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THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY

advances WALES

SPECIAL BIOSCIENCE EDITION

Vital signs visualised

Welsh scientists create head-mounted display that enables medical staff to continually monitor vital signs right before their eyes

Llywodraeth Cymru
Welsh Government

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Sustainable motoring:
Hydrogen fuel cell technology for cars

"If I have seen further, it is by standing on the shoulders of giants."
Sir Isaac Newton

For advancement in science, engineering and technology, collaboration is key. Bringing together great minds sparks new ideas and innovation. This bioscience special edition of Advances Wales, launched at BioWales 2016, celebrates examples of partners working together with combined strength to achieve the level of creativity necessary for scientific breakthroughs.

Research, industry and the clinical community collaborate to develop new technology in our feature on clinical innovation (page 12). Anaesthetists are at the centre of a new technology that allows a healthcare professional to monitor patient vital signs in their visual periphery without distracting them from patient care. Leading scientific research uses genetics to accurately predict clinical outcomes (page 16), which could be used to transform cancer treatment with a personalised service in the future, and collaborative research identifying an enzyme that affects cognitive and memory disorders could lead to new treatment (page 19).

There has been a shift in the way we think about the future of energy, fuel, technology and the supply chain. Wales is pushing for an eco-friendly world, and is building towards a sustainable future with a bio-based solution for temperature-controlled packaging to transport products, such as vaccines (page 20). Engineers have created a sustainable solution for driving with hydrogen fuel cell technology for fuel-efficient cars (page 26), and processes of gasification (page 21) and biomethanation (page 22) help support renewable and sustainable energy solutions.

We hope you enjoy this edition, featuring collaborative success, scientific breakthroughs and novel technology alongside key developments for the future of Welsh health, research and industry.

Tess Coughlan-Allen
Editor

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Advances Wales is a high-quality, quarterly 'transfer of technology' journal produced by Welsh Government to showcase new developments in science, engineering and technology from Wales. Devoted to concise reports and commentary, it provides a broad overview of the current technology research and development scene in Wales.
Advances raises the profile of the technologies and expertise available from Wales in order to facilitate collaborative relationships between organisations and individuals interested in new technologies and innovation.

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Cardiff University welcomes Wales' most powerful MRI scanner

A giant £6M MRI scanner with superior power to detect disease inside the human brain has arrived at Cardiff University.

The MRI scanner is referred to as a 7T system, as the magnet inside is 7 Tesla (a unit of magnetic field strength). It will help researchers at Cardiff University Brain Research Imaging Centre (CUBRIC) study a range of neurodegenerative and psychiatric disorders including dementia, schizophrenia and depression.

The 7T weighs in at 40 tonnes and is the third of its kind in the UK. Supplied by Siemens Healthcare, it will aid the early detection of disease and the development and monitoring of new therapies.

The secret of 7T scanning technology lies in the strength of its giant magnet, which helps create more finely detailed images of the human brain, and can reduce scanning times for patients. The 7T magnet is around 7 times stronger than magnets used to pick up cars in junk yards, producing very high resolution images.

Magnetic Resonance Imaging (MRI) is a technique that shows internal body structures. It can distinguish soft tissues, and is often used to image the brain, muscles and heart. A non-invasive technique, it is now the most used imaging method in neuroscience.

COURTESY OF MAX PLANCK INSTITUTE, LEIPZIG, GERMANY

"The arrival of the 7T scanner is the next big step in the evolution of CUBRIC. It will enhance our capability for high quality research, helping us understand mechanisms of disorders such as dementia, autism and learning disabilities. Working with NHS Wales and industry helps us bring advanced technology closer to patients."

Prof Derek Jones, Director of CUBRIC

The delivery of the new scanner marks another milestone in the completion of the new CUBRIC research facility on the Cardiff Innovation Campus, due to open in Spring 2016.

www.cardiff.ac.uk

Digital health strategy for patients in Wales

Welsh patients will access their medical record online and use smartphones to manage their health as part of a new five-year digital health strategy.

'Informed Health and Care: a digital health and social care strategy for Wales' sets out the country's ambitions to improve access to patient information across health and social care and to make better use of digital technology.

By 2017, the initiative will include the launch of an online citizens portal enabling patients to view their GP medical record, update contact details and other information, view letters related to their care and carry out self-health assessments.

Later additions planned for the portal include the ability to view test results, to view which professionals have accessed the record and to share relevant information collected by the individual from devices such as wearable technology. This will be in addition to the My Health Online portal, which has been rolled out to all 458 GP practices in the country and allows NHS patients to book appointments and order prescriptions online.

'Informed Health and Care' focuses on the capability of new technologies such as smartphones and wearable devices to collect patient information, such as blood pressure, heart rate or blood sugar levels. This will provide health and social care workers with the digital tools and access to information they need to make it easy to co-ordinate care and support people in their homes or local communities.

The strategy also pledges to make free Wi-Fi available at all NHS Wales hospital sites for patients, visitors and staff.

www.wales.nhs.uk

Bevan Commission Innovators – Health Technology Exemplars

Welsh Government, in partnership with the Bevan Commission, has launched the Health Technology Exemplars programme to provide support and funding to innovative solutions developed through NHS and industry partnerships.

The programme will enable NHS Wales' staff to work in partnership with industry to implement innovative health technology in their clinical area. The aim is to improve NHS Wales' ways of working, solving health problems and improving health outcomes. The programme will also provide a mechanism to accelerate the scale up and widespread adoption of innovative health technology products and services.

Successful projects will receive enablement funding and project leads will be provided with structured coaching, mentoring and support. The programme's broader aim is to realise increased healthcare value for NHS Wales as part of prudent healthcare delivery; and to drive wider Welsh Government objectives to improve health, wellbeing and stimulate economic growth.

www.wales.nhs.uk

Wound Care Management goes 3D with GPC and Intel® RealSense™

A collaboration between GPC and Intel® RealSense, combining 3D camera capabilities with a mobile app, aims to deliver better patient outcomes, lower organisational costs and improve clinical management.

The team at GPC are utilising depth-sensing technology that records real-time data in 3D, which allows a clinician to rotate and interact with a wound image. These cameras can also enable a carer to accurately assess and monitor an ulcer. The image can benefit tissue viability experts and help clinicians record the progress or deterioration of the ulcer.

The data is taken from the camera and combined with analytical expertise to provide wound care specialists with a view that is consistent, both in terms of visual changes across time and in respect of size and colour. Additionally, the company has developed an algorithm to more accurately measure wound severity and consequently healing.

"It is the monitoring of the ulcer that is the most powerful development. After the initial assessment, the treatment can be started using locally agreed protocols and the progress of the ulcer can be accurately predicted while removing the subjective element in previous classifications. Every clinician involved in ulcer care understands this is a powerful development in measurement."

Dr Ian Wiles
Medical Director
GPC

www.gpcsl.com

£14m EU backed boost for advanced engineering in Wales

A new £14m EU-backed project to develop the next generation of leaders within Wales' engineering sector has been announced by Finance Minister, Jane Hutt.

Swansea University's Materials and Manufacturing Academy will provide training in specialist technical and management skills key to the advanced engineering and materials sector. The project will see 149 people take part in an industry-backed programme offering postgraduate qualifications including Research Masters and Engineering Doctorates.

The participating businesses will be actively involved in the programme by formulating research projects based on the technological developments taking place within their industries.

The programme will also utilise the University's new £9m Advanced Imaging of Materials (AIM) facility at their Bay Campus, which is a scientific imaging facility unique in Europe. The £450m Bay Campus opened its doors to 5,000 students in September after securing £100m of EU investment, and aims to generate around £3 billion of economic impact in the Swansea Bay region over the next ten years.

In addition to the EU investment, the project will also be financed by the participating businesses, Swansea University and the Engineering and Physical Sciences Research Council.

www.swansea.ac.uk

Diurnal's AIM-listing strengthens Wales' medtech sector

When Diurnal raised £30m following its successful Initial Public Offering (IPO) last December, it joined MedaPhor and Midatech (which acquired Q Chip) as the third company in Finance Wales' technology ventures portfolio to be admitted to the London Stock Exchange's Alternative Investment Market (AIM) in the last 18 months.

Headquartered at Cardiff Medicentre, Diurnal will use the new funds to accelerate the development of its two leading product candidates, Chronocort® and Infacort®, which target diseases of cortisol deficiency.

