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THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY

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Rapid test to diagnose rare genetic conditions

Scientists have developed a rapid test for diagnosing a set of rare and debilitating genetic conditions

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Advances Wales showcases the latest news, research and developments in Welsh science, engineering and technology. This edition and past editions can all be viewed online.

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Advances Wales highlights groundbreaking innovations in science, engineering and technology across Wales.

This edition of Advances Wales highlights a new test for diagnosing a set of rare genetic conditions (page 7) and a medical device that can stop the progression of heart disease (page 6). There is also a collaborative project working on the development of healthy, climate-resistant oats (page 16).

Environmental innovations across Wales include efforts to improve energy efficiency in cement production (page 10) and to create a sustainable alternative to plastic bait bags used in the fishing industry (page 12). Researchers have also revealed results from a novel house designed to generate more energy over a year than it needs (page 14).

Meanwhile, digital technologies featured in this edition are helping to protect society's critical infrastructures from cyber threats (page 19) and to improve monitoring and security on farms (page 20).

Sophie Davies
Editor

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Advances Wales is a quarterly technology journal produced by Welsh Government to showcase new developments in science, engineering and technology from 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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New findings to improve pollen forecasting

Research that brings together public health data and environmental science could set a roadmap for refining pollen forecasts in the future.

Current pollen forecasts, which are crucial for people with allergic asthma or hay fever to manage their symptoms, rely on measuring the total load of grass pollen in the atmosphere. However, these do not distinguish between pollen from different types of grass. Now, a potential link between pollen from certain grass species and respiratory health issues has been revealed.

The results have been produced by the first project to use an ecological biomonitoring method called eDNA (environmental DNA) to explore the relationships between airborne pollen and human health. The research, involving Aberystwyth University, Bangor University and other partners, is part of the larger PollerGEN research project, which previously featured in Advances Issue 89 and established the use of eDNA techniques to identify different types of microscopic grass pollen grains.

This latest stage of the work matched two years of public health data records (asthma-related hospital admissions and GP prescribing of respiratory and nasal allergy treatments) with the eDNA monitoring data for pollen from different grass species made at 14 locations throughout the UK. Pollen grains from different species of grass look almost identical, even under the microscope, so before the advent of eDNA and alongside molecular tools such as metabarcoding and quantitative PCR, it was impossible to identify grass pollen from different species and explore whether different grasses were causing a greater allergenic reaction.

www.pollergen.bangor.ac.uk

Next steps for industry decarbonisation project

The South Wales Industrial Cluster (SWIC) project, which is looking at decarbonisation schemes and the infrastructure required for a hydrogen economy in South Wales, has been granted phase two funding of £20m to continue its development.

"The organisations represented in this project are a vital part of the economy in South Wales, who have joined forces to provide engineering solutions that will deliver major carbon reductions, whilst maintaining competitiveness. We will be assisting the partners by identifying R&D solutions and supporting skills development necessary to achieve the zero-carbon goal."

Jon Maddy
Director of the University of South Wales' Hydrogen Centre and academic lead for SWIC

Phase two of the project involves engineering studies to explore the routes to decarbonisation. This includes the use and production of a hydrogen supply, carbon capture usage and storage, and CO2 shipping from South Wales, which would be the first CO2 shipping industry in the UK.

The project is led by Costain and supported by a range of partner organisations from the industrial, academic, law, public and private sectors, working across the region to create the world's first net-zero emissions industrial zone. As well as contributing to the UK's carbon reduction commitment, the project will enhance the ability to locally manufacture low or net-zero carbon cement and steel products, helping to drive the low carbon future of UK construction and other sectors.

www.swic.cymru

Innovative female health platform in development

Medtech start-up Forth has been awarded an innovation grant to develop a female hormone profile platform.

The Chepstow-based company, which featured in Advances Issue 89, provides a range of home finger-prick blood tests to help people get a better understanding of their own health and of what they can do to improve their wellbeing. Their new product, specifically for female health, seeks to reduce the inequalities that women face in certain areas of healthcare.

The objective is to help women see how their hormones vary, on an individual level, during their menstrual cycle. Although there are female population averages for length of cycle and average ranges for hormones during the different phases of the cycle, these can vary from woman to woman. The personalised platform is designed to give women a clearer picture of the changes that occur in their personal hormone profile over the course of a lunar month, and also throughout different life stages.

"Women face many health inequalities and they have historically been underrepresented in clinical trials due to the added complexity of monthly hormone fluctuations. As a female-led business, we want to give women better insight about their bodies and how their changing hormones levels impact on their daily wellbeing."

Sarah Bolt
CEO and co-founder
Forth

www.forthwithlife.co.uk

IN BRIEF

Project launched to safeguard oak trees

The UK is home to around 170 million oak trees, and more ancient oaks than the rest of Europe combined, but Acute Oak Decline (AOD) poses a significant threat to their health. The FUTURE OAK project, comprising scientists at Bangor University, Aberystwyth University, Forest Research and Sylva Foundation, intends to study how oak microbiomes are affected by environmental change and disease. Professor James McDonald from Bangor University explained: "The project will analyse hundreds of native oaks across Britain to understand which microbes promote health and fight diseases. We will then test the ability of these microbes to suppress bacteria which cause disease. This will help us to develop biocontrol treatments for the oak microbiome, to promote healthier trees and suppress the symptoms of AOD. Working with forest managers, we'll seek to understand how microbiomes fit with established understandings of tree health, and how our research can help."

Partnership to accelerate energy project

Pembrokeshire-based Bombora has formed a strategic partnership with TechnipFMC to develop a floating wave and wind power project, in support of a more sustainable future. This brings together Bombora's multi-megawatt mWave technology, which converts wave energy into electricity, with TechnipFMC's experience delivering complex projects offshore. The partnership will initially focus on the InSPIRE project and develop a hybrid system utilising the mWave technology. The hybrid system demonstrator will deliver 6 megawatts of combined floating wind and wave power, followed by Series 1 and Series 2 commercial platforms which are expected to deliver 12 and 18 megawatts respectively. Sam Leighton, Bombora's Managing Director, said: "We are collaborating with TechnipFMC to accelerate development of our floating integrated mWave platform solutions for commercial wind farms. With their extensive track record of delivering large-scale projects to the energy sector and our innovative technology, we are confident that InSPIRE will play a key role in the offshore energy sector."

