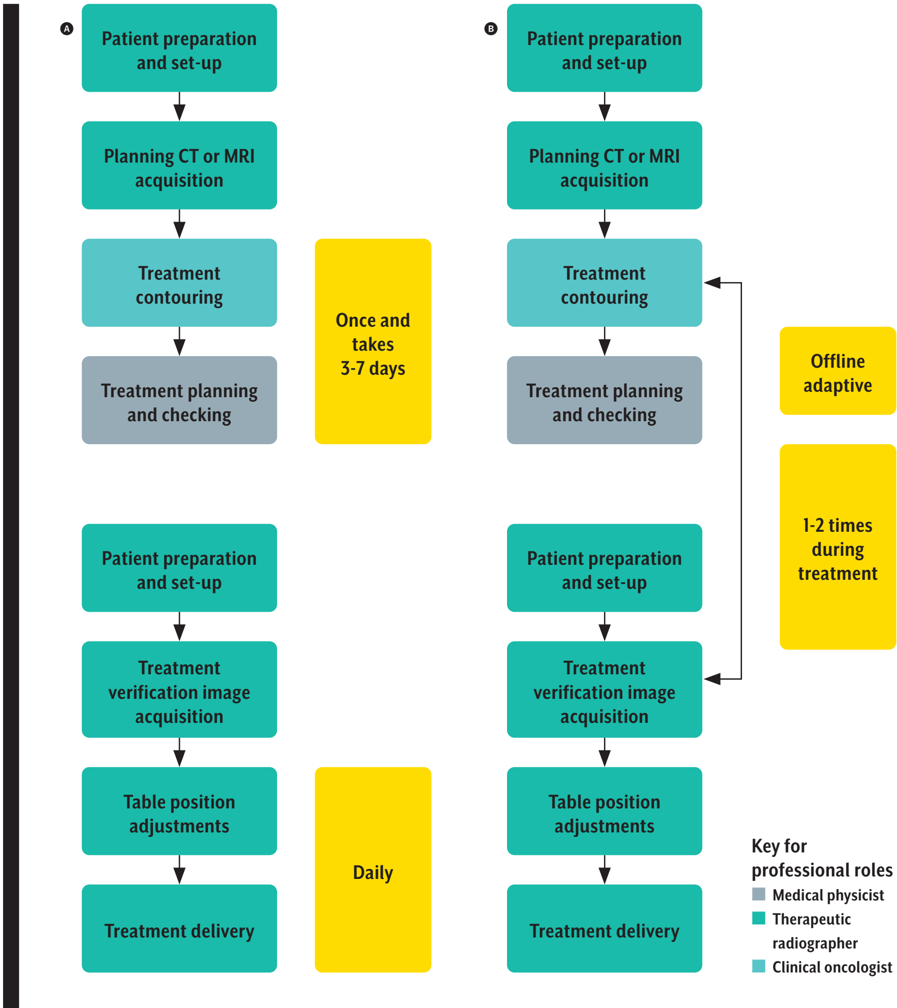
Image-guided radiotherapy

Conventional radiotherapy is planned using CT images acquired 7-10 days prior to the first treatment. The images are, therefore, a "snapshot" and subsequently, skeletal (anatomical) and internal organ position, volume and shape can all change. To compensate for anatomical changes, images are acquired immediately prior to each treatment and compared to the planning CT images. Then, if necessary, the position of the patient can be adjusted. This process is called image-guided radiotherapy (IGRT) [1].

Tumour motion is particularly common in the pelvic and abdominal regions, due to changes in volume and shape of the bladder, rectum and small bowel; this can move tumours, such as prostate, bladder, cervix or rectal, in the order of 1-3 cm. Planning or "safety" margins added to the target volume to encompass such motion increase the amount of normal tissue irradiated. The use of IGRT to increase accuracy has allowed the safety margins to be decreased, thus reducing toxicity. However, current IGRT practices only compensate for changing tumour position, not for changes in volume and shape. The latter would

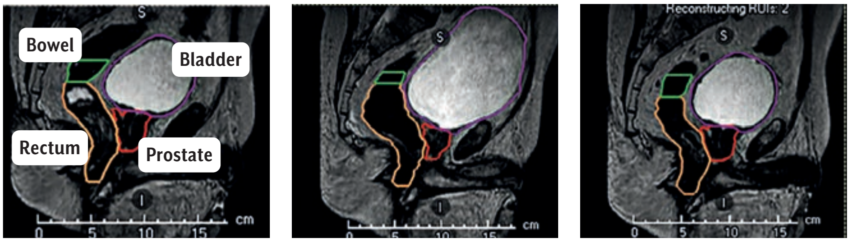
IMAGE: ALAMY





❶A Image guided radiotherapy pathway, B offline adaptive work flow

involve re-planning the treatment (adaptive radiotherapy; ART) and is currently rarely used once the treatment commences. This generally occurs only when, after review of the treatment images, therapeutic radiographers (TRs) observe excessive anatomical changes. If so, images are exported to the planning system, assessed and used to re-plan the treatment (offline ART) ❶. This process risks not identifying patients who require re-planning, incorrectly selecting some patients for re-planning, and is resource-intensive with multiple professional disciplines required.



❷ Prostrate and organ at risk (bladder, bowel, rectum) position on three different days

In bladder cancer, a prospective adaptive approach has been used where a number of plans, usually three, are created upfront, so the TR has a daily, although limited, choice, depending on the size of the bladder. This has been successfully implemented clinically but planning studies have shown that, on balance, daily re-planned treatments are likely to be superior.

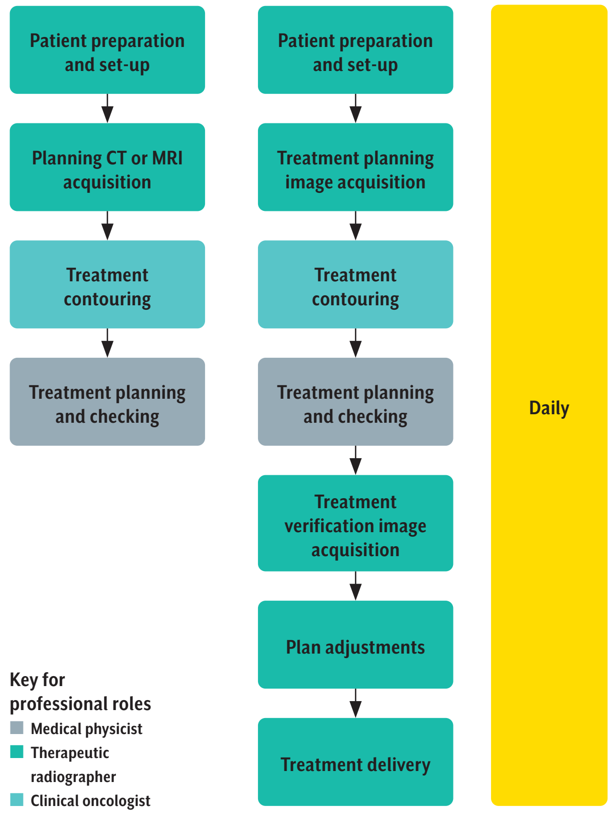
Adaptive radiotherapy

Adaptive radiotherapy was first described by Yan *et al.* in 1977 as “a radiation treatment process where the treatment plan can be modified using a systematic feedback of measurements”. The national radiotherapy action group (NRAG) described adaptive radiotherapy as “allowing the treatment set-up and dose delivered to be verified and then changed as necessary during a course of treatment". There are many other definitions but the consistent principle is to adapt to patient and/or tumour changes over time. These changes can occur during the time interval between CT planning scan and treatment, the treatment course or the treatment delivery. Figure ❷ shows an example of anatomy changes which occurred during three days for a patient receiving radiotherapy for prostate cancer. The different size, shape and position of the bladder and rectum are visible, which can affect the prostate shape. Adaptive radiotherapy aims to compensate for these changes by redefining, recontouring, the target and/or OARs. A new plan can be created to maintain the prescribed dose to the target whilst ensuring the dose to normal tissues is not increased ❸. Although currently the planning stage remains, there is potential to deliver the workflow on an adaptive system without prior planning or reference images.

Both hybrid linacs and conventional linacs have been developed to allow online ART. Early reports of MR-guided radiotherapy (MRgRT) have described a nine-stage workflow that was staff-intensive, requiring the physician and/or physicist to participate in seven stages, resulting in a median treatment time of 54mins (range 34-99mins). The TR was only active in two stages – image acquisition and treatment delivery. Waiting for staff to attend and the unfamiliarity of staff with the patient and treatment system were the main factors contributing to increased treatment times. TR's responsibilities have previously evolved to include new roles in decision-making, from evaluating treatment portal images and verification images for hypofractionated treatments to selecting the plan-of-the-day. TRs contouring the target and OARs for MRgRT has been shown to be effective in early study performed in the Netherlands. TRs at the Royal Marsden Hospital (RMH) NHS Foundation Trust have undertaken a training programme and an evaluation of contours of the target, prostate, and OARs in patients receiving radiotherapy to the prostate. The online radiographers' contours were compared to doctors' offline contours and plans were clinically acceptable. As a result TRs at RMH now perform the contouring for patients receiving 60Gy in 20 fractions. Contours are being audited and future work will include patients receiving five fractions.