Finance Wales was a cornerstone investor in Diurnal and its investment first attracted the company to Wales. Finance Wales has since become a long-term backer of Diurnal, co-investing alongside IP Group and other investors. The company has also received Welsh Government funding.

Dr Melanie Goward, Deputy Fund Manager in Finance Wales' Technology Ventures team believes that the increasing number of AIM-listed companies is contributing to the strength of the medtech sector in Wales: "It's exciting to see Wales become home to listed specialty medtech companies like Diurnal, MedaPhor and Midatech. I look forward to more of the companies in Finance Wales' growing technology ventures portfolio following their example."

"We are delighted to have been able to complete our IPO successfully. The new funds will allow us to accelerate the development of our two leading product candidates, which are in, or expected to commence shortly, late-stage clinical development targeting diseases of cortisol deficiency."

Martin Whitaker
Chief Executive
Diurnal

www.diurnal.co.uk

Genesis Biosciences wins Sustainability Product Innovation award

Genesis Biosciences has won the 'Sustainability Product Innovation' category at the EDIE 2015 Sustainability Leaders Awards after creating an environmentally responsible cleaning product and delivering a genuine alternative to the harsh chemicals offered by competitors.

The winning technology was Evogen, an innovative new cleaning product that uses microbe bacteria instead of traditional chemicals. The product range delivers superior levels of cleaning through the harvesting of tailored microbes.

During the research process, target soiling was analysed and broken down into its constituents, such as protein, starch and fats. Each element was matched with a specific bacterial strain to ensure 100% efficacy. All strains were screened for compatibility to ensure they did not compete against each other.

The research findings have been applied to create a natural soil-removal system that out-performs the environmentally damaging chemicals of alternative products. All products are labelled as 'eco-benign', so in the event of a major spillage of concentrated product, the surrounding environment, animal life, flora and fauna would not be put at risk.

A key innovation with every Evogen product is the verification and independent validation of its efficacy in terms of any claim that is made. Genesis can deliver complete data files on the performance of tests in both laboratory and in-use conditions.

www.genesisbiosciences.co.uk

Building sustainably with the Eco-House Builder

Eco-friendly educational app game teaches children about building and living sustainably.

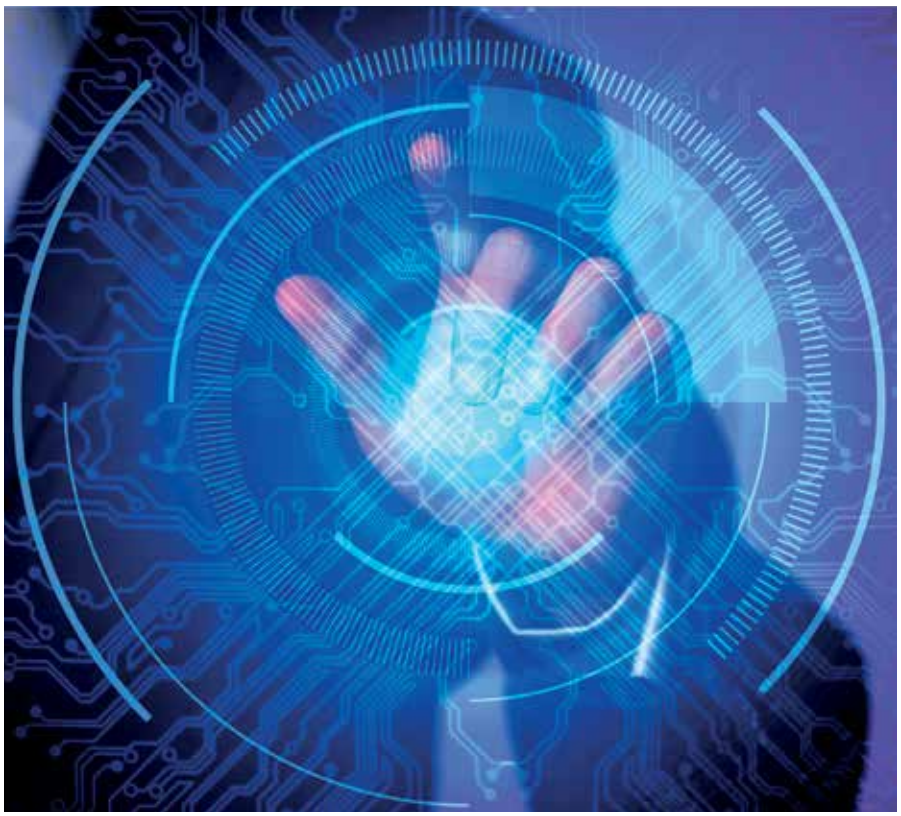
Serial property renovator and eco-enthusiast, Natalie Kober, created the educational app game and rhyme to educate children about how to build an eco-friendly house. The app includes an eco-rhyme about a quest to build a composting toilet in order to help save water and money; and help the local environment.

Natalie Kober has a desk space at Welsh ICE's entrepreneurial start-up hub in Caerphilly, which offers comprehensive support for start-up companies. She collaborated with the Centre of Excellence in Mobile Applications and Services (CEMAS) to develop the app after reading about the CEMAS app development fund in a previous copy of Advances Wales. The fund supports eligible businesses in Wales with developing new mobile applications and services.

The Eco-House Builder app allows users to read through the rhyme as they progress through the game. The game itself requires users to build an eco-friendly house by choosing which materials to use for building, for example, wood or brick; straw bales or newspaper insulation. Points are awarded for eco-friendly choices and the eco-rhyme is unlocked in full once the user has built the most eco-friendly house possible. The purpose of the app is to engage children about the realities of building and living sustainably, in a fun and simple way. It also fits in with the National Curriculum, so it is a useful aid for teachers.

www.welshice.org/member/koberland

New compound semiconductor innovation centre to come to Wales



During a recent visit to Wales, George Osborne, Chancellor of the Exchequer, announced that UK ministers would invest £50m in a ground-breaking new innovation centre in Wales. The centre will specialise in compound semiconductors, which is the technology behind devices such as smart phones.

Visiting Cardiff University, Mr Osborne said the innovation centre would bring together leading businesses, engineers and experts. The university has recently been working with IQE, a Cardiff-based semiconductor technology company, on plans for the world's first compound semiconductor technology cluster to be sited in Wales.

The chancellor called Wales an exciting, innovative nation that is home to world-class research and pioneers of technology, saying it should be at the centre of the high tech economy of the future. The location of the centre will be revealed in due course.

> "We will establish a new UK national centre – based here in Wales – that will develop the semiconductors that are at the heart of modern technology. It will be part of our network of R&D catapults. It will bring together scientists and businesses with expertise in this cutting edge technology."
>
> **George Osborne**
> **Chancellor of the Exchequer**

Dr Drew Nelson, Chief Executive and President of IQE said: "The compound semiconductor catapult will help provide the critical mass to launch the first compound semiconductor hub of its kind in the world, taking great academic research and seamlessly turning it into high-volume manufacturing, securing a global industrial and manufacturing platform for Wales and the UK."

www.gov.uk

World's first rapid testing device to identify chemicals during attack

Cardiff-based technology company, BBI Group, has developed the world's first rapid testing device to identify the chemicals used in a terrorist attack.

The company has developed a diverse range of assays for clinical, forensic, food safety, drugs of abuse and clean room applications. The team creates bespoke tests for a particular threat agent, using a variety of labelling methods; including gold nanoparticles, latex beads or magnetic particles.

The company is working with the US and UK military on the innovative device that can identify the source of a chemical attack, which could range from anthrax to smallpox. Having developed and manufactured rapid tests to detect explosives and biothreat agents, the company uses high quality antibodies and innovative sampling devices to provide a simple and fast route to accurate results.

> "If tonight there was a major incident on the New York Metro or London Underground, it would be our little device designed here in South Wales which has the test strips that will tell you whether you are in the presence of anthrax, ricin, smallpox, or whatever."
>
> **Alan Peterson**
> **Chairman**
> **BBI Group**

www.the-bbigroup.com

Swansea University to host the 2016 British Science Festival

The British Science Association (BSA) has announced that Swansea University will host the British Science Festival 2016 in September. The four-day event is one of Europe's leading and longest-established science festivals.

Vice Chancellor of Swansea University, Professor Richard B. Davies said: "We are delighted that the British Science Festival has chosen Swansea to host its vibrant celebration of science, technology and engineering. Swansea University is driving knowledge economy growth and hosting this iconic festival will be a wonderful opportunity to celebrate the power of science to deliver social and economic transformation.