Innovation award for AI healthcare assistant

An AI avatar assistant, developed through a Cardiff University Knowledge Transfer Partnership, has won the Innovation of the Year award at the OTCToolbox Consumer Healthcare Industry Awards. Created with help from computer science experts at Cardiff University in partnership with Orbital Global, the AI assistant (called VirtTuri) is trained to address a range of frequently asked questions around a patient's ailment. Thanks to machine learning, its accuracy improves with every use. It also aligns with Covid-19 restrictions where online virtual chat functions have become increasingly necessary. David Marshall from Cardiff University commented: "We are delighted to have played our part in this award. Our team worked to develop the visual avatar aspect of VirtTuri, which integrated with the natural language interface developed with the University of Essex." The technology has already been adopted and tested by some leading brands, and is now ready for extensive rollout to the consumer healthcare industry.

Double awards success for mattress topper

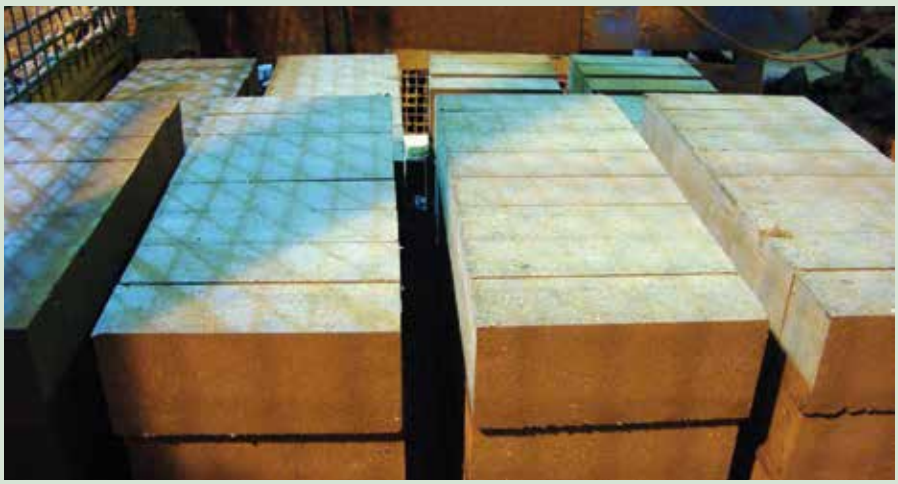
A medical student from Cardiff University, who created a pressure ulcer sensing mattress topper, has won two innovation awards totalling £40,500 across just two days. Luthfun Nessa teamed up with a Harvard University data scientist to create CalidiScope – a mattress topper which integrates novel sensors and machine learning to reduce the incidence of pressure ulcers. First, CalidiScope won a £10,000 prize fund in the Institute of Global Health Innovation's annual Health Innovation Awards. Then, two days later, it won Imperial Enterprise Lab's Venture Catalyst Challenge, receiving £30,000 plus an audience prize of £500. The technology will help to predict pressure ulcers before they develop, monitor patient movement and automate documentation. It aims to improve the prevention strategy for patients at risk of developing these ulcers by helping nurses to personalise patient care.

Hydrogen car production moves a step closer

Siemens is collaborating with Welsh hydrogen car maker Riversimple (featured in Advances Issue 78) to help it prepare for full-scale production. The two companies have signed a Memorandum of Understanding that cover skills development, sustainability initiatives and securing the required funding for volume production. Riversimple aims to start commercial production of its eco coupe, the Rasa, in 2023 and a light goods vehicle the following year. The Powys firm is currently building a low volume production run of Rasas for a trial with the general public, based in Abergavenny. Brian Holliday, MD of Siemens Digital Industries GB & Ireland, commented: "We are delighted to be working with Riversimple, which has designed and built a revolutionary electric car that runs on hydrogen. We support firms that produce boundary-breaking products in terms of design, manufacturing and performance. It is particularly satisfying when we get to support a programme with sustainability at its heart that can make a difference to the health of our planet."

Increasing use of sustainable construction materials

Research at the University of South Wales is helping to advance the development and use of soil-based construction materials.



Professor John Kinuthia is looking at the development of sustainable building and construction materials which utilise natural, industrial and agricultural waste, as well as other by-product materials. Soil has significant potential in sustainable construction, not only due to its abundance and low cost, but also its ability to work in close synergy with a variety of waste streams. Trials at brick-making plants have already demonstrated the feasibility of industrial-scale production of unfired clay bricks.

In the UK, soil-based materials developed at the University of South Wales have been considered for use in a wide range of projects, including as foundation layers for high-profile projects such as HS2. Further afield, deployment of soil-based novel materials has been carried out as part of UNESCO-backed field trials in Kenya and Cameroon. These projects in Africa show how developing countries can make progress towards sustainable infrastructural development by utilising agricultural waste from, among other crops, the growing of coffee, sugarcane, rice and palm oil.

The technology also helps developed countries to diversify their approaches towards meeting emission targets by utilising industrial waste streams, such as from the manufacture of steel, recycling of aluminium and burning of coal. Professor Kanuthia's work has achieved recognition including the Royal Society Brian Mercer Award for Innovation on unfired clay systems.

www.southwales.ac.uk

Welsh tech to reduce hospital waste in Europe

Cardiff-based Thermal Compaction Group (featured in Advances Issue 81) has entered into a joint venture with Dutch sustainability specialist Greencycl to reduce the amount of plastic waste produced by hospitals in the Netherlands. The Welsh company's Sterimelt technology melts polypropylene sterilisation materials, such as surgery drapes and tray wraps, into neat plastic briquettes that can then be re-used. In addition to reducing waste and saving money, the system also helps to reduce carbon emissions. Because the technology removes all contamination, the resulting plastic can be re-used in a wide range of products. Working with Greencycl, Thermal Compaction Group has established a showroom in Utrecht, where hospital decision makers can see the Sterimelt machine in action. Hospitals can also sign up for a 'try before you buy' scheme, in which their surgical waste is collected and processed for three months so they can see an immediate reduction in the waste they produce.