The remaining task, to create a workflow similar to conventional radiotherapy, where TRs alone deliver the treatment, is that of plan creation and checking. Although this skill is taught at undergraduate level, this is usually performed by medical physicists or TRs specialising in treatment planning and located away from the linear accelerators. To enable TRs to perform planning and checking will require not only learning the skills but guidance as to thresholds of clinical goals and dose constraints for acceptable plans. Effective communication between clinical oncologists, medical physicists and TRs will be required to develop protocols to achieve this. However, problem solving will require experience, which could result in physics and oncology staff being "on call" in the early stages. To evaluate plans and images online for ART is not only a logical progression, but also a necessary step to enable an efficient workflow and allow ART to be clinically implemented.

The shift in roles will potentially increase the uptake of ART, which is essential to determine the effectiveness. Early reports have shown similar outcomes and no increase of toxicity in MRgRT treatments. Now confidence has been gained in the systems the advantages can be leveraged to potentially reduce the number of treatments required and increase dose. For example, the Hypofractionated Expedited Radiotherapy for Men With localisEd proState Cancer (HERMES) trial has opened at RMH to deliver ultrahypofractionated radiotherapy with a primary end point of short-term genitourinary toxicity. Patients are randomised between 27Gy in two fractions and 36.25 Gy in five fractions. Gastrointestinal toxicity and patient-reported outcomes measures will be measured in 46 men at 12 weeks, one-, two- and five-years post-treatment.



❸ Patient preparation and planning stage remains with daily adaptive introduced

Conclusion

Adaptive radiotherapy has the potential to improve delivery of the dosimetry to the target whilst maintaining reduced dose to the organs at risk. However, the effect on patient outcome remains to be determined. Efficient tools need to be developed to enable further investigation into the need for accurate replanning and to determine application, frequency and effectiveness on outcome.

Helen A McNair *is Lead Research Radiographer, HEE/NIHR Senior Clinical Lecturer and Reader at Royal Marsden NHS Foundation Trust and Institute of Cancer Research*

Member profile: John Boulter

I work as a Medical Equipment Specialist in Clinical Engineering in the NHS. My role involves various responsibilities, such as planned and corrective maintenance of complex medical devices and being responsible for all work required by the department regarding device alerts.

Why did you join IPEM?
I joined IPEM because I believe it is the best institute to be a part of for clinical engineering – it brings together multitudes of disciplines in one place, where we can learn, grow, and develop together.

Why did you decide to volunteer for the IPEM?
I volunteer because I want to support IPEM in delivering its mission and because I feel IPEM really wants to make a difference to the professional development of physicists, engineers, and technologists in our industry.

What sort of work are you doing for IPEM?
I work with the Communication and Engagement Committee to support them with outreach and to engage with other clinical engineers to show them what IPEM has to offer as a professional institute. While there are other engineering institutes, there are few quite so focused on our profession within the wider healthcare sector.

Tell us more about your day-to-day role, what does it involve?
My day-to-day role is quite varied. I could be working on planned maintenance, such as on critical care ventilators, or installing and setting up central monitoring on acute respiratory wards, or writing technical procedures for incorporation into our quality management system.

What is the big issue facing your profession?
Attracting new colleagues to clinical engineering – it's one of those roles that would benefit from wider outreach to show aspiring engineers that this is a career you can really make a difference in, to be part of something great, and where what you do really matters to people's lives.

Which member benefits do you value or use the most?
IPEM gives me access to really useful tools for my CPD, which makes planning and recording the work I do easy. This means that my professional progression is easy to track and develop.

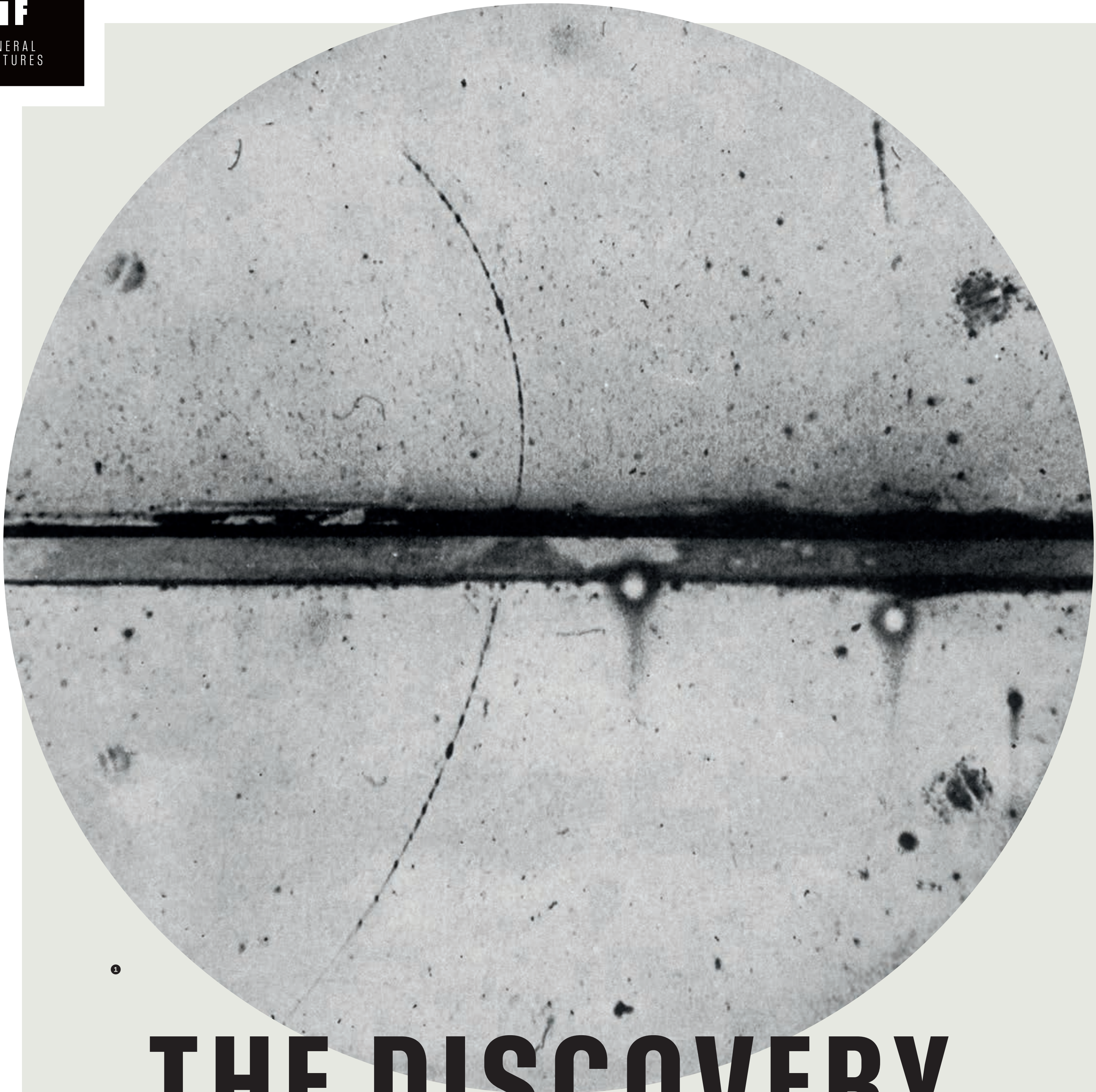
What do you enjoy the most about your work?
Being able to make a difference to patient outcomes by ensuring that medical devices work as intended, when needed, so my clinical colleagues have the equipment available to deliver the best care possible.

What do you enjoy most about volunteering?
Being able to see and speak to people I wouldn't normally have the chance to, and to give back by supporting the Institute where I can.

What do you do in your free time?
Mostly studying. Alongside my full-time role I also study full-time at the Open University for my BSc Combined STEM, although listening to Audible helps keep me going!

What has been the most valuable part of your volunteering experience?
Being able to communicate with colleagues from around the country and encouraging other clinical engineers to look at IPEM as their institute of choice.