The British Science Festival 2016 will focus on an audience of non-specialist adults with a broad interest in science, delivering 100 events, specially curated by the BSA in partnership with Swansea University. World-leading academics from across the UK will present, discuss and debate cutting-edge science across the scientific spectrum including technology, engineering and social sciences at a range of different events, from talks to performances.

The Science Festival will take place between Tuesday 6 and Friday 9 September and the fringe festival for families and community audiences will take place on Saturday 10 and Sunday 11 September.

www.britishscienceassociation.org/Swansea

IN BRIEF

Revolution for aerospace

Welsh scientists are set to revolutionise the global aerospace industry by better protecting aircrafts from lightning strikes. The £2.6m project is led by Cardiff University and North Wales based aircraft manufacturers Airbus, and will be funded by the UK Research Councils. Vital research will be undertaken on new and advanced materials, such as carbon fibre, for use in aircraft technology and to improve understanding of what occurs physically and chemically when a plane is struck by lightning.

TrakCel gets £315k grant

Cardiff-based TrakCel, a pioneer in cell therapy process management and supply chain integration technology, has won a £315,000 European investment to take part in a cell therapy project to help treat cancer. The company develops software for clinical trials and aims to improve the performance and safety of cellular cancer therapies. It will join forces with research groups and manufacturers for products being used to fight cancer. This news comes after the company's recent announcement that it is launching a partner services ecosystem to synergise the organisations that provide essential functions in cell therapy treatments. The aim of the Connected Services ecosystem is to accelerate cell therapy success by enhancing TrakCel's platform with links to participant firms, specialising in logistics, cell therapy manufacturing, patient treatment, storage, compliance and other essential tasks in the supply chain.

Energy Effective introduces water replacement to Wales

Energy Effective Ltd. is the first Welsh company to distribute a fluid replacing water in heating and cooling systems. Hydromx is a heat transfer fluid that has been designed to replace water or glycol mixtures in all heating and cooling systems and is hoped to become a key tool in combating fuel poverty. The invention works with nano-particle technology on a microscopic level, and use of the technology can reduce energy bills by 20-35%. The heat transfer fluid uses leading-edge technology in a specially formulated organic solution that is mixed 50:50 with water.

Flexible and lightweight Space Solar Cell

Glyndwr University's Centre for Solar Energy Research (CSER), the University of Surrey and industrial partners Qioptiq Space Technology and Surrey Satellite Technology Ltd are collaborating to develop a new solar cell technology to meet the emerging demands of future space applications. CSER's Cadmium Telluride thin film solar cell is directly deposited onto a cerium-doped ultra-thin glass that is just one-tenth of a millimetre thick. The glass is space qualified, designed to withstand the intense radiation environment and is the standard protective cover on solar panels for satellites. The ultra-thin cover glass absorbs the high intensity radiation that would otherwise darken any standard glass and damage the semiconductor layers making up the solar cells.

Smartpipe Solutions opens new software and development research centre

Smartpipe Solutions has opened its new software and development research centre in Cwmbran, South Wales, in a move backed by £6m in funding from a range of investors including Welsh Government, Notion Capital, Finance Wales and private investors. The company has recruited 13 new employees for the Welsh centre and plans to appoint more than 30 other IT engineering specialists in 2016. The company is developing new highly innovative technology and hardware to enable mobile network operators to monetise their data in real time. The solution is already being deployed by leading operators in Europe and the Middle East, and the hiring of a highly skilled product and technology team is due to play a key part in supporting the company's further expansion.

BEACON+ backed by £8 million for renewables

Backed by £8 million of EU funds, the BEACON+ project will see scientists from Aberystwyth, Bangor and Swansea University working with industry to develop renewable materials, fuels and chemicals.

Bio-refining is the scientific process of transforming plants into valuable chemicals and commercial products such as cosmetics, fuels, pharmaceuticals, textiles and health products. The funding will enable specialists in bio-refining to develop research and innovative products with 100 small and medium sized businesses in North Wales, West Wales and the South Wales valleys.

Today's investment allows the participating universities to build on the success of the first BEACON project, which created closer links between Welsh academia and industry in the area of low-carbon technology, and won the EU's prestigious RegioStars award for its contribution to sustainable growth. The project aims to create over 100 new products or processes in partnership with businesses over the next four years.

"Today's £8 million EU investment in the project is excellent news which will allow businesses in Wales to benefit from advanced scientific research to develop new products, create jobs and grow Wales' low-carbon economy."

Jane Hutt
Finance Minister

"BEACON is driven by the challenging targets for the adoption of green technologies and reductions in greenhouse gas emissions that have been set by national governments and the European Union. Low carbon technologies including bio-refining and industrial biotechnology are seen as important growth sectors and will need sustainable supply chains that will generate economic activity and jobs, and it is these that provide the focus for the work being done in and for Wales."

Professor Iain Donnison
Aberystwyth University

www.beaconwales.org

Wi-Fi specialist snapped up by listed telecoms firm

A Cardiff-based Wi-Fi experience-monitoring specialist has been acquired by listed telecommunications testing company Spirent Communications. Epitiro, which was founded in 2005, has been sold to Spirent Communications to build on the success of a strategic partnership. Communications and network testing company Spirent makes products that enable providers to proactively identify problems. Epitiro's web-based platform, which provides continuous visibility of the end-user experience, is now part of Spirent's newly formed mobility product line.

Research shows deep fjord temperatures control calving

A team of researchers led by Swansea University has found a direct link between the temperature of Arctic fjord waters and the rate at which glaciers discharge ice to the ocean. Marine-terminating glaciers gain mass from snowfall and lose it through surface melt and iceberg calving. The balance between these processes determines the rate at which ice on land contributes to sea level rise. The new research shows that where submarine melt of ice in direct contact with the ocean can keep pace with ice flow, the calving of the balance is controlled by the water temperature deep in the fjord. During a process, known as 'melt undercut calving', the ocean erodes the glacier beneath the waterline and the ice above crumbles into the fjord under its own weight.

Success for CellPath at Powys Business Awards

CellPath Ltd retained the Innovation and New Product Development Award for two cancer diagnosis products at the Powys Business Awards dinner, held at Hafren, Newtown. The company, which recently celebrated its 25th birthday, specialises in the manufacture and supply of histology and cytology products. The two winning products were the Supa Mega Mothership Cassette, which offers an innovative solution to large specimen cancer diagnosis, and the TruSlice specimen grossing system. CellPath partnered with the world renowned Guy's and St Thomas' Foundation NHS Trust to develop the TruSlice range of instruments, which allows the user to easily dissect a specimen into slices of even thickness, eliminating common problems.

International expansion for Moleculomics

For the past three years, Moleculomics has been developing Intellectual Property and delivering contract research for prestigious organisations such as the UK Ministry of Defence, Unilever and Dow AgroSciences, and has recently expanded, establishing an office in Montréal, North America. The company has experienced tremendous growth since spinning out of Swansea University's Institute of Life Science in 2012, and continues to maintain a close relationship with Swansea University Medical School. The company develops capabilities in high performance computing biosimulation tools, data resources and platforms that can predict molecular interactions.

Cardiff astronomers lead history of galaxies study

A team of international scientists, led by astronomers from Cardiff University, has unravelled the history of galaxies for the first time. Researchers discovered that galaxies could change their structure over the course of their lifetime. They also found that 83% of all stars formed since the Big Bang were in a disc-shaped galaxy, whereas today only 49% are; the rest are in oval-shaped galaxies. Professor Steve Eales from Cardiff University's school of physics and astronomy said it was the first time this metamorphosis had been accurately measured.

Bio-printing living tissue

3D bio-printers use human cells to grow tissues for implants

Plastic surgeons at the Welsh Centre for Burns and Plastic Surgery at Morriston Hospital in South West Wales are working with engineers and scientists to develop printed tissue made from human cells for the first time.

The collaboration between the Welsh Centre for Burns and Plastic Surgery at Morriston Hospital, Swansea University Medical School and the Welsh Centre for Printing and Coating aims to help patients who have lost all or part of their ear or nose through trauma or cancer to have reconstructive surgery using new tissue, grown from their own cells.

3D printing is increasingly used to manufacture prosthetics and implants from materials like plastic or titanium, but bio-printing – using human cells instead of man-made material – is still a very new science.