Research tackles hospital acquired infections

Genesis Biosciences (featured in Advances Issue 88) and the University of Huddersfield have received funding from the National Biofilms Innovation Centre for a collaborative study into a major cause of hospital acquired infections (HAI). The project will explore how contagion bacteria can survive even deep cleans with chemical products and evaluate a novel approach to reduce HAI through the use of probiotic hard surface cleaners. HAI represent a significant threat to the NHS and have increased over the past year due to Covid-19. Despite regular and thorough cleaning, potentially infectious organisms can survive on hard surfaces by forming a dry biofilm which acts as a barrier between infectious microorganisms and sanitising agents. After investigating the form and function of biofilms, the research project will examine how effective probiotic cleaners, like those created by Genesis, prevent dry biofilms from forming onto a surface and whether they can decrease both biofilm coverage and pathogen surface loads.

Platform to identify overlooked Chinese AI

Cardiff-based company AMPLYFI (featured in Advances Issue 80) has partnered with Georgetown University's Center for Security & Emerging Technology (CSET) to develop a new machine learning platform capable of uncovering unlisted companies. The platform uses AI to access previously unexplored data on the Deep Web, finding 'hidden' Chinese companies that are AI-related but not listed on leading commercial databases. The Deep Web is a part of the internet that is not indexed by search engines and is usually made up of unstructured data. Chris Ganje, CEO of AMPLYFI, said: "Organisations that are making decisions without considering the value of unstructured and Deep Web data are 'flying blind' and may not be aware of the huge steps forward in the abilities of machines to read, analyse and support strategic decision making. We are excited to continue to demonstrate the power of our platform to extract value from this vast untapped online resource."

Investment for Cwmbran engineering firm

Meritor has won support for a £31.9 million project to develop zero-emission 'smart' powertrains for heavy goods vehicles to manage extreme levels of electrical power. The technology will integrate the key elements of motor, inverter, gearbox, differential and brakes in a single lightweight system for vehicles up to 44 tonnes, including coaches, off-highway and construction vehicles. John Bennett, Vice President and Chief Technology Officer at Meritor, explained: "With this award, our consortium will develop a game-changing electric powertrain for heavy-duty vehicles. This technology will provide a solution to meet CO2 reduction targets, in addition to other benefits such as better efficiency, reduced weight, longer-range capability, and greater application flexibility when compared to existing systems." The grant for the EPIC (Electric Powertrain Integration for Heavy Commercial Vehicles) project will enable Meritor's existing air disc brake facility in Cwmbran to house a new European eMobility Centre of Excellence, with expanded laboratory and R&D facilities.

Fast-track for digital health solution

Nearly one third of people in Wales suffer from musculoskeletal (MSK) conditions such as arthritis and back pain. As part of the Covid-19 Digital Solutions Fund, Connect Health, an independent provider of community MSK and pain services, was chosen to roll out its PhysioNow digital tool to select NHS Wales health boards, supporting 1000+ patients in an initial eight week pilot. PhysioNow is a clinically led chat-bot, providing a remote triage and support tool for MSK conditions. Algorithms guide users to the appropriate pathway, enabling the right care, at the right time, from the right person. It helps people to remotely access an initial assessment, which is particularly beneficial for those who are apprehensive about face-to-face services due to the threat of Covid-19. Connect Health worked with partners EQL and PhysioSpace Cardiff to rapidly test the PhysioNow technology within NHS environments, and there is potential for scaling up across Wales.

Undoing the damage of heart failure

Ceryx Medical has developed technology that could revolutionise the way patients with serious heart problems are treated.

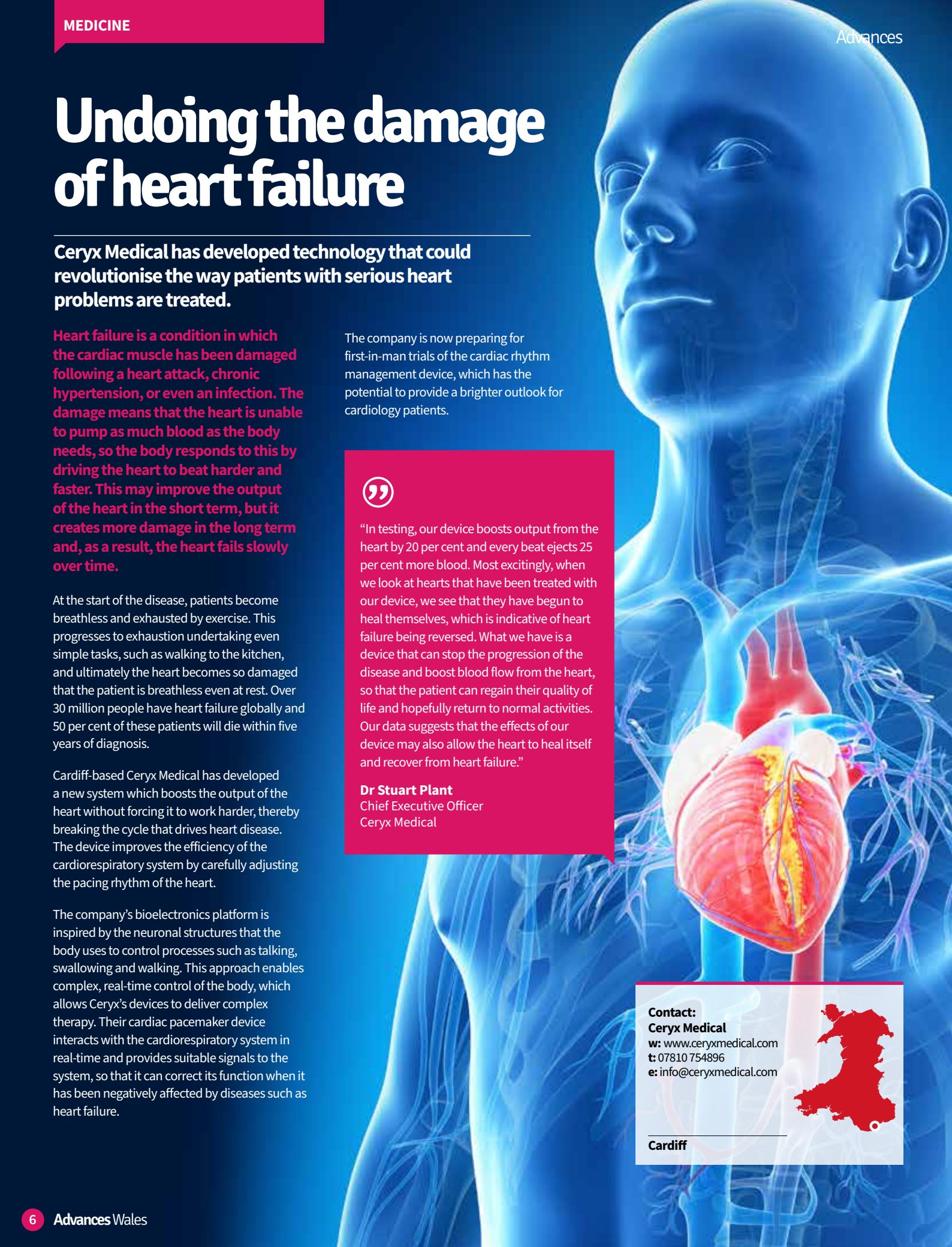
Heart failure is a condition in which the cardiac muscle has been damaged following a heart attack, chronic hypertension, or even an infection. The damage means that the heart is unable to pump as much blood as the body needs, so the body responds to this by driving the heart to beat harder and faster. This may improve the output of the heart in the short term, but it creates more damage in the long term and, as a result, the heart fails slowly over time.