IMAGE: ISTOCK



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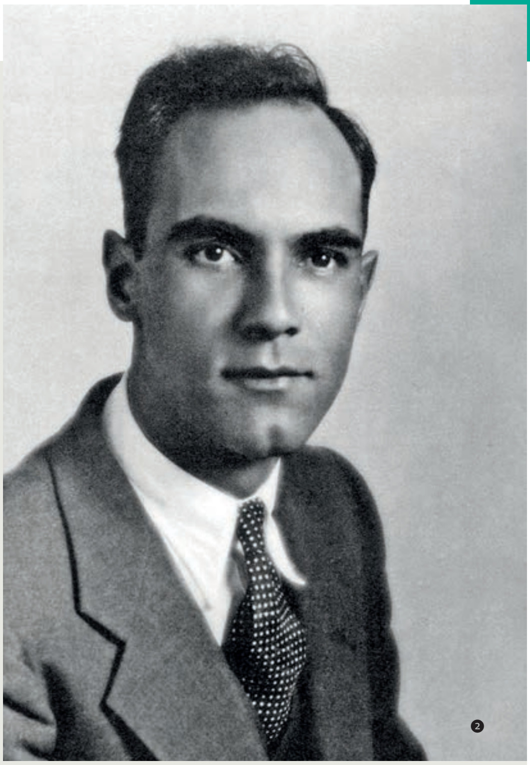
THE DISCOVERY OF THE POSITRON

On 2 August 1932 Carl David Anderson discovered the positron. Here we look back at the historic discovery and its implications, from theoretical physics and space exploration, to real-world applications and positron emission therapy (PET) scanning.



❶ First evidence existence of positron single track antiparticle of electron from California Institute of Technology; Cloud Chamber; adduced by C.D. Anderson's 1932.

❷ Carl David Anderson, working at the California Institute of Technology.

Like all subatomic particles, the positron has been around since the universe flashed into being with the Big Bang 13.8 billion years ago. From a human perspective, though, this particular particle was discovered just 90 years ago – in cosmological terms, something far less than a blink of a blink.

The possibility that this particle might exist was first posited in 1928 by the British physicist Paul Dirac ❸, who, mulling over the implications of Albert Einstein's $E=mc^2$ equation, suggested that the calculation might apply not just to a positive form of energy but also a negative one.

Even by the standards of theoretical physicists, Dirac was an eccentric character, but his extraordinary work on the theory of relativity and quantum mechanics would soon establish him as one of the most brilliant thinkers in a field of brilliant thinkers.

In 1929, pursuing his initial supposition from the year earlier, he now proposed the existence of a negative-energy counterpoint to the electron, and that this might be the proton. Robert Oppenheimer, of all people, was sceptical. It couldn't possibly be the proton, he argued, because they were proven to be much heavier than electrons, whereas Dirac's presumed mirror-image particle would have to weigh the same. In 1931 Dirac responded by proposing an "anti-electron", which would be that particle's twin in every respect, except with an opposite charge, with the consequence that should the electron and anti-electron come together, the result would be instant annihilation for both.

The Wilson cloud chamber

Dirac had effectively established a theoretical framework for the existence of antimatter. Experimental physicists found the prospect of this particle tantalising and set to work on finding the evidence to prove its existence. The key piece of equipment in this quest was the Wilson cloud chamber ❹, a sealed container of supersaturated vapour that could illuminate the brief path of ionised radiation particles. While a number of scientists came close, producing slithers of evidence but not quite putting the pieces together, Carl David Anderson ❷, working at the California Institute of Technology, was first, in August 1932, to make the vital connection. He passed cosmic rays through a cloud chamber and captured photographs ❶ that revealed the telltale trails of a particle with the precise properties of an electron but travelling in a different direction, indicating it had an opposite charge.

With that discovery, Dirac's theoretical antimatter particle became science fact. In a slightly more prosaic moment, it was the journal editor of the *Physical Review*, where Anderson published his findings, who actually christened the new particle as the "positron" – to all intents an electron, but with a positive charge rather than the electron's negative charge.

Matter and antimatter

The two key scientists received the ultimate recognition for their efforts, Dirac winning the 1933 Nobel Prize for Physics, and Anderson the 1936 prize. However, this was just the beginning. Much remained to be understood about the positron and other antimatter particles. One particular knotty issue that came to the fore was the question of the balance between matter and antimatter – an issue that continues to occupy physicists today.

According to the theoretical models, the Big Bang should have produced equal amounts of matter and antimatter: for every proton an antiproton, for every electron a positron, and so on. But given how the particles react to each other when they come face to face, if that perfect balance had existed, it would have been only for the briefest of moments, as one mass would have destroyed its mirror-opposite in an instant, leaving not a speck of dust behind them, just the afterglow of pure energy.

The evidence that this didn't happen is all around us – the stars, the sun, the earth and everything on it. In other words, the stuff that constitutes our material universe.

IMAGES: ALAMY

This is the surplus matter that the Big Bang flung outwards in every direction at dizzying speed.

Quite why more matter than antimatter was created is unclear, and it's one of the problems that physicists are still trying to solve by smashing atoms together in massive particle accelerators. Another key question is what happened to all the antimatter?

As Dirac and Anderson proved, it's there and it can be detected, but so far in vanishingly small quantities. The first explanation for the dominance of matter came in 1967 from the Russian nuclear physicist Andrei Sarkharov, who suggested three conditions for creating baryongenesis – the name for the process, whatever it might have been, that resulted in more matter (baryons) than antimatter (antibaryons). Among these conditions are that the antimatter particles would have decayed just that bit quicker than their counterparts – otherwise known as CP violation, as it upsets other laws of particle physics. The resulting imbalance may have been minuscule, but it was still enough to create everything that we can observe here on earth and in deep space.

Another theory suggests that all the antimatter that failed to obliterate us is still out there, perhaps in impossibly far-flung regions of the universe, where we might find antimatter planets, antimatter stars, antimatter galaxies. However, if this were the case, we'd be able to pick up the signature of the radiated energy created where the border of a region made of antimatter collides with a region made of matter. Instead, all is silence.

FINDING THE POSITRON

1928 Paul Dirac writes the equation that combines quantum theory and special relativity, suggesting the existence of negative energy.

1929 Russian physicist Dimitri Skobeltsyn and Caltech student Chung-Yao Chao independently observe traces of an electron-like particle in a cloud chamber. Both dismiss the results.

1931 Dirac predicts the electron has an anti-electron, identical but with a positive charge, so the two would annihilate on contact.

1932 Carl David Anderson takes photos of an electron-like particle and correctly interprets it as Dirac's anti-electron: the positron.

1951 Positron emission tomography is born, as William Sweet and Gordon Brownell suggest the radiation released by annihilating positrons can enhance the quality of brain imaging.