The process involves growing someone's cells in an incubator and then mixing them with a liquid, which is printed into a bespoke, jelly-like tissue for reconstructive surgery. The researchers have already succeeded in bio-printing small pellets of living tissue, proving the delicate cells can survive the printing process. They have also developed a jelly-like support structure, which can be used as the ink for printing the intricate shape of an ear or nose and, critically, is compatible with the human cells.

The next stage is to blend the jelly and cartilage cells together and print them into bespoke tissue for reconstructive surgery. The resulting implant will need to be strong enough to not only withstand the surgical procedure to attach it to the patient, but survive indefinitely as healthy tissue afterwards.

The team, led by Professor Iain Whitaker, consultant plastic surgeon and chairman of plastic and reconstructive surgery at Swansea University's Medical School, anticipates that real-life surgical trials could begin in three to four years. Dr Daniel Thomas, an engineer at the Welsh Centre for Printing and Coating, designed and custom made the bio-printers currently used by surgeons in the lab.

The researchers are at a relatively early stage of development and are working on growing up large numbers of cells to print larger constructs. Dr Thomas has praised the unique mix of expertise brought together in this project, saying that this collaborative approach will be continued and strengthened by the work of the ARCH Programme. ARCH (A Regional Collaboration for Health) combines ABM University Health Board, Swansea University and Hywel Dda University Health Board in a collaborative approach and a new way of thinking for health, innovation and skills across South West Wales.

> "Lots of people have heard about 3D printing, which is becoming more mainstream... but we are working on the next stage – 3D bio-printing – which is printing living tissues, living structures. We are using human cells, growing them up, to combine them with a printable material, print them and implant them into the human body."
>
> **Professor Iain Whitaker**
> **Clinical Chair in Burns & Plastic Surgery**
> **Swansea University**

Profile

Product
3D bio-printing

Applications
Growing human tissue for implants

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Face of the future

Innovative imaging solution for 3D photography developed for skin analysis and simulation

The 3D LifeViz™ Mini is a compact 3D camera for skin analysis and simulation of the face. Developed by University of South Wales spin-out Photometrix Imaging from Pontypridd, and Quantificare, from Valbonne in France, it is the first portable camera system capable of skin analysis and simulation.

The first applications for the cameras were in clinical trials for the photo documentation and measurement of wound volume, psoriatic plaques and cosmetic and aesthetic volumising effects with botulinum toxin and hyaluronic acid fillers. Augmented with a 3D simulation tool and a skin complexion analysis module, the technology has progressed and is used by aesthetic dermatologists and plastic surgeons to simulate images in 3D.

The technology uses dual beam pointers to reproduce pictures quickly, without the need for repositioning systems. The photos are automatically stitched and the patient's face is reconstructed in 3D, allowing a consultant to project the image of the patient into the future and show a simulation of the face after treatment.

The instruments are based on a particular version of stereo-photogrammetry where the 2D images are merged by a computer into a 3D representation. The technology enables quantification of volume changes and detection of fine surface details. The accuracy achieved by this reconstruction is essential for complying with the precision of the medical sector, and the photographic systems are portable and reproducible. The technology allows plastic surgeons, dermatologists and aesthetic doctors to improve their patient's follow-up care using different measurement capacities allowing before-after treatment comparison in 3D.

> "Our researchers have worked tirelessly to achieve an accurate 3D reconstruction with a reliable geometry. This 3D reconstruction is completed by 3D matching to offer high reproducibility between pictures over multiple visits and the technology enables quantification of volume changes and detection of fine surface details."
>
> **Aurore Baud**
> **Marketing & Sales Coordinator**
> **QuantifiCare**

The development of the product was a collaborative effort, with input from a range of Welsh companies aiding the process from design through to regulatory testing. Photometrix Imaging Ltd is currently working with Cardiff Metropolitan University and two Welsh hospitals to extend the application of the technology into other aspects of healthcare for the future.

Profile

Product
3D imaging solution

Applications
Skin analysis and simulation

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Vital signs visualised

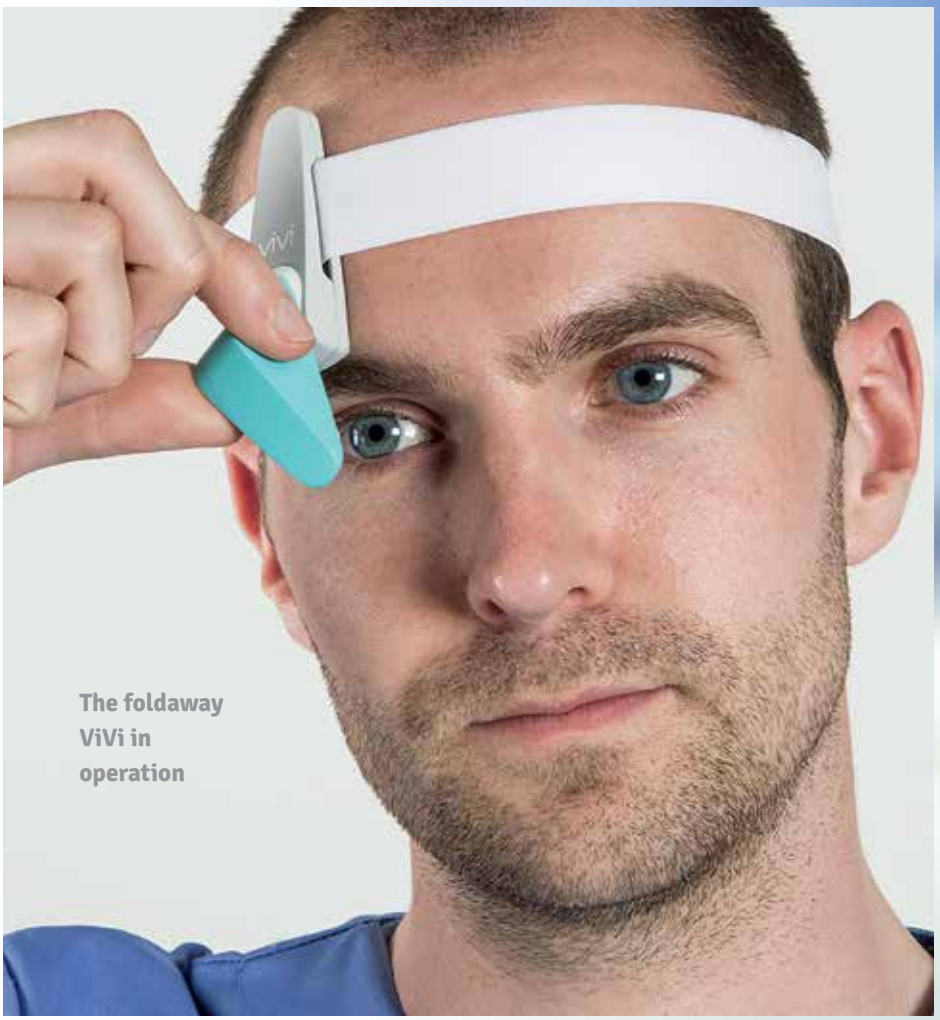
Anaesthetists from Swansea revolutionise surgical patient care with new wearable technology

Consultant anaesthetists at Morriston Hospital and lecturers at Swansea University's Medical School, Dr David Williams and Dr John Dingley founded Bay Innovations Ltd with support from Swansea Innovations and developed a new wearable technology to monitor patient vital signs.

ViVi is a head-mounted display that enables anaesthetists, nurses and paramedics to continually monitor and rapidly recognise abnormal changes such as heart rate, blood pressure and oxygen levels.

The novel foldaway product has a display that can be configured to individual requirements using a smartphone app. It connects to medical equipment via Bluetooth technology, projecting real-time patient data into the peripheral vision of a clinician's eye. The technology will help anaesthetists carry out procedures on an anaesthetised patient, such as putting in specialist intravenous lines and performing nerve blocks, which sometimes require ultrasound guidance and need full concentration.

The data is sent to the wearable device through a gateway unit based around an Intel Edison processor that plugs into the back of the medical vital signs monitor. These are typically used in operating theatres and Intensive Care units to measure blood pressure, heart rate, oxygen saturation of the blood, exhaled carbon dioxide and other parameters in real time. The gateway unit decodes the data stream coming



The foldaway ViVi in operation

"Anaesthetists carry out a number of procedures having just anaesthetised a patient that require full concentration. Clinicians are distracted from these activities by looking away to keep timely checks on a patient's vital signs. ViVi provides an effective solution to this problem, improving response time and allowing more attention to be directed towards patients and the surgical field."