At the start of the disease, patients become breathless and exhausted by exercise. This progresses to exhaustion undertaking even simple tasks, such as walking to the kitchen, and ultimately the heart becomes so damaged that the patient is breathless even at rest. Over 30 million people have heart failure globally and 50 per cent of these patients will die within five years of diagnosis.

Cardiff-based Ceryx Medical has developed a new system which boosts the output of the heart without forcing it to work harder, thereby breaking the cycle that drives heart disease. The device improves the efficiency of the cardiorespiratory system by carefully adjusting the pacing rhythm of the heart.

The company's bioelectronics platform is inspired by the neuronal structures that the body uses to control processes such as talking, swallowing and walking. This approach enables complex, real-time control of the body, which allows Ceryx's devices to deliver complex therapy. Their cardiac pacemaker device interacts with the cardiorespiratory system in real-time and provides suitable signals to the system, so that it can correct its function when it has been negatively affected by diseases such as heart failure.

The company is now preparing for first-in-man trials of the cardiac rhythm management device, which has the potential to provide a brighter outlook for cardiology patients.



> "In testing, our device boosts output from the heart by 20 per cent and every beat ejects 25 per cent more blood. Most excitingly, when we look at hearts that have been treated with our device, we see that they have begun to heal themselves, which is indicative of heart failure being reversed. What we have is a device that can stop the progression of the disease and boost blood flow from the heart, so that the patient can regain their quality of life and hopefully return to normal activities. Our data suggests that the effects of our device may also allow the heart to heal itself and recover from heart failure."
>
> **Dr Stuart Plant**
> Chief Executive Officer
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Cardiff

Rapid test to diagnose rare genetic conditions

Scientists at Cardiff University and Queen Mary University of London have developed a rapid test for diagnosing a set of rare and debilitating genetic conditions.

Telomeropathies are caused by premature shortening of the tips of chromosomes. They can result in a range of symptoms, including bone marrow failure, pulmonary fibrosis, cancer and liver disease in adults and children. There are currently around 1,000 people with telomeropathies in the UK, many of whom remain undetected and are currently living without a diagnosis.

Researchers have now created a rapid laboratory test to diagnose patients showing the many different types of symptoms that can arise from telomeropathies. The technique, called high-throughput single telomere length analysis (HT-STELA), is a DNA-based blood test that provides high-resolution information. The researchers say that it can be applied to a broader range of samples than existing tests, including fresh or frozen blood samples.

Telomeres are structures that protect the ends of chromosomes, and they shorten with advancing age. When they become too short, cells are no longer able to divide, and scientists believe this may underlie the natural ageing process in humans. In telomeropathies, they shorten too early because of defects in their maintenance caused by mutations in specific genes.

Dyskeratosis Congenita (DC) is a telomeropathy that affects many parts of the body, including abnormalities in the skin, fingernails and toenails and mouth in both adults and children. To test the efficacy of the new tool, the researchers used it to compare telomere length in healthy individuals with patients who had diagnoses for DC and other related disorders. They found the group with these diagnoses, particularly the younger patients, displayed shorter telomere length.

HT-STELA also allowed the researchers to identify a smaller group of patients where telomeres, shorter than that expected by age, caused a five-fold greater risk of death. The team believes this is the first time that the extent of telomere shortening has been shown to have such a significant impact on life expectancy.

The test is provided by the Cardiff University spin-out company TeloNostiX (previously featured in Advances Issue 78), which has set up the technology in a clinical testing laboratory.

> “If a patient presents with a severe symptom such as bone marrow failure, we can now test more accurately and rapidly than ever before if this is the result of a telomeropathy, thereby speeding up the process of providing a diagnosis for these patients. We believe the speed and accuracy of this technology will provide a step-change in the clinical utility of telomere testing.”
>
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Cardiff

New study to improve pneumonia treatment

Scientists at Cardiff Metropolitan University are hoping to improve understanding of lung infections with new research, which could help medical professionals to predict the severity of cases and tailor their treatment accordingly.