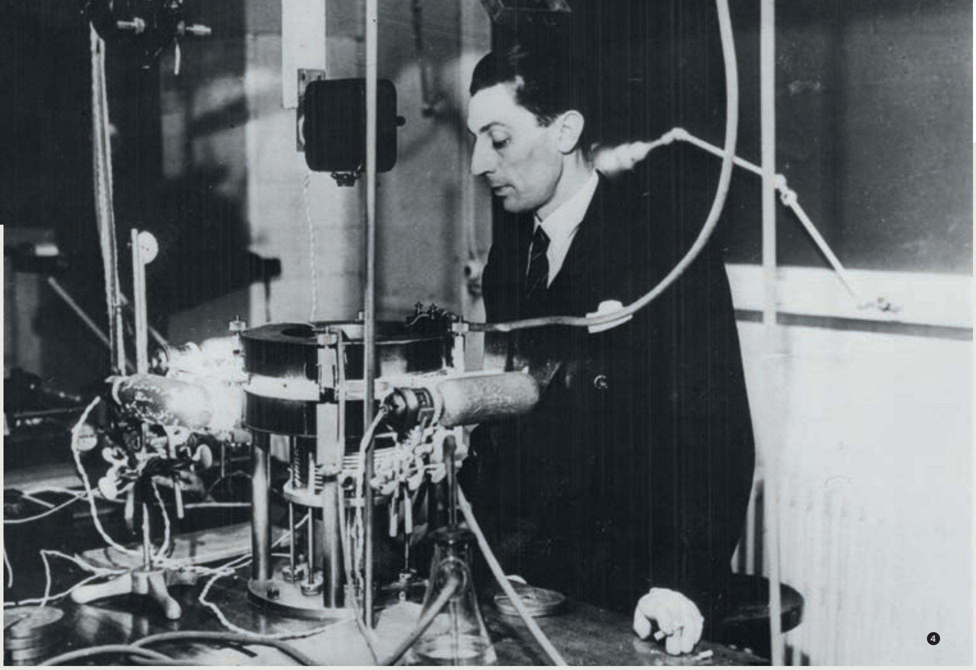
Positron production

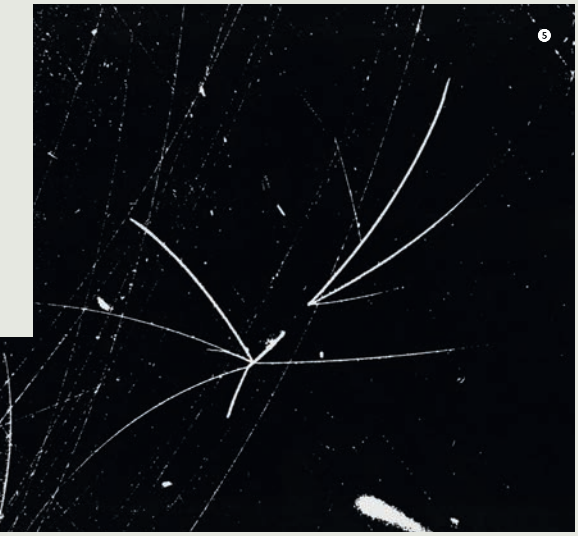
One day, perhaps, we'll be able to send a starship out to investigate, but it's a fine paradox that the only way we'd realistically be able to achieve that would be to develop an antimatter engine. It's not for nothing that any fictional starship worthy of the name is equipped with an antimatter drive of some sort – and until something even more esoteric becomes feasible, antimatter is our best hope. However, the biggest obstacle to using antimatter as a fuel is its scarcity. Out in space, positrons are found in cosmic rays, some of which make it to earth, and are possibly produced in neutron stars and black holes, and following high-mass collisions. None of which present any realistic opportunities for extraction. Here on earth, the natural sources are somewhat less exotic. In 2011 NASA's Fermi Gamma-ray Space Telescope observed brief bursts of antimatter above thunderstorms on earth, which, true to form, expired the moment they encountered any nearby matter. Much closer to the ground, an unlikely source of antimatter is the banana. This abundant fruit contains a tiny amount of the isotope potassium-40, which, as it decays, emits the occasional positron. However, the moment these particles are produced they run into a lot of banana matter, with predictable results. The slightly better news is that antimatter such as positrons can be produced artificially. The piece of equipment that


3

can achieve this is the cyclotron, a type of particle accelerator that smashes atoms together, and as the energy of the collision decays, subatomic fragments are produced. The first cyclotron was developed by Ernest Lawrence in 1930 at the University of California in Berkeley. Straight-line particle accelerators had been built earlier, but with its spiral path Lawrence's machine allowed the particles to gather more speed and so produce more energy on collision. The cyclotron soon evolved into an even more powerful variation called the synchrotron, proposed in 1944 by the Russian physicist Vladimir Veksler 6, and built just a year later, again in Berkeley, by Edwin McMillan. This closed-loop design could power collisions that created even greater levels of energy, producing more positrons and other particles. Probably the most famous accelerators, Tevatron at Fermi National Accelerator Laboratory near Chicago in the US, and the Large Hadron Collider at CERN in Switzerland, are both advanced synchrotron designs.

However, these modern feats of engineering are still no solution to the problem, as even this technology can produce only tiny amounts of antimatter.





❸ Paul Dirac, in the course of reconciling quantum theory with special relativity, predicted the existance of antimatter.

❹ Frederick Joliot-Curie in about 1930. The apparatus is a Wilson cloud chamber.

❺ The image shows two carbon and oxygen atoms breaking apart when struck by a high-energy neutron.

❻ Soviet experimental physicist Vladimir Veksler.

Just a positron here and an antiproton there, useful for research purposes but little else. The estimated cost for developing just 1g of antimatter is estimated at trillions of dollars. The logistics get even more complicated when it comes to storing positrons, which, of course, have to be kept a good distance from any electrons. This requires lots of expensive infrastructure in the form of electrical and magnetic fields and hard vacuums.

PET scanning

Away from the fields of theoretical physics and space exploration, positrons have actual real-world applications. The most common of these is positron emission therapy (PET) scanning. First described and then demonstrated in a crude form in 1953 by William Sweet and Gordon Brownell at Massachusetts General Hospital in the US, more than 60 years of intervening development has meant that this now-sophisticated imaging technique has come to occupy a pivotal position in modern medicine.

PET scans revolve around radionuclides. These are created when a radioactive atom is attached to a chemical substance that is produced naturally in an organ or tissue of the human body as part of the metabolic process. For example, the brain metabolises glucose, or blood sugar, so an atom is attached to create a radionuclide called fluorodeoxyglucose, or FDG, which is commonly used in PET scanning. Other types of radionuclide might be based on oxygen, nitrogen or carbon, depending on the part of the body that is being scanned.

Once the radionuclide is inside the body, the cells soak it up: if they are fast-growing, such as cancer cells, they take up larger amounts. The radionuclide then slowly begins to breakdown, releasing positrons. These soon encounter electrons, resulting in the usual mutual annihilation and release of energy in the form of photons – these are what the scanner is looking for. Based on this picture of the activity going on inside the body, a detailed image is produced that shows how well the organ or tissue is functioning and also highlights any abnormalities.

As well as detecting tumours in the internal organs, PET scans are also useful for looking at the effects of Alzheimer's disease, stroke and epilepsy, and for diagnosing heart disease.

Other uses

Positrons may also have a role to play in treating cancer. In 2021 an Australian team published research that suggested the positrons emitted by radionuclides could also destroy prostate cancer cells. They've named this nascent technique "positron emission radionuclide therapy".

Another real-world application is positron annihilation spectroscopy. This employs an isotope that emits positrons to create that annihilation energy, allowing scientists to study solid materials at an atomic level for weaknesses, abnormalities and other defects. The goal of exposing and exploring these minute vulnerabilities is to create stronger and more resilient matter, from building materials to computer chips.

In the 90 years since the discovery of the positron, the pace of the thinking and development around the practical applications for the particle, from looking up to the stars to looking down into the human body, has been brisk. Particularly as an energy source, the potential of the positron seems limitless. But a lot more brain-work needs to be done over the next 90 years and beyond if the potential of the positron is to be fully realised. ◘

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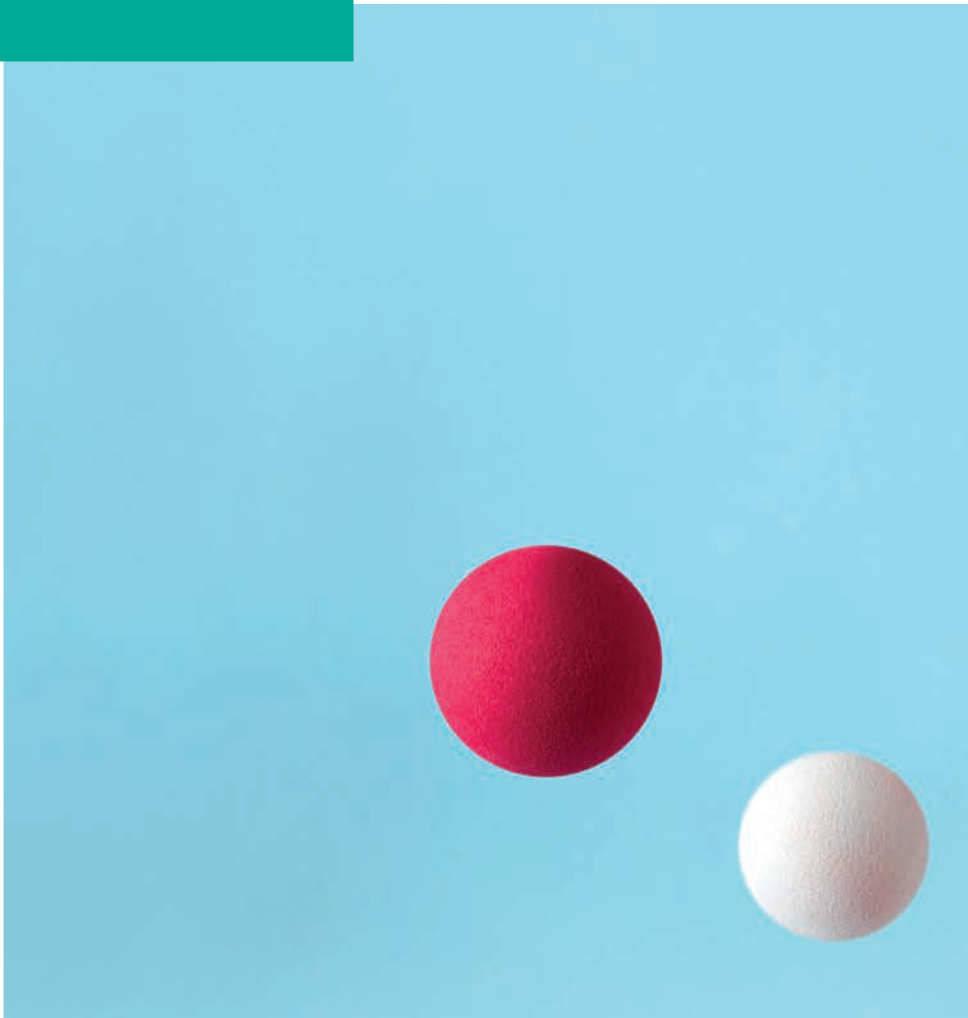
GENERAL FEATURES



IPEM SCIENCE LEADERSHIP STRATEGY LAUNCHES

IMAGE: GETTY IMAGES

We look ahead to the launch of a new IPEM strategy and outline the background and details.