Dr David Williams
Consultant Anaesthetists
Morriston Hospital

from a multi-pin connector on the rear of the vital signs monitor, extracts the key information and sends this to the wearable.

The triangular part of the wearable contains the Bluetooth receiver, processor, screen, prism and lens, and is mounted on a ball joint so it can be moved in or out of view easily. When in use, the product enables clinicians to visually perceive patient vital signs data within their field of view. This improves response time and allows more attention to be directed towards patients and the surgical field, without the clinician needing to look around for monitor screens. The display appears to float approximately 2m away from the face so the wearer does not have to change the focus of their eye from 'far' to 'near' in order to view it, and the screen layout can be altered using an app on a paired smartphone.

Dr David Williams and Dr John Dingley manufactured the first prototypes themselves, before enlisting the design expertise of Method and engineering support from GlobalLogic, to tightly craft every aspect of the product experience from the ground up and with a single, cohesive vision.

The next step for the technology is clinical testing and in-theatre action. Other potential non-medical applications include use in sports when a sports app running on a paired phone might send data on speed, distance, real-time clock or heart rate to a cyclist or runner. It is envisaged that many different mountings might be feasible, such as to a cycling helmet.

"By designing for users and not software engineers, we were able to focus on the clinician's needs. The product is smaller, lighter, cheaper, more reliable, and has longer battery life than any other head-mounted display device on the market. With universal value, this product will help healthcare professionals to save lives."

David Rajan
CTO
Method

Profile

Product
Wearable head-mounted display

Applications
Visualisation of vital signs data

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Best foot forward for haemodynamics

New vascular assessment technology designed to improve efficiency and effectiveness in delivering quality care

Huntleigh is a leading global provider of innovative medical equipment based in Cardiff, South Wales that has developed a new award-winning digital handheld Doppler for assessment of the haemodynamic system.

One of the many applications of this device is screening for peripheral arterial disease (PAD), a common circulatory problem in which narrowed arteries reduce blood flow to the limbs. If you develop this, your extremities — usually your legs — don't receive enough blood flow to keep up with demand. This can cause symptoms such as leg pain when walking (intermittent claudication), although many people have no symptoms.

PAD is likely to be a sign of a more widespread accumulation of fatty deposits in your arteries (atherosclerosis). This condition may be reducing blood flow to your heart and brain as well as your legs which could lead to heart attack or stroke.

The traditional and recommended method to screen for the condition is to measure ankle brachial pressure index, where arterial blood pressure in the ankles is

> "We have been supplying arguably the best vascular Doppler for many years. This new product, the DMX, revolutionises handheld Doppler assessment and should greatly improve clinical referrals and benefit both clinicians and patients."
>
> **Greg Baily**
> **Technical Director**
> **Huntleigh**

compared with that in the arms. Due to the difficulty in measuring blood pressure in the ankles, Doppler ultrasound is the recognised technique as opposed to the better-known stethoscope or automated blood pressure devices.

Huntleigh's new DMX device provides Doppler ultrasound with an audible representation of bloodflow. The system uses advanced adaptive filtering techniques to enhance the quality of sound - a revolutionary Dynamic Digital Noise Reduction (DDNR) system, eliminating noise and hiss caused by electronic thermal effects and crackle noise when moving the transducer searching for blood vessels. This facilitates the assessment of small and diseased vessels.

Additionally, it uses state-of-the-art signal processing to provide peak frequency bi-directional waveforms on a colour graphic display, incorporating algorithms that optimise their presentation. This gives the clinician objective evidence to assist in the diagnosis of vascular disease that other Dopplers may find difficult or impossible to achieve.

Patients with diabetes can suffer from calcified arteries in the lower limb, making them incompressible and resulting in false measurements. In patients with chronic swollen limbs (lymphedema), the limb can be incompressible and the arteries hard to identify. For these patient groups, a toe pressure is often used, although this can be an extremely difficult measurement to make. This device incorporates an optical sensing system (arterial photoplethysmography or APPG) and pressure sensing in order to readily measure blood pressure in the toe, this provides a far quicker and more accurate measurement than Doppler.

These features and measurement techniques have previously only been available with large and expensive desktop laboratory systems.

The design uses USB and Bluetooth communication channels for transfer of electronic records to computer systems, allowing reports to be easily created. Measurements can also be stored on the device or an SD card for later review or transfer to a computer. The device can also be useful as an educational resource tool; using pre-stored files on the SD card to demonstrate the relationship between Doppler waveforms and sounds for teaching and training purposes.

In the future, the noise cancellation techniques will be adopted in other products including fetal monitors. The handheld unit will be further developed for assessment of pregnancy, using the colour graphic display for large fetal heart rate numbers and to display and record a mini cardio-graph. Using apps for smartphones, the unit could communicate wirelessly from remote community sites to central servers for remote expert analysis.

Profile

Product
Vascular assessment technology

Applications
Screening for peripheral arterial disease

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Genetic predictions

New research shows cancer prognosis is written in the genes

Cardiff-based TeloNostiX has developed a test that provides a step-change in the ability to accurately predict the clinical outcome for several common cancer types at the individual patient level.

People with a diagnosis of cancer face an uncertain future; despite significant advances in treatments, patients have mixed survival outcomes. Some patients do not respond well to therapy and succumb rapidly to their disease, whereas others can live treatment-free lives for decades with a diagnosis of the same condition. This presents a significant health challenge, as the current prognostic tools are not reliable enough to aid accurate clinical decision-making.

New prognostic tools are urgently required to allow doctors to choose the appropriate course of treatment at diagnosis, tailored to a personalised clinical strategy for each patient. This would result in more efficient use of healthcare resources and judicious use of treatment options.

Chromosomes are thread-like structures made of protein and a single molecule of DNA. Passed from parents to offspring, DNA contains the specific instructions that make each type of living creature unique.

> "Our tests provide precise prognostic information that will allow cancer patients and their clinicians to make informed choices about their treatment options. We are looking forward to making the test available to patients in the near future."
>
> **Professor Duncan Baird**
> **Scientific Director**
> **TeloNostiX**

Building on novel research findings from Cardiff University that were previously featured in Advances Wales (p10, issue 75), the technology to determine telomere length, known as single telomere length analysis (STELA), was developed to allow researchers, led by Duncan Baird, to study the fundamental biology of how telomeres become short and dysfunctional.

STELA was used to analyse how the cells of patients suffering from Chronic Lymphocytic Leukaemia (CLL) have divided. Researchers found that all of the patients with late stage disease displayed very short telomeres in their cancer cells. Patients with early stage disease that had not yet clinically progressed displayed a range of telomere lengths, some with essentially normal telomere lengths and others with telomeres that were as short as those observed in patients with late stage disease.

Based on these observations, the researchers hypothesised that telomere length might predict which early stage patients would progress to a more critical stage. Prognosis based on using defined telomere length ranges to observe when telomeres had become dysfunctional allowed accurate prediction of clinical outcome, defining which patients with early stage disease would progress and die of their disease (13% survival at ten years) and which would not (91% survival at ten years).

STELA is unique in its ability to detect telomeres within the length ranges at which they become dysfunctional and capable of fusion to other chromosomes. This fusion leads to the large-scale genomic mutations and play a key role in driving tumour progression. TeloNostiX has now developed STELA into a high-throughput system to allow for large scale clinical testing.

This technology allows experts to identify the tumours with short dysfunctional telomeres that are capable of fusion, genomic instability and rapid disease progression; and tumours with long functional telomeres, a more stable genome and less disease progression. Therefore, the technology can determine which patients will develop the most aggressive disease.

In the future, TeloNostiX is hoping to expand its work to examine the ability of its technology to predict response to treatment. Having already proven that its tests predict the response to standard chemotherapies, this technology could be used to identify which patients will require treatment and could be a crucial tool for targeting resources to the patients that need them.

Short **telomeres** can be dysfunctional and could fuse with one another. Cancer patients that have tumours with short telomeres are more likely to suffer from genomic instability and rapid disease progression.

A **telomere** is a region of sequences at each end of a chromosome, which protects the end of the chromosome from deterioration or from fusion with neighbouring chromosomes, protecting our genetic data.

Profile

Product
Single telomere length analysis (STELA)

Applications
Accurate prognosis for personalised cancer treatment

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Non-toxic crop protection

Environmentally friendly microorganisms used as bio-pesticides to protect crops from insect damage

Bionema is a spin-out from Swansea University, driven by Dr Minshad Ali Ansari and a team of experts with extensive experience in applied entomology and microbial biotechnology.