Researchers from the School of Sport and Health Sciences are studying a bacterium called 'Mycoplasma pneumoniae' which causes infections in the human body, and especially lung infections such as community-acquired pneumonia. In this type of pneumonia, the patient becomes infected in a community setting, as opposed to a hospital, nursing home or other healthcare setting.

Mycoplasma pneumoniae is recognised as a leading cause of community-acquired pneumonia, accounting for between 15 and 20 per cent of cases. In more severe infections, such as those affecting the brain, the bacterium can be found in 6 to 13 per cent of patients who become hospitalised.

In the UK, outbreaks of infection caused by M. pneumoniae occur every 3-7 years and these can affect people of all ages, but it is predominantly seen in children of school age. These infections can be difficult to treat due to a limited number of antibiotics which are active against the bacterium. In a study published last year and led by Cardiff Met, the bacterium was detected in 95,000 samples from people with suspected infections from 11 countries across Europe and Israel over five years.

In the new study, Cardiff Met is working in partnership with experts from Public Health England, Cardiff University, University of Bath, University of Bordeaux and Antwerp University Hospital. The biomedical scientists from Cardiff Met are examining 200 isolates of the bacterium, all taken from patients in England, France and Belgium. When examining this bacterium, the team will look at the genetic code to detect how it affects the severity of the infection.

They will also examine how much of an immune response is generated by each isolate, the quantity of toxin produced, and whether the isolates are able to form multi-cellular communities known as biofilms, all of which may impact on disease severity. By pairing this information with the genetic code, the researchers will look for genetic signatures which are associated with these properties and may predict severity of disease.

Additionally, the research project will explore the antibiotic resistance of the bacterium. This could help medics to tailor their treatment for patients suffering with pneumonia and other associated infections.

"This is an exciting multi-national collaborative project taking place here in Wales. We are hopeful this study has a real-world impact in the future. By identifying specific genetic signatures associated with more 'dangerous' variants of M. pneumoniae, medical staff may be able to deliver a more personalised treatment for patients and be on alert for severe disseminated infection."

Mike Beaton
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Cardiff

Optimising the drug discovery process

Antiverse has developed a drug discovery platform, powered by artificial intelligence (AI), which speeds up and optimises the discovery of new antibodies.

Antiverse's name came from the goal of comprehensively mapping out the antibody 'universe'. The Cardiff-based startup's AI-augmented drug discovery (AIDD) platform is currently being trialled by a number of companies, including global pharmaceutical firms.

Drug discovery projects are based around two scientific steps – finding suitable antibodies and modifying them to improve their properties. The first step defines the limits of what your options are, and a typical challenge is a lack of diverse options. The AIDD platform can recover potential antibodies that would otherwise be lost through conventional methods. Another difficulty occurs when some antibodies are able to bind but are deficient in other ways, and in this case, the platform can generate new variants to expand the options. Considering the huge number of potential antibodies, a project to find the right one can be time-consuming. The process can sometimes take years, but by providing a better selection of antibodies to be tested, the platform can reduce the drug discovery process from years to weeks.

Some companies are either spending a lot of money on building custom hardware to generate data, or relying on academic research for antibody optimisation. Antiverse is able to be data-independent thanks to its Cardiff lab, which enables the team to quickly generate data, update their models and test predictions.

When a company is undertaking a drug discovery project, their antibody library is screened against a disease-related target in three iterative steps, known as panning. The stringency is increased at every step. Normally, around a hundred clones would be randomly chosen from the last pan. These clones get sequenced and the outcome is a shortlist of around ten antibodies that can be further developed. However, these antibodies sometimes do not show good efficacy. Antiverse monitors each step by generating data with NGS (Next Generation Sequencing). The technology analyses the data with machine learning models and offers six to thirteen times more antibodies to choose from. The drug development process becomes less lab coat and pipette, more machine learning and algorithms.

Companies trialling the platform have already achieved ten times more diverse biologics and antibodies. By streamlining and accelerating their drug development process, the platform will help them to get drugs clinically approved, manufactured, and ultimately distributed to patients quicker. This could help companies to increase their revenue, and the platform could also help with the development of drugs for difficult targets associated with cancer and heart or lung diseases.

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Cardiff

Improving energy efficiency in cement production

A collaboration between cement producer Hanson UK and researchers at Swansea University has seen the installation of a new green hydrogen demonstration unit at the company's Port Talbot plant.

Cement production is energy intensive due to the high temperatures required to produce clinker. This is the main component of Portland cement – the type of cement used in most concrete.

Hanson UK's plant in Port Talbot produces Regen GGBS, ground granulated blast furnace slag, which is used as a replacement for up to 80 per cent of the cement in concrete. Although Regen is also an energy intensive product, using large amounts of natural gas and electricity, its carbon footprint is about one tenth of Portland cement.

Researchers at Swansea University's Energy Safety Research Institute have worked with Hanson UK to develop a new demonstration unit, which generates green hydrogen through renewable energy. The unit has now been installed at the company's Port Talbot plant.

The aim is to replace some of the natural gas used at the plant with green hydrogen, which is considered a clean source of energy as it only emits water when burned, reducing CO2 emissions from the burner and lowering the carbon footprint of Regen even further.

The demonstration unit, developed as part of the Reducing Industrial Carbon Emissions (RICE), produces hydrogen through the process of electrolysis. Renewable energy is generated through wind and solar on site, and the energy is directed into the electrolyser or water splitting device. The electrolyser can efficiently utilise this energy to split water into hydrogen and oxygen.

Clinker is the main component of Portland cement

> "It is amazing to see technology from our labs interacting in real time with local industry, actually producing hydrogen that can be burned in exchange for natural gas to lower their greenhouse emissions. Cement manufacture is one of the most energy and carbon intensive industries and therefore a perfect place to start making impacts in carbon reduction."
>
> **Dr Charlie Dunnill**
> Energy Safety Research Institute
> Swansea University

The hydrogen is then passed into the burner to enrich the combustion mixture, saving carbon emissions from the burning of natural gas.