In 2021 IPEM launched its IPEM 2025 organisational strategy, which committed the Institute to three areas of strategic focus, including leadership, about which it stated:

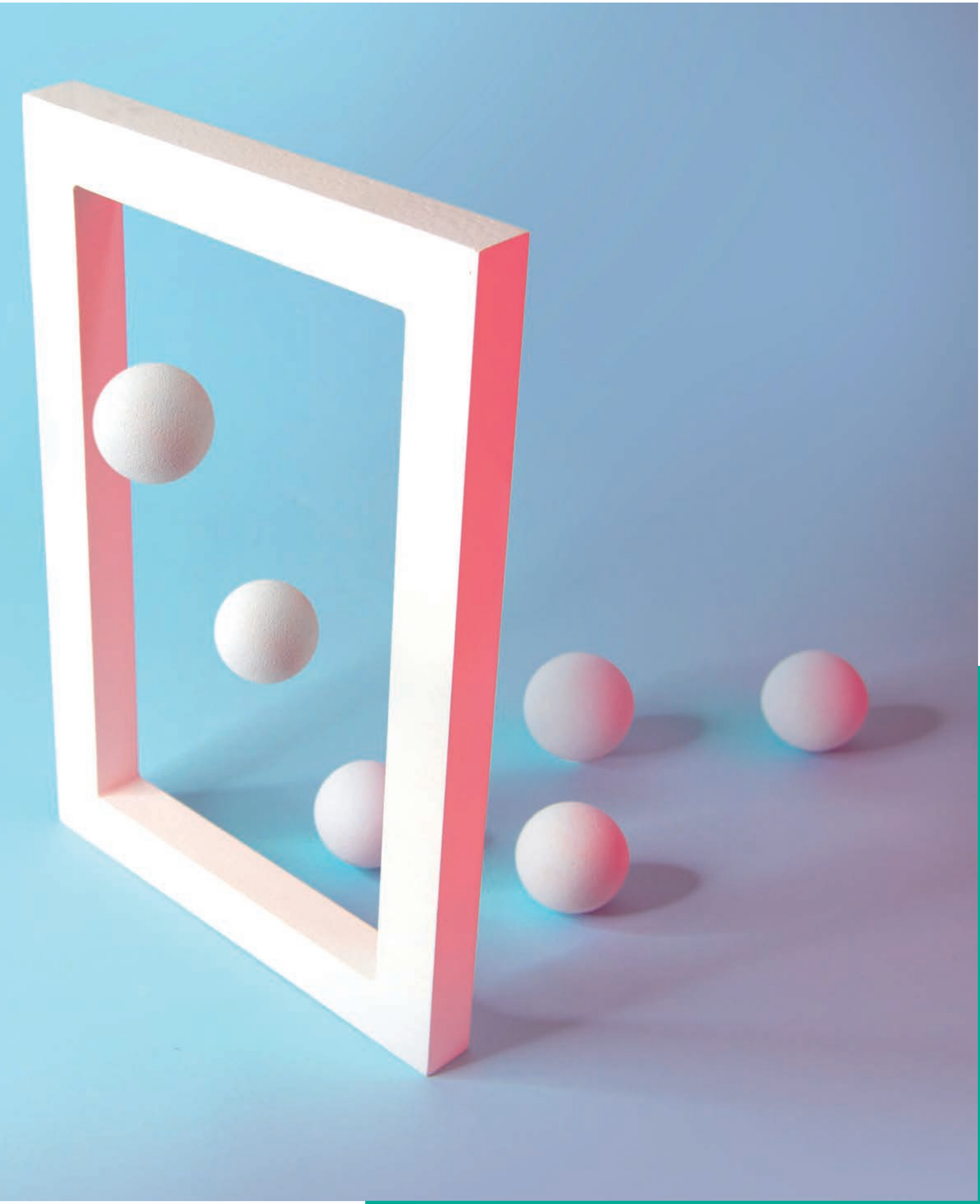
"To deliver leadership in healthcare science, we will emphasise the importance of professional knowledge and innovation, identify and raise awareness of the key challenges that lie ahead for physics and engineering in medicine and biology and be a trusted and effective voice for the profession."

Since then, detailed work has focused on developing a "Science Leadership Strategy" for physics and engineering in medicine and biology – a framework identifying the key challenges and drivers of change and anticipating how these will impact the operating environment within which our members work.

The Science Leadership Strategy will focus IPEM's activity and scientific outputs, growing our reputation and credibility and ensuring the Institute remains relevant, engaged and engaging in a fast-changing operating environment. It will be applied to both the way IPEM operates internally and how we interact externally with stakeholders across healthcare research, development, delivery and governance spheres. The strategy champions the importance of professional knowledge and innovation, identifying and seeking opportunities to lead the conversation in national and international dialogues on issues across healthcare science, as well as with the wider public on how they may be impacted.

Collaboration and research

The groundwork for developing the strategy was undertaken through direct engagement with IPEM members and volunteers from multiple disciplines, sectors and career stages, as well as through horizon scanning



activities, literature surveys and desktop research. The strategy also takes alignment with those from other organisations, such as the NHS, EPSRC and IET, into consideration, but is focused on championing the role and voice of healthcare scientists; the value of these varied roles in the health and care system of the future, and the assurances and resources that will be required.

Strategic focus

The new leadership strategy complements IPEM's 2025 Strategy, primarily seeking to address the leadership and professional development elements but also offering focus to public outreach activities and engagement with other professions. The idea is that by identifying specific challenges and trends impacting the professions, IPEM can take a more proactive approach: engaging early and leading conversations and anticipating and identifying gaps in policy and practice. This approach in turn will generate information that can be used to engage with policy and decision makers in a timely manner to ensure healthcare scientists, engineers and technologists are adequately represented and heard on the key issues. Through coordination with STERIC, (IPEM's Science, Technology, Engineering Research and Innovation Council) and SIGs (Special Interest Groups), as well as the Publications Committee, we can continue to refine the focus and identify gaps in professional knowledge within IPEM and within the healthcare sector more generally.

Dr Catriona Inverarity, IPEM's Professional Knowledge and Innovation Manager said: "As interdisciplinary and cross-functional work increases, science and engineering will be at the forefront of innovation. IPEM's broad membership can work together to shape best practice by continuing to produce high quality books, papers and statements in a proactive way so that the professional knowledge produced by our members is regarded as the first and last point of reference.

"Advances in digital capability and digitisation of healthcare will increase rate of change and mean we must change our models and workflows to lead rather than follow. Regulation and safety guidance must also keep pace with innovation

"IT IS FOCUSED ON CHAMPIONING THE ROLE AND VOICE OF HEALTHCARE SCIENTISTS AND THE VALUE OF THESE VARIED ROLES

SCIENCE LEADERSHIP STRATEGY GOALS

- Utilising IPEM member networks to respond to challenges and opportunities
- Gathering data and intelligence to identify opportunities
- Defining the role and value of healthcare sciences
- Increasing performance capability; minimising risk
- Optimising detection, diagnosis and treatment
- Developing strategies and technologies for resilience
- Aligning academia, industry and clinical practice.

Actions

The strategy is designed to be a working document, translated into actions that do not distract from the core functions of 'today', but aim to give focus and direction to how we tackle issues on a lengthier trajectory.

Actions will address preparing for and mitigating against identified grand challenges, and seeking to harness emerging trends to drive innovation, improve patient outcomes in health and safety, and address workforce issues, such as staffing levels and workload. We aim to capture and share the wealth of expertise and experience within IPEM through targeted discussions and events that provide opportunities for learning and development internally, and lead to the generation of respected, high-quality professional knowledge (in the form of books, papers, guidance and policy notes, talks and workshops) which sit at to protect patients, workforce and the reputation of health professions.

"Finally, there is an opportunity to design robust criteria and frameworks to guide the way that technology, data, data management and the ethics associated with these fields, evolve. Our new Scientific Leadership Strategy provides a sense of direction and focus to where we concentrate our efforts."

The detail

The Science Leadership Strategy is built around grand challenges, emerging trends and actions. It identifies six topics encompassing science and technology trends in healthcare, environmental and societal shifts, as well as plans for NHS transformation relating to digital and achieving net zero.

Grand challenges

Grand challenges are some of the major issues that will affect healthcare sciences in the near future. IPEM can contribute by leading the conversation, championing and lobbying for protection of services and resources to ensure healthcare science can thrive for the betterment of patient care. The grand challenges are:

Climate change

- Addressing gaps in the Greener NHS programme to plan for net-zero or true reduction, ensuring continuity of service without threat to patient access or safety
- Reduction and rationalisation of single-use items
- Carbon costing and energy costing essential services and resources
- Safe disposal of radioactive waste
- Securing sources of medical radioisotopes and rare earth elements against shifting political landscapes and attitudes to extraction.