The company specialises in chemical-free crop protection to reduce the use of synthetic pesticides, which harm the environment and negatively impact on human health.

Researching and developing environmentally friendly and naturally occurring microorganisms (bacteria, fungi and nematodes) as bio-pesticides, the team aim to protect crops from insect damage, enhance global food safety and security and increase crop yields.

The team has developed an eco-friendly, non-toxic bio-pesticide that is a cost effective technology, based on a natural microorganism insect-pathogenic fungus called Metarhizium anisopliae. The bio-pesticide is either applied to the soil or foliar sprayed onto crop leaves; a simple and user-friendly application.

Many insect species and pests are particularly susceptible to infection by naturally occurring, insect-pathogenic fungi, which invade insects by attaching to their cuticle or 'skin', where it can penetrate the exoskeleton. Once inside the insect, the fungus rapidly multiplies throughout the body and kills the insect.

The technology could be used to help protect strawberries from Western flower thrips, a pest insect in agriculture that has developed resistance to insecticides and is difficult to control because adequate and reliable biological controls are not available. In 2013, Western flower thrips caused crop damage of more than £15 million to high value protected strawberries in the UK, with worldwide direct damage in excess of £5 billion per annum.

Currently used chemical pesticides are harmful to humans and the environment, so a natural pesticide provides a solution for an important crop protection problem in primary horticultural food production worldwide. This technology will lead to a substantial reduction in crop losses in strawberries and can be applied more widely to protect other high-value crops across Europe, North America, Canada and Asia in future.

Adult thrips killed by fungi

The technology can be adapted for both conventional and organic markets using a non-toxic, bio-based material, found within a natural organism. The intelligent pest control technology can be used in agriculture, horticulture and forestry and offers competent and inexpensive solutions for a wide range of pest control.

Metarhizium anisopliae is a fungus that grows naturally in soils throughout the world and causes disease in various insects by acting as a parasitoid

Profile

Product
Non-toxic bio-pesticides

Applications
Environmentally friendly crop protection

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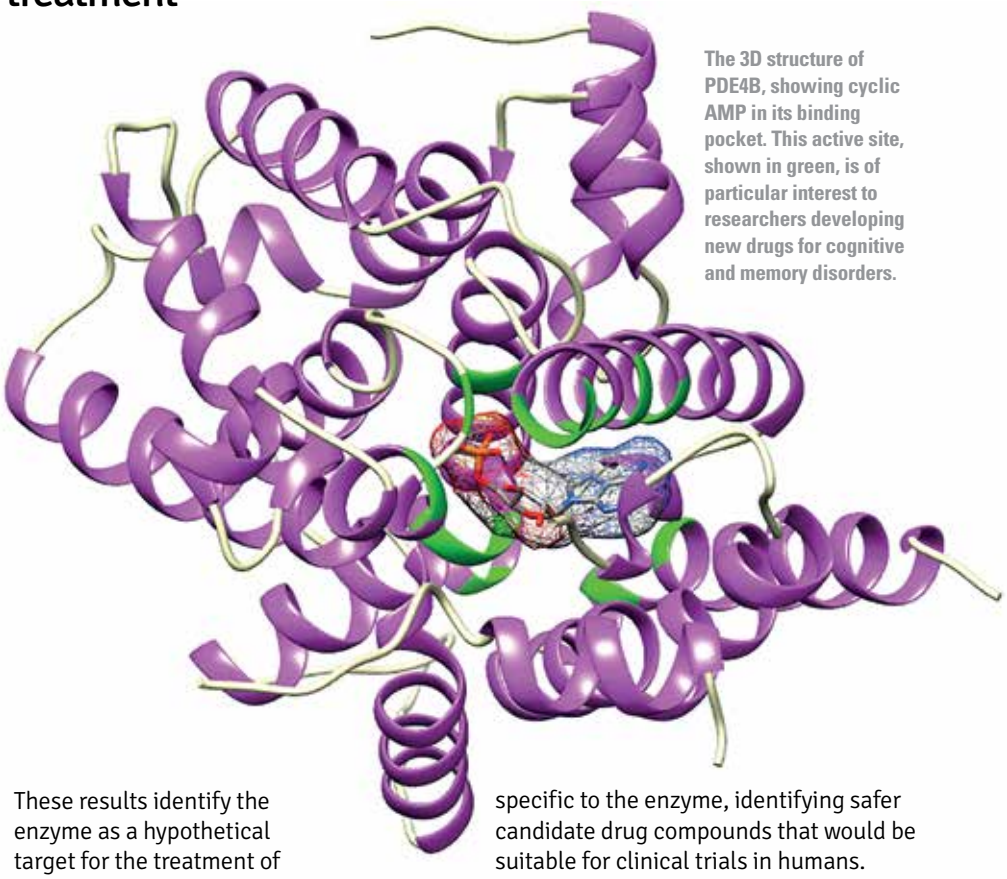
Matching molecules with memory

Collaborative research identifying enzyme that affects cognitive and memory disorders could lead to new treatment

A recent research collaboration between Swansea University, the University of Leeds and Mount Sinai Hospital in Toronto has led to the discovery of new drug targets for compounds for the treatment of cognitive and memory disorders that target an enzyme in the brain called Phosphodiesterase-4B (PDE4B).



The 3D structure of PDE4B, showing cyclic AMP in its binding pocket. This active site, shown in green, is of particular interest to researchers developing new drugs for cognitive and memory disorders.

Researchers identified that the enzyme regulates the concentration of a substance called cyclic AMP (cAMP), which mediates a number of cellular responses to hormones, light, and neurotransmitters. In the brain, changes in cellular cAMP levels can have a dramatic effect on an individual's psychiatric presentation.

For this study, researchers looked at mice that carry a novel missense mutation of the enzyme PDE4B. Research partners studied the functional, molecular and behavioural consequences of the genetic disruptions to the interactions of the mice. In behavioural tests, the mice without the mutation showed enhanced cognitive abilities. They tended to learn faster, remember events longer and solve complex exercises better than ordinary mice, providing compelling evidence for the role of the enzyme in fear, learning and memory.

An enzyme is a protein manufactured by a cell, and is a catalyst in various biological functions

A missense mutation occurs when a part of the DNA structure is changed so that a different amino acid is inserted into a protein

These results identify the enzyme as a hypothetical target for the treatment of cognitive impairment and disorders of fear memory, such as post-traumatic stress disorder. Dr Jonathan Mullins, who leads the Genome and Structural Bioinformatics Group at Swansea University's Medical School, carried out the molecular modelling of the structure of the enzyme in this study.

The collaborative efforts of the researchers move forward the scientific understanding of the role and molecular function of the enzyme, creating a promising drug target for a number of seriously debilitating cognitive and memory disorders. Knowledge of the molecular structure of this enzyme allows researchers to computationally screen hundreds of thousands of chemical compounds to identify potential drugs that interact with the target.

With much of the 3D structure of the human proteome modelled, researchers can also cross-check to find compounds specific to the enzyme, identifying safer candidate drug compounds that would be suitable for clinical trials in humans.

If the researchers at Swansea University are successful in identifying compounds that will interact with the enzyme, these drugs will be tested in the future to see whether any would be suitable for clinical trials in humans.

Profile

Product
Molecular modelling of PDE4B enzyme

Applications
Treatment of cognitive and memory disorders

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Welsh wool helps keep vaccines cool

Bio-based insulated packaging solutions for the cold chain supply systems

Collaboration between the BioComposites Centre at Bangor University, Woolcool in Shropshire and Sustainable Packaging Solutions in Swansea has led to the development of a range of bio-based insulated packaging solutions.

Wool is one of the most sustainable natural materials existing, being available in abundance as a by-product of rearing sheep. Research and design efforts from the collaborative parties have led to sustainable, compostable, recyclable and recycled materials being used for packaging, pioneering change in the packaging industry for a sustainable future.

The novel packaging can maintain the critical vaccine temperatures of between 2°C and 8°C for over 72 hours, something that has previously only been achievable with a large amount of polystyrene and many ice packs.

A range of insulated packaging has been designed to maintain a consistent temperature when transporting vaccines and other temperature sensitive pharmaceutical products. The team of researchers and designers has pioneered the use of wool as a natural 'smart fibre' for the design and manufacture of high-performance, environmentally friendly insulated packaging, as a superior alternative to conventional materials.