Cement is estimated to be the source of just under 1.5 per cent of UK CO2 emissions. With demand for cement and cement replacement products predicted to increase by a quarter before 2030, researchers and industry are working hard to reduce the level of carbon emissions associated with production.

Data from the unit installed at the Port Talbot plant will be monitored in order to achieve maximum efficiencies and highlight any potential enhancements. Further units will be deployed at additional sites, and the research team is also in discussions with other heavy industries about the possibility of installing units at other sites.

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Swansea

Producing carbon spheres in a faster, greener way

Researchers at Swansea University have created a fast, green and one-step method for producing porous carbon spheres, which are a vital component for carbon capture technology and for new ways of storing renewable energy.

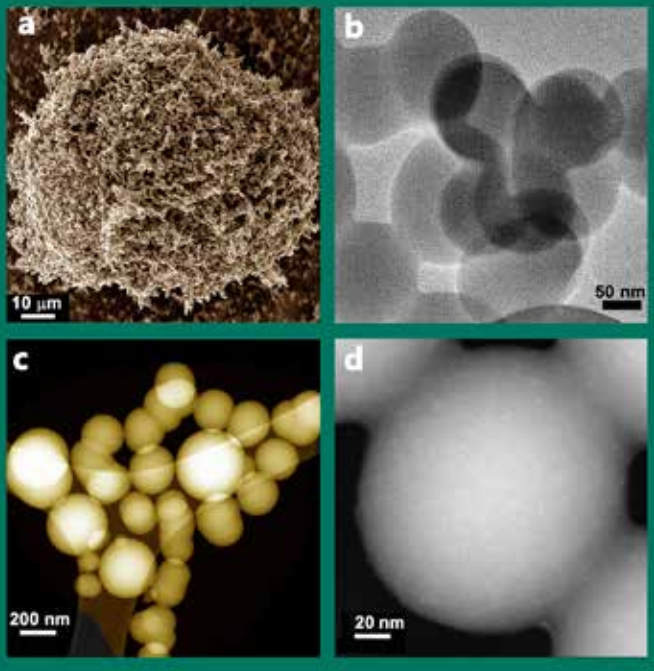
Carbon spheres range in size from nanometers to micrometers. Over the past decade, they have begun to play an important role in areas such as energy storage and conversion, catalysis, gas adsorption and storage, drug and enzyme delivery, and water treatment. They are also at the heart of carbon capture technology, which locks up carbon rather than emitting it into the atmosphere, thereby helping to tackle climate change.

Existing methods of making carbon spheres can be expensive or impractical, or they can produce spheres that perform poorly in capturing carbon. Some use biomass, making them more environmentally friendly, but they require a chemical to activate them.

To address these issues, researchers from Swansea University's Energy Safety Research Institute have developed a safer, cleaner and quicker way of producing carbon spheres. The team adapted an existing method known as CVD – chemical vapour deposition. This involves using heat to apply a coating to a material. Using pyromellitic acid as both carbon and oxygen source, they applied the CVD method at different temperatures, from 600-900°C. They then studied how efficiently the spheres were capturing CO2 at different pressures and temperatures.

The new method produces spheres that have good capacity for carbon capture, and it works effectively at a large scale. It has several advantages over existing methods of producing carbon spheres. For example, it is alkali-free and doesn't need a catalyst to trigger the shaping of the spheres. It uses a cheap, safe feedstock which is readily available in the market. There is also no need for solvents to purify the material.

Carbon spheres are currently being examined for potential use in batteries and supercapacitors. Therefore, in time, they could become essential to renewable energy storage, just as they already are for carbon capture.



"Carbon spheres are fast becoming vital products for a green and sustainable future. Our research shows a green and sustainable way of making them. Crucially, the micropores in our spheres means they perform very well in capturing carbon. Unlike other CVD methods, our procedure can produce spheres at large scale, without relying on hazardous gas and liquid feedstocks."

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Swansea

Bait bag alternative to reduce marine plastic pollution

Marine conservation charity Sea Trust Wales is working with shellfish supplier Macduff Shellfish and Bangor University's BioComposites Centre to prevent a common source of plastic from entering the marine environment.

Plastic bait bags are commonly used in the whelk fishing sector, by shellfish fishermen and in seafood processing factories. They are not easily recyclable so often end up in landfill, and they can sometimes fly away overboard when used at sea, impacting on marine and coastal wildlife. They are also not easy to clean for re-use.

The team aims to develop a robust, commercially viable, biodegradable bioplastic bag. If successful, it could also have wider applications across aquaculture, agriculture and in food processing. The project also explores alternative bio-based materials that could be used in the future. If these materials were to fall accidentally into the ocean, they could biodegrade over time, unlike the current conventional materials.

The collaborative project seeks to find a sustainable alternative to these woven, plastic bait bags. Researchers are initially looking at how the bags are currently used by fishermen and studying their characteristics, including the polymers and processes used to make them. Following on from this, they are exploring how the bags could be collected and cleaned, and how the material could then be reprocessed into a polymer bag which is more robust and readily recyclable.

Rob Elias from Bangor University said: "An important aspect is ensuring that any replacement bait bag performs better than what it would replace. We know that currently shellfish get caught in the mesh of the bags and are difficult to extract. A key part of the project was working with SeaTrust Wales and the whelk fishermen to find out the issues they face. From that, we could then look to enhance both the usability and sustainability of the bags, while retaining the robustness needed."

The feasibility study was all about sustainability, and measuring this can be a challenge. To help with this task, the expertise of a Life Cycle Assessment (LCA) specialist at the BioComposites Centre was needed. Campbell Skinner studied the processes of manufacturing a bag using a LCA approach. He explained: "This is a complex process, but working to understand the carbon footprint of a product or a process is critical. This understanding can inform the direction of the research steps needed in the future to improve the environmental performance. Working with the project team to gather data and model these impacts gave me a fascinating insight into the fishing industry."