Workforce and skills

- Demonstrating and advocating the value of physics, engineering and technology in medicine
- Technology to help ease acute and chronic staffing issues; using data to make informed recommendations
- Gap analysis of skills required in the workplace of the future, addressed through training or outsourcing
- Upskilling and reskilling existing workforce for career progression or change, avoiding "brain drain"
- Greater fluidity between disciplines and settings to promote retention of talented staff.

Safety and security

- Cybersecurity of cloud- and edge-systems, Internet of things devices and equipment requires investment in digital literacy as well as infrastructure
- Systems must be robust, interrogatable and adaptable to ensure operator and patient safety
- Planning and protecting against resource scarcity
- Management, storage and use of ever-increasing quantities of patient data from new and traditional sources
- Ensuring ethical use, transparency, privacy, accuracy and compatibility between various sinks and sources
- Increased data, and emergence of longitudinal data may expose new concerns with existing practices.

Emerging trends

Emerging trends are some of the key technologies, enabling platforms and ideas expected to make a significant impact on the health and care landscape. Harnessing these will be essential to addressing the grand challenges.

Alignment and collaboration

- Different disciplines and departments providing a seamless patient-centred pathway
- Working with outside specialisms and organisations to upskill, reskill and fill gaps
- Promoting understanding and discussion between academia, industry and the NHS to ensure clear routes to adoption and successful clinical translation.

Smart digitisation

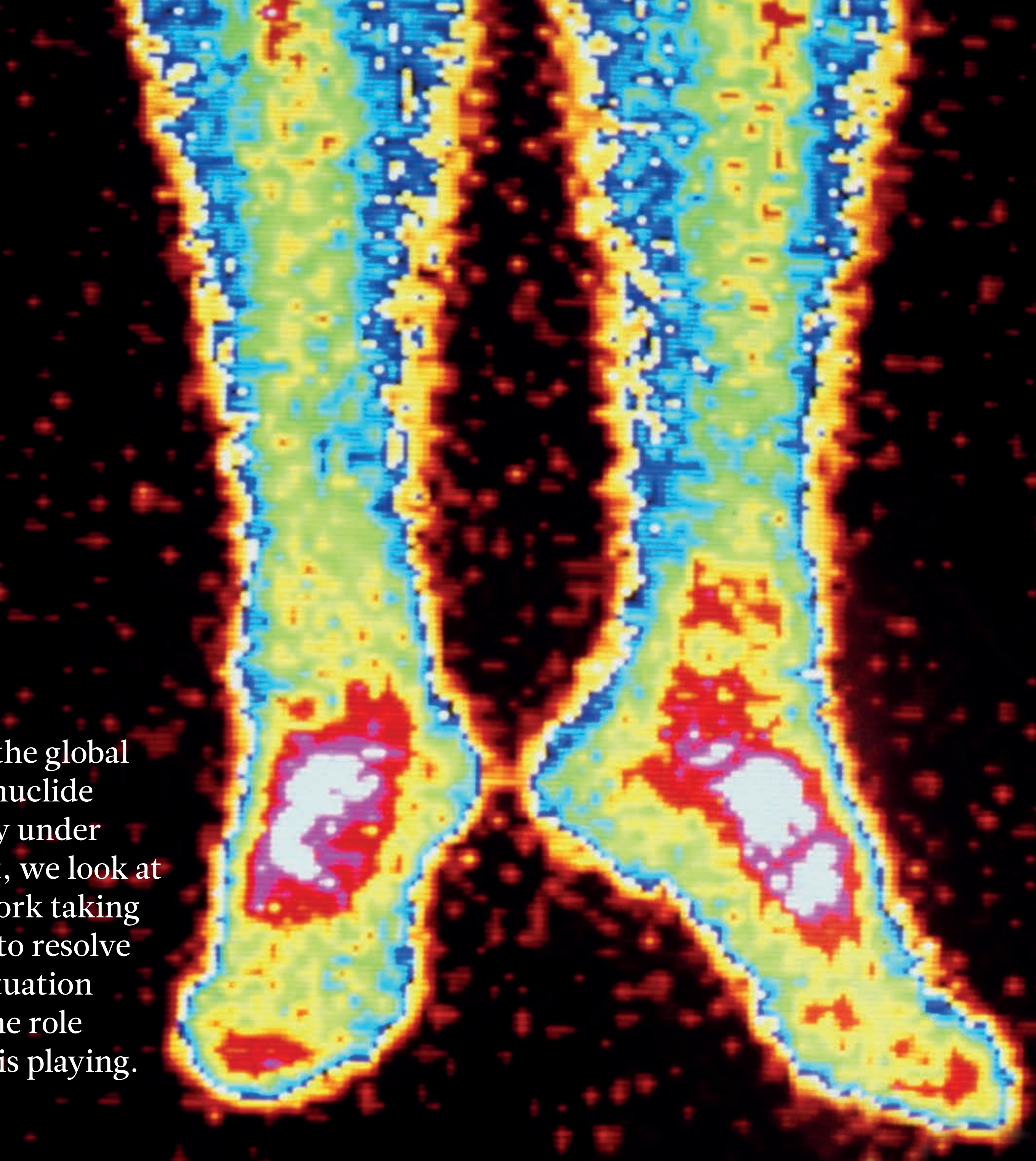
- Increased data prevalence, richness and capability from home and health settings
- The rise of AI as an enabler of workflow productivity and innovative technologies, and as a step into the regulatory unknown
- Modular capabilities offering flexibility for expansion and development to stay fresh.

Personalised health

- Empowering patients with their own health, while maintaining quality and equality of care
- Increased individual and population-scale data from wearables, sensing, biomarkers and -omics
- Combining individual data with population [data] and powerful computing drive towards preventative care.

the forefront of developments. Currently, lack of alignment and communication between sectors, disciplines and functions is a serious limiting factor. Trends such as digital health technologies or bioinformatics will require input from across IT, data science, clinical, biological and various engineering backgrounds. Many of these roles are already represented in IPEM's diverse membership so there are real opportunities to exploit new territory by strategically linking groups to address specific tasks.

Dr Robert Farley, IPEM's President said:
"The challenges and trends identified in the strategy are transformative, and the role of healthcare scientists and engineers in connection with such issues not previously explored, understood and acknowledged. However, we believe healthcare scientists should be at the forefront of thinking about and tackling such issues. Charged with identifying novel therapies and improve our understanding, rapid advances in science and technology make healthcare science one of the most exciting, challenging and rewarding areas of the NHS, industry, academia and beyond. Our fundamental involvement in monitoring, measurement, diagnostics and analysis means we are ideally placed to be at the forefront of change in healthcare in the coming decades. Alongside our overarching IPEM 2025 Strategy this is a strong platform to raise the profile of members and appreciation of the vital role they play in our ever-changing healthcare ecosystem."
www.ipem.ac.uk/scienceleadershipstrategy



With the global radionuclide supply under threat, we look at the work taking place to resolve the situation and the role IPEM is playing.

RADIONUCLIDES UK

Securing the future of the UK's nuclear medicine infrastructure

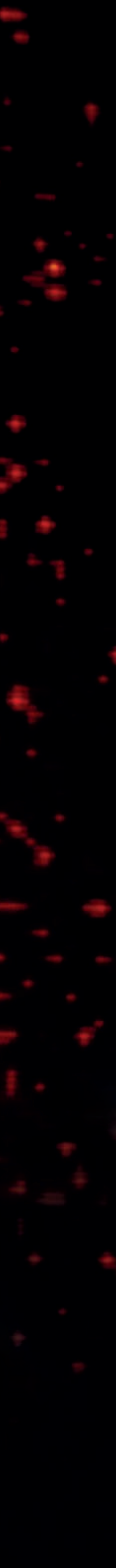


IMAGE: CNRI/SCIENCE PHOTO LIBRARY

There is an impending decline in radionuclide supply, which can cause significant challenges for healthcare and medicine in the UK. Global supply is in decline following the decommissioning of many reactors worldwide capable of producing these materials.

This shortage will have a significant impact on the UK's therapeutic and diagnostic capabilities, including for cancer patients. For some cancers, radionuclide shortages can have major consequences for individual patients. For the NHS, it could mean paying higher prices for even established treatments, with a knock-on effect on health budgets and capacity.

It will also seriously compromise the UK's research and development capacity, threatening the future of emerging treatments, such as molecular radiotherapy. This presents a major health security issue for the UK. Supply chains, already exposed as fragile following supply disruption in the aftermath of the UK's exit from the EU may be compromised further. The war in Ukraine will impact the availability of target materials for irradiation, and these factors will exacerbate the global shortage.

The UK has a viable opportunity to reverse this decline, address this shortage, and create an independent UK supplier of radionuclides. This will help realise a core objective in the Government's Life Science Vision: "[To build] on the UK's science and clinical research infrastructure' and turn the UK into a life sciences superpower."