The wool-based packaging can be used in cold chain compliant delivery systems, meaning the temperature is controlled and uninterrupted during delivery of vaccines and other medication. All packaging products are rigorously tested to meet these logistical challenges, with quantifiable performance data to assist with good distribution practice (GDP) legislation compliance.

Wool interacts with the environment and, therefore, acts as a thermal and moisture buffer, maintaining stability. The work that was undertaken at the BioComposites Centre to understand the moisture buffering ability of the wool within the packaging has been vital to the development of the products and has led to an understanding of the interactions between the water holding capacity of the wool and the temperature control within the packaging solutions.

Since 2009, more than 500 tonnes of non-biodegradable plastic packaging waste has been saved from landfill by UK customers switching to wool-based packaging.

An additional benefit of the use of wool fibre packaging's ability to buffer the moisture is greater hygiene for the products being transported. The initial success of the packaging has led to the concept of a Welsh Wool Initiative, utilising wool from Welsh mountain sheep and contributing to further positive economic and social impact.

Profile

Product
Bio-based insulated packaging

Applications
Cold chain compliant delivery systems

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Waste energy is not wasted energy

Renewable energy solution re-uses waste wood for fuel

Refgas, based in Sandycroft, North Wales, was established with the primary focus of developing a medium scale renewable energy solution using downdraft gasification knowledge.

The company has recently announced a power generation project that will be fuelled by waste wood. The first project will generate 112,000 MW of heat and electricity each year, which is enough to power over 12,000 homes.

During the development process, experience of gasification was combined with skills of manufacturing modular equipment to oil and gas standards. This combined knowledge was used to develop a robust renewable energy solution and meet a potential gap in the market. The gasification system was designed to also run on non-recyclable waste, therefore providing a secondary benefit by contributing to minimising landfill sites.

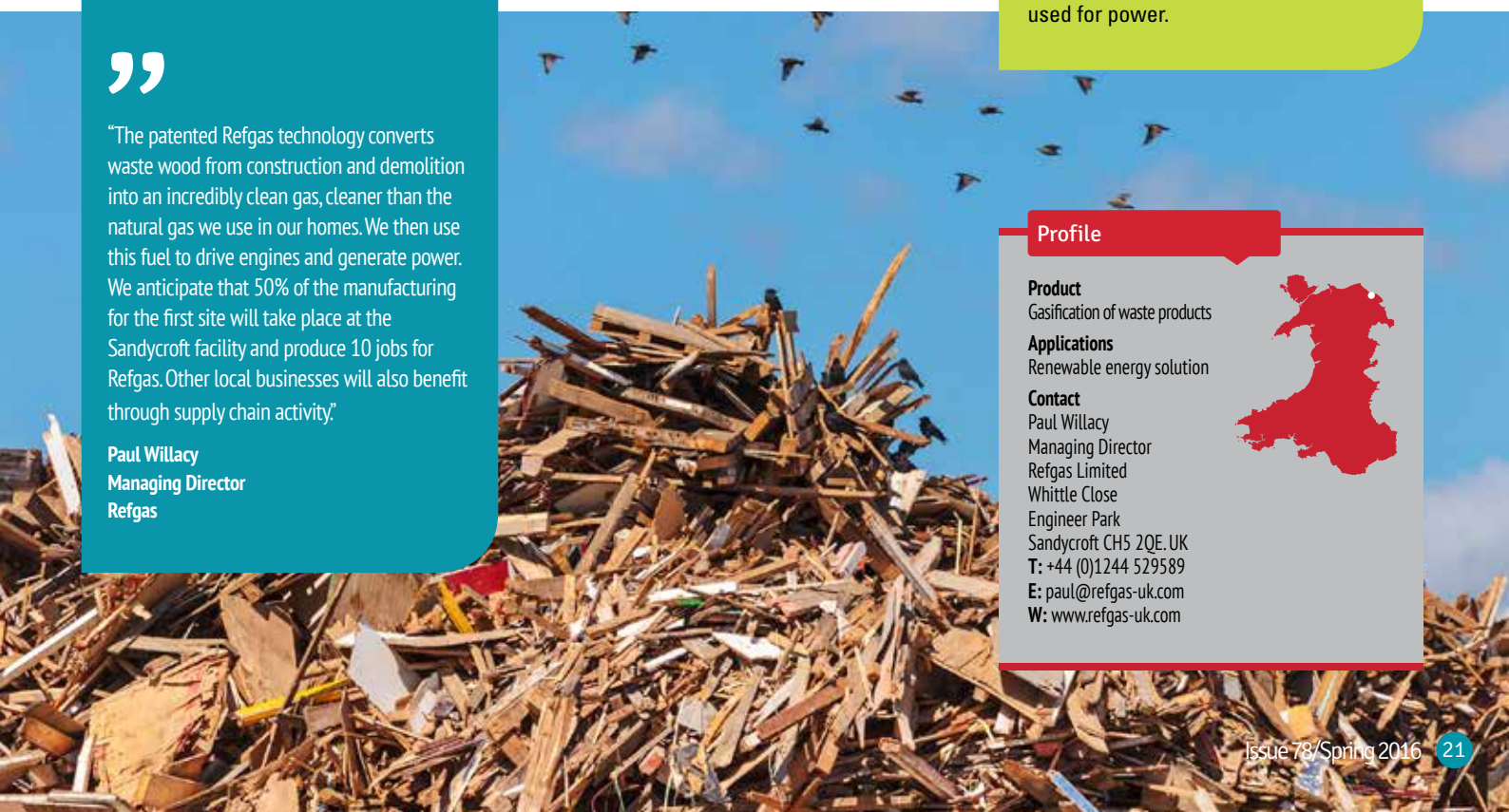
The system Refgas has developed is 1 MW electric and modular, which makes it a flexible and scalable solution that can be easily tailored for different size applications and can be used with a number of different feedstocks.

Refgas currently has acceptance from the Environment Agency (EA) that it meets the end of waste regulations for waste wood (grade B and C). The EA has acknowledged that the waste derived gas produced after the process is as clean as natural gas, meaning the end product is not classified as waste. For the future, Refgas intends to demonstrate it meets the EA end of waste regulations for a wider range of waste materials, meaning that waste that would typically go to landfill could be used to create energy.

Feedstocks are raw materials used to supply or fuel a machine or industrial process. A system that uses a range of different feedstocks to produce energy could allow waste materials to be re-used for power.

"The patented Refgas technology converts waste wood from construction and demolition into an incredibly clean gas, cleaner than the natural gas we use in our homes. We then use this fuel to drive engines and generate power. We anticipate that 50% of the manufacturing for the first site will take place at the Sandycroft facility and produce 10 jobs for Refgas. Other local businesses will also benefit through supply chain activity."

Paul Willacy
Managing Director
Refgas



Profile

Product
Gasification of waste products

Applications
Renewable energy solution

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Biomethanation for energy integration

Researchers biologically produce green methane from renewable hydrogen and excess carbon dioxide for energy use

Researchers at the University of South Wales have developed a biomethanation process catalysed by microbes that could provide the link between electricity and gas grids and lead to sustainable and integrated energy management at regional and national scales.

The way in which energy is produced and managed in the UK and Europe is changing. Since the late 1960s, the UK has increasingly utilised natural gas from the North Sea as a means of generating thermal energy and electricity. In 2014, gas accounted for 63% of primary energy consumed by domestic users and for 30.2% of UK electricity production (DECC, 2015).

However, indigenous UK gas production from North Sea reserves has fallen sharply in the last decade. Gas grid operators are also under increasing pressure to de-carbonise the gas grid, and one of the ways to achieve this is to increase the supply of low carbon gas added to the grid.

The deployment of renewable electricity generation is increasing across the UK and much of Europe. As this share of renewable electricity continues to increase, new challenges have to be addressed by electricity grid operators.

The movement of energy between electricity and gas grids could be one approach to managing energy challenges including shortage of indigenous gas; increasing low carbon gas within the gas network; prolonging the useful life of the UK's gas infrastructure; and optimising the use of renewable electricity generation by storing energy in the gas grid. This low carbon gas can also be used as a transport fuel.

University of South Wales researchers have created a low energy process, called the Aeriogen process, to convert low carbon hydrogen and carbon dioxide to produce synthetic green methane. The team were already using microbes to convert organic wastes and recover valuable products, which

"The ability to biologically produce green methane from renewable hydrogen and excess carbon dioxide has the potential to make a step change in the way in which energy grids across the world are operated, leading to significant increase in energy storage and distribution efficiencies. As energy demand increases and the way in which we produce energy diversifies, integration of gas and electricity infrastructures can provide real benefits to all within the supply chain including renewable energy generators, grid operators and, ultimately, energy consumers."