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Bangor

Results from groundbreaking energy-positive house

Researchers from Cardiff University have revealed benefits of the UK's first affordable, energy-positive house after five years of analysing the data.

The SOLCER House was built in 2015 and named the UK's first purpose-built, low-cost, energy-positive house. It was designed to generate more energy over a year than needed to heat, ventilate, light and power appliances in the building.

The three-bedroom house was built using locally sourced materials wherever possible, and incorporates technologies for generating electrical and thermal energy into the architectural design. For example, the photovoltaic solar panels form the south-facing roof, reducing the need for roof tiles, while a solar air heating system makes up the first-floor external wall finish instead of a traditional render. All of the novel technologies used within the house were selected to work together and operate as a single system to provide heating and domestic hot water.

Over the past five years, the Cardiff University team has been continuously monitoring the house at five-minute intervals, using sensors integrated into the building and technologies. As a result, the researchers have had an abundance of data to examine. Simulations have also been run, allowing the team to understand the annual hourly thermal performance of the building, combining local weather data, building construction details and occupancy profiles.

Analysis has indicated that the house, under normal occupancy, imports around 25 per cent of its energy from the grid, mainly to meet heating needs during colder months. However, over the course of a year, 1.3 times the amount that it imports is exported back to the grid, so it has a positive impact overall. The total annual electricity imported from the grid is 1112 kWh compared to the exported value of 1458 kWh, giving an overall energy-positive performance of 346 kWh.

"Our research has illustrated how a combination of energy modelling and detailed monitoring can lead to a better understanding of how a building performs. This is very important as we combine individual low energy components into whole systems. We aimed to keep the construction costs affordable, to provide the housing market with something to replicate, particularly social housing, where low energy costs can be a huge benefit for residents."

Dr Jo Patterson
Welsh School of Architecture
Cardiff University

The researchers have determined that savings of up to £1,000 a year could be made on energy bills by living in the SOLCER House. Since the original house was built, Wales has seen the construction of over 1,400 affordable and low-carbon houses, many of which were based on technologies demonstrated in the SOLCER House.

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Cardiff

Progress in developing healthy, climate-resistant oats

A collaborative project between Wales and Ireland is furthering the development of oats as both a healthy food product and a climate-resistant crop.

Demand for oats is increasing as consumers look for healthier foods and plant-based alternatives. Food manufacturers are rapidly expanding their ranges of oat products from traditional porridge and oatcakes to cereal bars, breads and drinks.

The 'Healthy Oats' project seeks to develop new climate-resistant varieties of oats, as well as innovative products and procedures with industrial partners. The project is led by University College Dublin and includes scientists from Aberystwyth University, Swansea University and Teagasc, Ireland's Agriculture and Food Development Authority.

Dr Catherine Howarth, head of oat breeding at Aberystwyth University's Institute of Biological, Environmental and Rural Sciences (IBERS), explained: "In addition to examining modern oat varieties, this new project will explore the climate adaptability and grain composition of heritage varieties of oats from across Wales and Ireland. To increase the resilience and value of cropping systems to rural communities, we need to improve agrobiodiversity."

Welsh expertise in germplasm evaluation complements University College Dublin's expertise in disease screening, and together they will select

the most promising genotypes in terms of field performance. Their selection will be informed by complementary Welsh and Irish industry needs, which in turn will be informed by consumer and health behavioural studies.

> “In recognition of the growing incidence of obesity and type 2 diabetes in today’s Westernised society, ‘Healthy Oats’ is an ambitious project that seeks to improve the knowledge of beneficial properties of oats on human metabolism. By drawing on experts across both sides of the Irish sea, we aim to demonstrate a successful ‘farm to fork’ project that seeks to develop new consumer food choices that are healthier.”
>
> **Dr Richard Bracken**
> Swansea University

Some varieties of oats contain a higher protein and oil content and therefore have a high nutritional value. In addition, oats are particularly high in beta-glucan – a soluble dietary fibre which is strongly linked to improving blood cholesterol levels and boosting heart health. Researchers from Swansea University’s School of Sports and Exercise Science will contribute to the project by exploring the cardio-metabolic benefits of improved varieties of oat, which could help reduce the occurrence of heart disease.

The researchers will also work with agricultural communities to promote the health, economic and environmental benefits of growing oats, since it is a crop ideally suited to the climate of both Wales and Ireland. A digital platform will be built as part of the project for sharing information and knowledge with industry and other stakeholders.

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Aberystwyth

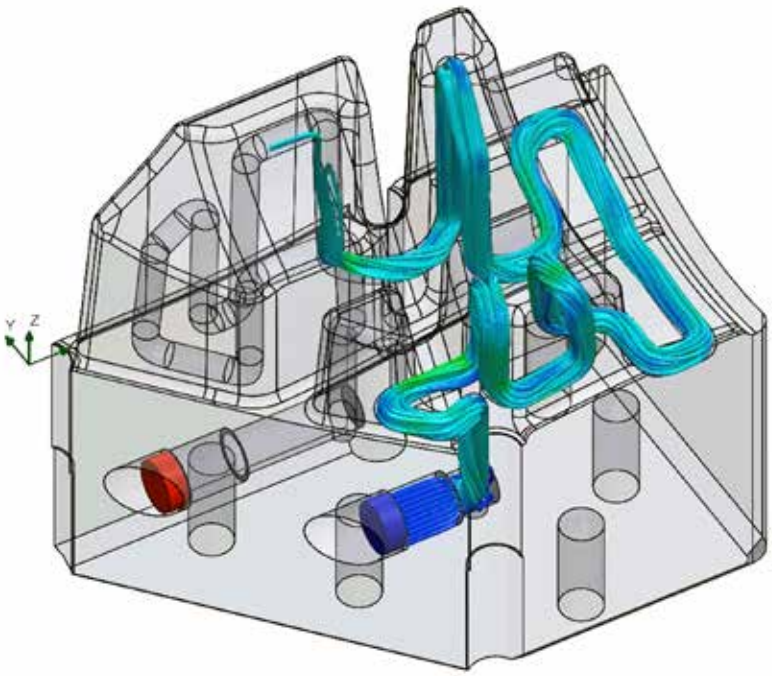
3D printing technology improves cooling of metal parts

CastAlum is using additive manufacturing (3D printing) to optimise the cooling of metal parts produced by die casting.