Health Policy Partnership's *Health system readiness for radioligand therapy in the UK*, in September 2021, concluded: "Inconsistent access to diagnostic radioisotopes can make it difficult to diagnose certain cancers and to identify those who might benefit from radioligand therapy. This situation may be exacerbated if increased use of the approach is not carefully planned for."

In 2021, the government published its long-awaited *Life Sciences Vision*, setting out its aspirations for the UK to become a "science superpower" and making cancer treatment one of the core missions for investment. For the first time in a generation, there is some political appetite to explore these issues, and consider whether a UK medical reactor, with research capabilities and associated infrastructure could be a worthwhile investment to deliver against multiple government priorities, establishing the UK as a world leader in this sphere.

An opportunity for UK life sciences

This impending health crisis comes at a time when the government is also under pressure to deliver on its levelling-up agenda. A UK medical reactor would open up significant opportunities for the UK's science capabilities, vastly expanding research capacity and addressing health security issues. It would also deliver on the UK government's agenda by creating sustainable, highly skilled jobs in areas of significant deprivation and historical under-investment.

The *Life Sciences Vision* states: "The UK's research and innovation response to COVID-19 demonstrates how the country can act as a global centre for innovation when government, the sector and NHS work together. For this reason, our *Life Sciences Vision* has been co-developed by these same partners to ensure we have shared goals that can be delivered by working and innovating together."

The Welsh government has been championing the idea of creating a new research reactor in Wales at the existing Trawsfynydd reactor site. This site is now being explored as a possible location for an SMR reactor as part of the Government's new energy strategy. Wherever a potential research reactor is located, to come online by 2030 and to avoid the worst of this looming health crisis, construction must begin in the next two to three years. But a reactor is only part of the solution. The UK also needs to invest in broader supply chain infrastructure, processing capabilities and skills.

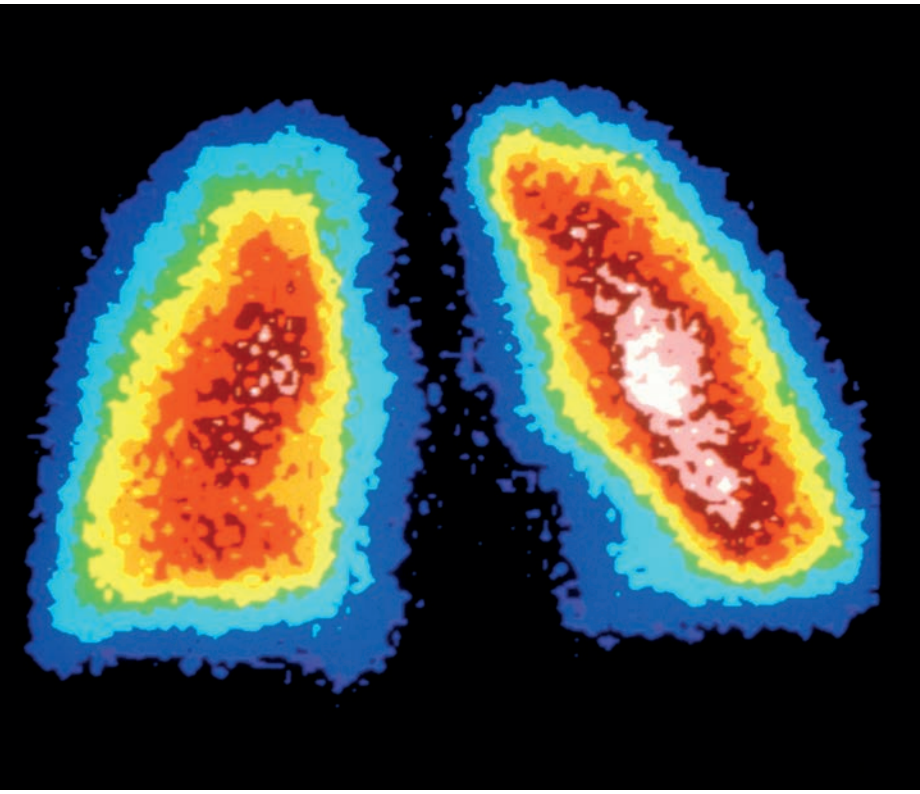
A collaborative response

In June 2022, IPEM, the Royal College of Radiologists, and the Society of Radiographers brought together a meeting of like-minded organisations, charities,

> **"THIS IS A VERY IMPORTANT ISSUE FOR THE FUTURE OF CANCER DIAGNOSTICS AND THERAPEUTICS AND HAS HUGE CONSEQUENCES FOR PATIENTS ACROSS THE COUNTRY**
>
> DR ROBERT FARLEY, PRESIDENT, IPEM

GET INVOLVED

This is a live and ongoing issue with the potential to have a transformative impact. If you are interested in contributing to discussions on this issue or in joining the coalition, contact Inflect Partners, who are providing professional public affairs support to the campaign, at **radionuclides@inflect.co.uk**.



OBJECTIVES

Create an independent UK supply of radionuclides
To combat the impact of the impending radionuclide shortage on the UK's therapeutic and diagnostic capabilities, and to help realise the *Life Science Vision* to "[build] on the UK's science and clinical research infrastructure" and to turn the UK into a life sciences superpower.

Deliver a roadmap for long-term investment in nuclear research infrastructure in the UK
Realising the potential of the sector requires a holistic approach to address short-term processing and capacity challenges as well as the longer-term ambitions of a dedicated research reactor.

Create a new research-friendly regulatory framework for nuclear medicines
Ensuring that regulation supports innovation and tackles the lack of capacity in the sector which undermines growth.

Build the case for a centralised radiopharmacy dedicated to research
Improving patient outcomes by bringing new treatments to market through investment in research-only radiopharmacy facilities.

Secure the UK talent pipeline necessary to support world leading nuclear medicine capability
Expanding training opportunities and delivering regulatory reform to allow more people to train to work in the sector.

industry representatives, and nuclear and cancer experts to discuss these issues. Attendees included representatives from the Regional Centre for Endocrinology and Diabetes, the British Thyroid Association, Neuroendocrine Cancer, Prostate Cancer UK, the Institute of Cancer Research, AXREM, Siemens, the British Thyroid Foundation, Bangor University, QM Radionuclides for Health UK, King's College London, the National Cancer Research Institute and the British Nuclear Medicine Society.

The meeting was positive and discussed forming a more formal coalition, which would conduct a campaign for a research reactor that would address domestic supply issues and establish the UK as a world leader in the field. The meeting shared the belief that the wider and political environment is ready and receptive to tackle this issue and that it is consistent with the recently published *Life Sciences Vision*, and the *10-Year Cancer Plan,* due to be published imminently.

IPEM Fellow and Head of Imaging Physics at NHS Grampian Professor Roger Staff attended the meeting on behalf of IPEM. He said: "The meeting was optimistic and constructive. The group was not naive and recognised the enormity of the project in terms of complexity and cost. The next step is to get Government(s) on board and coordinate the many diverse stakeholders to produce an achievable plan."

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> PROFESSOR ROGER STAFF PH.D. FIPEM. HEAD OF IMAGING PHYSICS, NHS GRAMPIAN

A dedicated campaign? Radionuclides UK

Conversations have continued with organisations exploring the idea of a Radionuclides UK coalition, with several commercial and not-for-profit partners already indicating a willingness to join. Alongside the formal partners, several academic or clinical advisers with

IMAGE: PROF. J. LEVEILLE/SCIENCE PHOTO LIBRARY

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INCONSISTENT ACCESS TO DIAGNOSTIC RADIOISOTOPES CAN MAKE IT DIFFICULT TO DIAGNOSE CERTAIN CANCERS AND TO IDENTIFY PEOPLE WHO WOULD BENEFIT FROM RADIOLIGAND THERAPY

HEALTH POLICY PARTNERSHIP 'HEALTH SYSTEM READINESS FOR RADIOLIGAND THERAPY IN THE UK'

expertise in nuclear medicine will support the work of Radionuclides UK as key opinion leaders. These experts will offer guidance and rigorous testing to the work of Radionuclides UK, underpin the campaign's credibility and support the wider dissemination of campaign messaging. With sufficient support, a dedicated campaign could potentially launch as soon as autumn 2022, coinciding with the early days of a new Prime Minister and refocused government.

The campaign's activities will focus on raising awareness of the issues and the campaign's objectives, whilst building relationships with critical advocates, influencers and decision-makers. Commissioning research will be crucial – in the first instance on the economic impact of investment in nuclear medicine infrastructure, including a research reactor; whilst focused policy and public affairs activity, PR and media relations, and a series of targeted events would seek to make the economic case for investment in nuclear medicine infrastructure with targeted audiences.

Dr Robert Farley, IPEM's President, said: "This is a very important issue for the future of cancer diagnostics and therapeutics and has huge consequences for patients across the country. I'm delighted IPEM, along with the RCR and SoR, has taken the lead to bring together such a wide-ranging group of organisations and industry partners to take this issue forward."