Professor Sandra Esteves
Director of the Wales Centre of Excellence for Anaerobic Digestion
University of South Wales

Methanogens are microorganisms that produce methane as a waste product of cellular metabolism.

led them to investigate a gas conversion process catalysed by a culture rich in methanogens.

The technology was initially proposed as a means of increasing the methane content of the biogas produced from the treatment of organic wastes such as food wastes, sewage sludge or agricultural slurries and residues. This coincided with a shared goal amongst gas grid operators to increase the amount of low carbon methane in the grid, as well as technology providers capable of producing low carbon hydrogen from renewable electricity.

The Aeriogen process provides a means of biologically converting renewably generated hydrogen gas and surplus carbon dioxide into synthetic green methane, which can be immediately utilised as a fuel. The conversion process can also be used for converting pyrolysis gas, coal bed gas, coke oven gas and landfill gas. The process has significant advantages in comparison with metal-based catalysts because it is lower cost, lower temperature with less energy consumption and is resistant to numerous catalyst deactivation contaminants.

The University of South Wales is working with industrial partners to develop a pilot scale demonstration plant at a live industrial facility. The aim is to operate and demonstrate the process using industrial plant components, to identify any scale up issues that require further research and development, and to optimise process performance at larger scale.

"International commercialisation of the biomethanation process would not only be environmentally favourable, but would provide economic benefits across a broad supply chain. We would expect innovation opportunities for existing engineering, manufacturing and instrumentation companies, and the potential to develop new specialist support services, all of which lead to skilled employment opportunities in the UK."

Dr Tim Patterson
Lecturer in Renewable Energy and Resource Management
University of South Wales

Profile

Product
Biomethanation process

Applications
Sustainable and integrated energy management

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Ocean's ecosystems influence climate change

Research shows that predators maintain the balance of blue carbon ecosystems

New research from Swansea University suggests that levels of marine plants that form 'blue carbon' ecosystems can contribute to climate change when there is a lack of top predators in the ocean.

Climate change is an urgent societal issue that can be addressed by a combination of reduced emissions and climate mitigation strategies, including those based on natural carbon stores. The influence of predators on carbon accumulation and preservation in vegetated coastal habitats (that is, salt marshes, seagrass meadows and mangroves) is poorly understood, despite these being some of the Earth's most vulnerable and carbon-rich ecosystems.

Predators continue to be harvested unsustainably throughout most of the Earth's ecosystems, and recent research demonstrates that the functional loss of predators could have far-reaching consequences on carbon cycling and, by implication, our ability to change and improve climate change impacts.

Changes to the structure of food webs can alter ecosystem function. In particular, a loss from the top of the food chain releases animals lower in the chain from top-down population control, leading to increased population levels and overreliance on particular food resources, causing a 'trophic meltdown'. New research from Professor Graeme Hays investigates how this can have cascading effects on oceanic carbon storage and consequently climate change, as herbivores destroy the capacity of blue carbon habitats to capture carbon.

These findings identify an urgent need for further research on the influence of predators on carbon cycling in vegetated coastal habitats and ultimately the role that these systems play in climate change mitigation. There is sufficient evidence to suggest that intact predator populations are critical to maintaining or growing reserves of 'blue carbon', and researchers hope that policy and management can be improved in future to reflect these realities.

Blue carbon ecosystems capture carbon 40-times faster than tropical rainforests and store the carbon for millennial timescales, making them one of the most effective carbon sinks on the planet.

Despite occupying less that 1% of the seafloor, it is estimated that blue carbon ecosystems capture more than half the ocean's carbon.

The carbon stored by blue carbon ecosystems is bound within plant biomass and within the ground.

In seagrass meadows in Bermuda and Indonesia, relaxed predation on herbivores has resulted in spectacular losses of vegetation, with the removal of 90–100% of vegetation above ground.

Losses of vegetation can destabilise buried carbon that has accumulated over geological timescales.

A trophic cascade-induced die-off of saltmarsh in Cape Cod of 1.5 km^2 liberated approximately 248,000 tonnes of belowground carbon. If only 1% of the global area of blue carbon ecosystems were affected in this way by trophic cascades, it could result in approximately 460 million tonnes of CO^2 being released annually. This is equivalent to the annual CO^2 emissions of around 97 million cars.

"In the case of turtles, the fear of being eaten by sharks restricts the movement and behaviour of entire populations. But when the fear of being eaten dissipates, we see that turtles eat more, breed more, and go wherever they please. Research shows that with the loss of some 90% of the ocean's top predators, the occurrences of trophic meltdowns are now widespread. In our study, we report trickle down effects on the capacity of the oceans to trap and store carbon, because as the prey become predator, their food of choice is 'blue carbon' ecosystems."

Professor Graeme Hays
Formerly of the College of Science
Swansea University

Profile

Product
Role of predators in 'blue carbon' eco-system

Applications
Promoting conservation to fight climate change

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The power behind sustainable motoring

Hydrogen fuel cell technology used to power cars sustainably

A radical new approach to personal transport and a step change in design has allowed Riversimple, based in Llandrindod Wells, mid Wales, to create a car that runs on hydrogen fuel cell technology, powered through four hub motors.

The design uses a smart, flexible approach that is more effective and efficient than inserting fuel cells into conventional, heavy, vehicles. This novel technique means the car is light, agile and fun to drive, and helps Riversimple work towards delivering cars that we can drive with zero cost to the environment.

The technology does not burn hydrogen, but has been developed to run on the power provided by hydrogen fuel cell technology, which converts electricity to power the car. Designing around hydrogen fuel cell technology has allowed the team to re-invent the car for the modern world with a sustainable approach. The hydrogen fuel cell produces a small amount of water but no harmful emissions, which means it also has enormous potential in terms of addressing climate change and eliminating pollution.

The electric motors in each wheel are also the brakes; the technology recovers over 50% of kinetic energy when braking. Super-capacitors store this energy, which is fed back into the system to provide 80% of the power for acceleration. The primary power source is a relatively low powered hydrogen fuel cell (8.5 kW) housed in a carefully constructed framework of lightweight carbon composites providing acceleration of 0 – 55 in 9 seconds, 300 mile range and 250 mpg (e) energy efficiency.

The business model is based on two basic principles; a commitment to making the new car available to people at an equivalent cost of ownership to a conventional car, and to challenge the assumption that

maximising sales of new cars is a priority. In fact, Riversimple have stated that they will never sell a car. The company is committed to designing cars of lasting quality, which are offered as part of a service contract of 1 to 3 years or longer term.

The production prototype of the first car is designed as a local car, efficient to use for short journeys that fit with normal life, unlike typical petrol cars with a catalytic converter that functions within the range of 430°C to 650°C and rarely gets warm enough to work efficiently on short local journeys. The hydrogen car does not produce noxious emissions like a diesel car, nor take a long time to refuel like a battery-powered electric vehicle.

A fundamental specification of the car is lightness, and the team at Riversimple worked on three key design elements to ensure that their electric cars would be exceptionally light without sacrificing strength, safety or durability:

1 – Fuel Cell technology

The hydrogen fuel cell is much lighter than any kind of battery and is therefore the best choice to meet energy efficiency requirements and maximise range. This power source allows the car to comfortably travel long distance on minimal fuel.

Energy Efficiency
250 mpg (equivalent)

Emissions
Less than 40g CO^2 (well to wheel), zero at tailpipe

Range
300 miles

2 – Carbon Fibre Monocoque

The chassis of Riversimple Mk2 is a carbon fibre monocoque made from very lightweight but extremely strong carbon fibre composites. Monocoque, meaning 'single shell' in French, is a construction technique that utilises a single shell to create the structural integrity of the car. Compared to older techniques, in which a body is bolted to a frame, monocoque cars are lighter and stronger, with very high strength-to-weight ratio.

3 – Mass Decompounding

Mass Decompounding is the overall design process, sometimes called vehicle light weighting, in which weight is minimised across all component parts of the car in a way that maintains overall integrity. The principle is to design a car with lightness, flexibility, intelligent use of technology, great performance and minimal environmental impact.

Profile

Product
Hydrogen fuel cell technology

Applications
Fuel efficient car with low emissions

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