Additive manufacturing (3D printing) of metals has been around for a number of years, but mostly in universities, high-end motorsports and medical applications due to the complexity of the machine process and the high costs involved.

Welshpool company CastAlum specialises in die casting – a manufacturing process for producing metal parts which involves forcing molten metal under high pressure into reusable metal moulds. In the process, after the molten metal has been injected into the mould, water cooling channels extract heat to help solidify the metal part. However, temperature distribution varies, particularly at edges and corners of the metal part, which can result in uneven cooling and therefore deformed parts.

Dealing with the heat generated by the casting process is a challenge. Molten metal is poured at around 700 degrees, injected at huge speeds and pressures, cooled down as quickly as possible, and then the process starts all over again. If the cooling process is ineffective, there can be certain quality defects, including soldering, leak paths and enhanced porosity. Many parts have pressure tight requirements, so ineffective cooling has the potential to cause costly downtime.



To solve the issue of poor cooling, CastAlum manufactures moulds and mould inserts using direct metal laser sintering (DMLS), which is a type of additive manufacturing. This makes it possible to create moulds with complex internal water channels that can be tailored around the metal part for more consistent cooling.

The components produced on the printer are large, dense and capable of withstanding the harsh environment of high pressure die casting. They differ from the traditional 3D printed components that people are more familiar with, which typically have lightweight lattice structures and thin walls.

3D printing allows the engineers to design cooling channels that follow the geometry of the metal part, known as conformal cooling, which wouldn't be possible with conventional machining techniques that consist of drilling straight lines. The optimised conformal cooling design gives the mould a better thermal balance, ultimately improving the quality of the final metal part, decreasing cycle times and reducing scrap rates.

The new technology is expected to play a key role in meeting the quality standards for electric and hybrid vehicles of the future. It makes it possible to produce aluminium components that are lightweight but still retain the strength and pressure tightness required for complex electric drive systems.

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Welshpool

Protecting vital technologies from cyber attacks

Awen Collective has created digital technology to help protect critical industrial organisations from cyber threats.

Cyber attacks targeting energy, water, transportation and manufacturing organisations can cause significant economic damage and disruption to services that people rely on in their day-to-day lives. Awen Collective is developing innovative software to increase the resilience of these organisations and reduce the impact of cyber attacks on society's critical infrastructures.

The Caerphilly-based company has created a software system called Dot, which is designed to help industrial organisations fully understand their devices 'on the factory floor' as well as the cyber vulnerabilities of these devices. The system is specifically built for Operational Technologies (technologies which control processes) used in environments such as water processing facilities, wind farms, oil refineries, manufacturing lines or traffic light systems.

Many industrial cyber security software companies focus on producing what are known as Intrusion Detection Systems (IDS), which essentially learn what normal behaviour is and notify, or in some cases block, anomalous behaviour. Dot listens in to data on a network, just as an IDS does. It also notifies users if a new device appears on an operational network, which could be deemed suspicious as these networks are not often subject to change.

However, it differs from a typical IDS because it is active before an incident occurs, rather than just during an incident. It securely maps out a network in as much detail as possible, and safely analyses this information based on potential vulnerabilities.

Cyber attacks to critical infrastructure and manufacturing companies are on the rise, so many of these organisations want to increase their cyber maturity. Dot aims to give them a better understanding of their own vulnerabilities, and to enhance visibility in operational technology environments before attackers have opportunities. The technology was recently selected for an innovation acceleration programme to improve cyber security in smart cities of the future.

> "We knew that we needed to create something, because industrial companies are either very mature in their cyber security or not at all, and going from 0 to 100 in cyber maturity is incredibly difficult. We created Dot to address this – the first step is essentially knowing what you've got, and what kind of risks there might be."
>
> **Daniel Lewis**
> CEO & Co-Founder
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Caerphilly

Sensor system enables farm monitoring

Dewin Tech has created an innovative sensor system to help farmers monitor activity and enhance security on their farms.

The Internet of Things (IoT) refers to an environment where objects or 'things' are connected to the internet, sense something, create data from what they have sensed, and then do something with this data.

Many different types of devices can be used within the Internet of Things, and LoRaWAN offers a way of linking certain sensor devices and applications together. LoRa stands for 'Long Range', so these devices are able to transmit and receive data over large distances, and WAN stands for 'Wide-Area Network'. In addition to the long range capabilities, such devices are becoming increasingly popular because they have a long battery life and are scalable and affordable. They also transmit at a very low power compared to mobile phones or WiFi.

Dewin Tech, based at Anglesey's M-SParc, is developing IoT and LoRaWAN technology for the agricultural and public sectors. The company has created a long range wireless sensor called open:close, which can be used to provide information on the status of any object with an open/close function. Therefore, the device can check whether doors, gates or windows have been left open and monitor entrances into secure rooms.

This technology has been introduced in the agricultural sector, with devices mounted to farm buildings and gates. Through the use of LoRaWAN, the system covers a wide area, enabling the farmer to work anywhere on the farm with confidence that the system is fully effective and they will be notified if there is an issue. Each device can be assigned a specific name, e.g. 'front gate' or 'shed door', making the system easy to navigate.

There is also a pre-programmed time delay to minimise false alerts. For example, a gate will sometimes waver in strong winds, potentially causing false notifications that the gate is open. To avoid this, Dewin Tech has developed a solution that will not be triggered by short intervals of open status. The hardware has been designed to withstand periods of harsh weather conditions, and the metal cabling also reduces the risk of rodent damage.

In addition to its applications on farms, open:close is available within all areas of the public sector to help provide a safer, more efficient public space.

The open:close system enables better control of land and stock, bringing financial benefits for the farm, as well as increased levels of security and safety. This is particularly helpful in areas of the farm where non-farm traffic is prominent, such as ramblers.

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