ROUTES TO REGISTRATION

Clinical Scientists

The different routes to becoming a registered Clinical Scientist are looked at by **Lauren Harrison**, IPEM's Training Development Officer, who also talks about IPEM's new Clinical Scientist Guided Training Scheme.

Clinical Scientists work closely with other healthcare professionals, in research, development, testing and maintenance of specialist medical equipment and play a central role in developing, planning, and implementing patient treatment programmes.

"Clinical Scientist" is a protected title and can only be used by those who are registered with the Health and Care Professions Council (HCPC).

There are currently several routes to registration as a Clinical Scientist, including the Scientist Training Programme (STP) operated by Health Education England, and "Route 2" through in-work training and assessment by the Association of Clinical Scientists (ACS).

IPEM currently offers the Part II Training Scheme to support those in work to reach the standards required to be successfully examined by the ACS and achieve HCPC registration. The scheme is open to those in pre-registrant Clinical Scientist roles, working with an HCPC-registered Clinical Scientist who will support them with creating a training plan, which is then submitted as part of the application to Part II.

In addition to the experience and guidance that the supervisor can offer, IPEM will also appoint an external advisor to each trainee who is individually selected based on their expertise in the trainee's field of specialisation. The external advisor will work in a different organisation and is available to the trainee for the duration of their training, including assessment.

Trainees using this route are also required to have a Level 7 (MSc equivalent) qualification. IPEM accredits degree programmes to provide prospective students with the confidence that their

BENEFITS OF THE CLINICAL SCIENTIST GUIDED TRAINING SCHEME

The Clinical Scientist Guided Training Scheme will continue to make use of all the benefits of Part II, such as the appointment of an external advisor and a training plan, whilst providing even more support. The scheme will offer more structure to trainees and include additional opportunities such as:

- A new induction day and opportunities to network
- Skills workshops supporting CPD and covering topics such as scientific report writing and critical reflection
- Case presenter sessions
- Annual reviews with external advisor
- Additional guidance and support in preparation for assessment by ACS, including a mock viva.

chosen MSc meets the expected quality and learning outcomes required for a career in medical physics or clinical engineering.

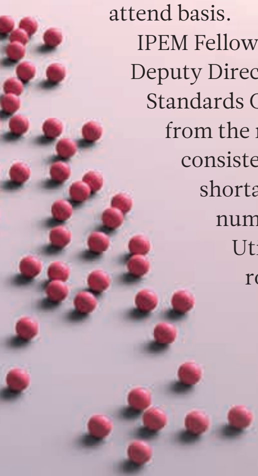
Route 2 in-work training, and IPEM's Part II training scheme as part of this, means registration is achievable in a way that is more flexible and tailored to the needs of the trainee and their departments.

Clinical Scientist Guided Training Scheme

IPEM is looking at how to enhance this training offer even further and is currently developing the Clinical Scientist Guided Training Scheme (CSGTS).

The application process and requirements for application will remain the same for the new scheme, and a charge will be introduced to cover the costs of the additional support being provided.

For those who already have the education and work experience required to achieve registration, but who perhaps just need additional guidance on their application to ACS or support in preparation for their viva, these sessions will also be made available on a pay-to-attend basis.



IPEM Fellow Professor Carl Rowbottom, Deputy Director of the Professional and Standards Council, said: "Census data from the medical physics community consistently highlights workforce shortages and the inadequate number of training places. Utilising other available routes to registration provides a complementary option to address workforce shortages.

"The Clinical Scientist Guided Training Scheme will offer essential support for physicists working towards registration as Clinical Scientists via Route 2. It provides an opportunity for medical physics departments to consider this alternative training route with the knowledge that there is significant support available from IPEM."

The CSGTS is looking to enroll the first cohort in 2023. If you would like to be the first to hear more about the scheme, contact **training@ipem.ac.uk**

IMAGE: GETTY IMAGES

● (left to right) Carl Rowbottom, Chris Walker, Zoë Davidson and Dr Marieke Van der Putten

THE EMPLOYER AND TRAINEE

The Northern Centre for Cancer Care at the Freeman Hospital in Newcastle upon Tyne is a prime example of Route 2 really flourishing, for both the employer and trainee.

IPEM Fellow **Chris Walker**, Head of Radiotherapy Physics at the centre, said: "For several years, as evidenced by the IPEM radiotherapy workforce surveys, it has been clear the more conventional STP route into the profession is not delivering enough Clinical Scientists to fill the shortfall in the radiotherapy workforce.

"Here, the Route 2 training scheme has been embraced to disrupt the bottleneck in training capacity. Temporary monies have been utilised to employ suitable candidates with the goal of achieving HCPC registration. Once appointed, trainees are highly motivated to produce their portfolio of evidence as there is always a vacant substantive post waiting for them.

"I am a true believer in the value that Route 2 brings as it allows us, as leaders in the profession, to be more proactive in delivering the workforce for the future. It also provides a methodology for attracting a different type of trainee to the profession that might be lost to the conventional STP route if they have already embarked on a research-focused start to their scientific careers.

"Not many departments have access to temporary money and centralised funding should be made available to departments to make use of this route to registration alongside the conventional STP route."

Zoë Davidson, a Route 2 pre-registration Clinical Scientist at the centre, said: "I am in the final year of my Route 2 training. So far, I have had opportunities to deepen my physics knowledge through courses and seminars, contribute to research, improve clinical practice, and further my CPD. Having these opportunities is an advantage of Route 2 that I very much appreciate."

And **Dr Marieke Van der Putten**, a Clinical Scientist at the centre, added: "Having completed a MSc and PhD prior to training as a Clinical Scientist, I felt Route 2 was the better option for me. I was able to contribute to routine and development work within my department whilst training, which enabled me to utilise the skills I had gained during my academic career. By the time I achieved my registration, I felt well prepared and was already an integrated member of the department. I really enjoyed Route 2 and would recommend it."

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BOOK PITCH

Black holes: The key to understanding the Universe

Brian Cox and **Jeff Forshaw** outline the ideas behind and the content within their new book.

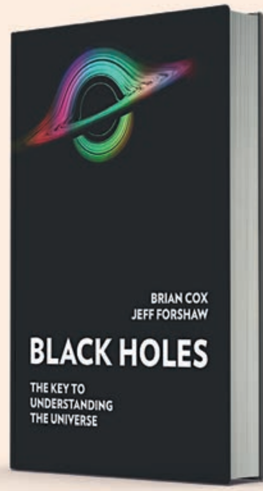
Triggered by the work of Stephen Hawking in the 1970s, present-day research into black holes has uncovered the idea that the world as we know it is a hologram, and that space is an emergent feature of quantum physics. More even, the entangled network that weaves space looks a lot like our current best efforts to build a quantum computer. There is a link, it seems, between research into quantum gravity (that bluest of blue skies research) and quantum computing. In *Black holes: The key to understanding the Universe* we present the intellectual journey from Einstein to Hawking to the current frontier of research.

The book starts out with a brief history of black holes, from the late 18th century conjectures of Michel and Laplace to the present-day observations of black hole mergers and the supermassive black hole in the centre of the Milky Way. Albert Einstein's general theory of relativity is a theory of space and time, and it predicts the existence of black holes – places where space and time are so distorted that it is possible to fit an entire other universe inside your cupped hands, linked to ours by a wormhole. We explain how. And why the centre of attraction, the spaghettifying singularity, is a moment in time rather than a place in space. We jump into a large black hole to explore beyond the horizon. A place where time stands still for those on the outside, making black holes the ultimate time machines to the future.

Mind boggling though they are, classical black holes are only the beginning. The first clue came with the discovery that black holes obey four laws that are identical to the four laws of thermodynamics. Taken together with Hawking's discovery that black holes have a temperature and can evaporate, the implication is that general relativity is underpinned by a statistical theory – just as thermodynamics is. In thermodynamics, the statistical theory is one of jiggling atoms and molecules. In general relativity, we do not yet know what is doing the jiggling but, since general relativity is a theory of space and time, the implication is dramatic: space and time are underpinned by a theory of elemental jiggling things.

> **"WE JUMP INTO A LARGE BLACK HOLE TO EXPLORE BEYOND THE HORIZON**

What is the fate of everything that falls into a black hole? Trying to answer this has fuelled theoretical research into black holes ever since Hawking. Only now do we have the answer: the information does come out. Confirmation of the holographic principle and the realisation that the inside of an old black hole is really on the outside are the clinching theoretical developments. With the holographic principle, we have come to appreciate that gravity can be traded for quantum physics – space can be traded for an entangled network of quantum bits. Quantum information and entanglement, it seems, are the tools we need to crack the puzzle of quantum gravity. The next few years promise to be a very exciting time.



Black holes: the key to understanding the Universe *is published by William Collins (£25)*

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