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THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY

advances WALES

Saving the spiny lobster

A Welsh company has managed to breed juvenile spiny lobsters – a first for this under-threat species in Europe

Llywodraeth Cymru
Welsh Government

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.

Guest Foreword

Abi Phillips, Head of Innovation, Welsh Government

Hello and welcome to the first Advances in my new role as the Welsh Government's Head of Innovation.

Having held various positions within the innovation arena and public sector, I have never wavered in my admiration for some of the fabulous R&D going on in our universities and businesses. Wales may be a small country, but in reading this edition – and catching up on older issues - I can certainly say it's also a smart one!

And I think I know why this always gives me heart. It's because you don't have to be in government long to realise that to deliver on any of the grand challenges facing society today, we need new ideas. But we need more than that. It is only by having the know-how to turn those ideas into scientific advancements or new and better innovations that humanity can make progress towards a better, healthier and greener world.

Consider the challenge of healthy ageing. In this edition alone, we have items on advances in the treatment of hearing disorders; of dementia; of bowel cancer; and of blood coagulation. What about improving our environment? There are stories on a new alternative for animal products in foods & cosmetics and a viable treatment for polluting concrete washwater.

If only every country as small as Wales was able to boast such varied scientific advances throughout the year.

Stand-out prosthetic leg covers made in Wales

LIMB-art, a Welsh company that designs and manufactures prosthetic leg covers, is expanding rapidly and has recently become an accredited supplier to the NHS. This is the first time that such covers have been available to people on the NHS.

The Conwy-based company, established by former Paralympian Mark Williams, is determined to give prosthetic legs a better shape and allow those who wear them to express their personality through the design. The prosthetic leg covers are completely customisable accessories, designed to be durable, lightweight and easy to fit. They are suitable for people with both above and below knee prostheses.

In addition to giving the wearer a full leg shape and restoring balance to their silhouette, the covers aim to boost confidence and self-esteem. There are various designs available, with a wide range of colours and patterns to choose from.

LIMB-art was named the Manufacturing Start-Up of the Year at the Wales Start-Up Awards 2019, which celebrate the best new businesses in Wales. To keep pace with the growth of the company, Mark is opening new offices and a distribution facility, and he is looking to start selling his products overseas in 2020. The company is also working on a number of new limb cover designs.

"Although prostheses have come on in leaps and bounds functionally, until now how they look has generally been overlooked. We don't want prosthetic wearers to hide away or be self-conscious. We want to be known worldwide for making the coolest prosthetic leg covers, so people who wear them feel they can stand out and stand proud. When you wear a cool looking cover, it breaks down barriers and cuts out awkward stares. I've lost count of the number of times I've been stopped in the street and told my leg looks amazing."

Mark Williams
LIMB-art

www.limb-art.com

Fabric colour discovery to control deadly flies

Researchers at Aberystwyth University have delivered a scientific breakthrough that could help control cases of a life-threatening tropical disease.

Tsetse flies infest an estimated 10 million sq km of sub-Saharan Africa, and their bites transmit parasites that can cause 'Sleeping Sickness' disease in humans and a similar disease in animals. Thanks to work led by Dr Roger Santer at the Institute of Biological, Environmental and Rural Sciences at Aberystwyth (which was previously featured in Advances 75), researchers have now been able to engineer an improved coloured fabric for the insecticide-treated targets used to control tsetse, based on an understanding of how the flies see colour.

Targets are traditionally made from large panels of black or blue-dyed cotton fabric, which are sometimes flanked by netting. They are coated in insecticide, so that flies attracted to make contact with it are dosed and killed before they can go on to infect humans and animals. More recently, it has been realised that polyester targets are lighter, last longer and hold insecticide better. However, some blue polyesters are not as effective in attracting flies as cotton equivalents, even though their colour may appear similar to the human eye.

Researchers calculated how a fly's photoreceptors would respond to a variety of coloured fabrics. They used these findings to engineer a polyester fabric to be more attractive and tested its effectiveness against savannah tsetse flies. This new fabric looked violet to the human eye rather than the standard blue or black colour that is normally used.

The team found that targets made from blue polyesters could be just as effective as black cotton ones. Most importantly, they discovered that their new violet polyester attracted approximately 50 per cent more female flies than either the traditional black cotton or a typical blue polyester, demonstrating its increased effectiveness in controlling tsetse.

www.aber.ac.uk

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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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Have you created a new technology or carried out research in Wales?
If so, we'd love to hear from you…
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Developing a novel antimicrobial textile

Hybrisan has created an advanced antimicrobial nonwoven textile for applications in the life science sector such as wound dressings.

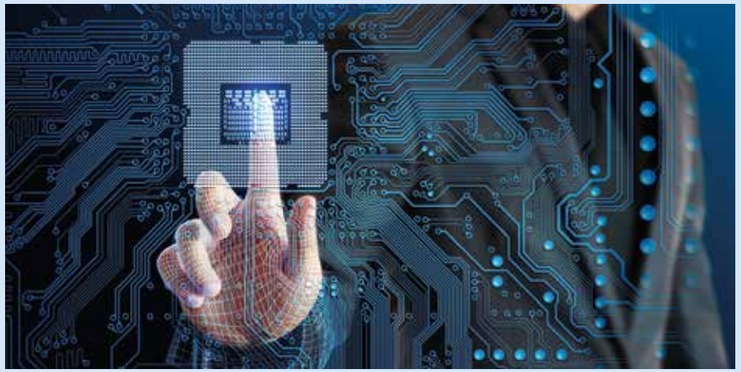
The biotechnology company, based in Port Talbot, has developed the innovative material over a number of years, using a scalable free-surface electrospinning technique to produce nanofibres that incorporate a polymeric biocide. The material is proven to exhibit significant antifouling properties and be highly effective against a number of organisms.

The composite nature of the biocide results in a broad spectrum kill and there is little to no risk of antimicrobial resistance, which is an issue associated with many existing biocides used for these applications. The technology can therefore reduce the use of antibiotics for infection control on surfaces. It can also reduce the use of heavy metals, such as silver, in products such as wound dressings where their bio-accumulative effects are not yet fully understood.

With recent funding, Hybrisan is now undertaking further development in order to commercialise its novel textile in the wound dressing sector. This project intends to revolutionise antimicrobial textile technologies through the application of new nanofabrication techniques. The company will also use its expertise to increase the awareness and use of electrospinning as a fabrication technique for nonwoven textiles.

www.hybrisan.com

Advancing compound semiconductor technologies



The Compound Semiconductor Applications (CSA) Catapult has won a TechWorks Award for R&D Excellence, in recognition of its approach to next-generation power electronics system development.

Semiconductors are at the heart of almost all modern electronic devices. Silicon semiconductors have widespread commercial applications, but this technology has its limits. Compound semiconductors combine two or more elements to create capabilities that cannot be achieved with conventional silicon devices, delivering performance improvements in power, speed and signal quality. This makes them ideal to use in areas such as energy efficiency, electrified and autonomous vehicles, mobile applications, new smart-sensing devices for the Internet of Things (IoT) and 5G applications.

The CSA Catapult is focused on accelerating the adoption of compound semiconductors and bringing applications to life in three technology areas: Power Electronics, Radio Frequency & Microwave and Photonics. In addition to the three technology areas, it is also working in the field of Advanced Packaging. The Catapult's Innovation Centre, built in 2019, is located in Newport and is home to dedicated laboratories specialising in different technologies. Its expert team has grown from 3 to 70 people in just over a year.

During 2019, the Catapult has won seven R&D projects and worked on 43 industrial collaborations. One such collaboration, recently announced, is SPECTRAIL which aims to deliver a novel IoT sensing capability for intelligent railway monitoring. The project will offer rail infrastructure operators, such as Network Rail, a cost-effective and energy-efficient way of collecting data, through the sensorisation of track areas that were previously inaccessible due to lack of power, connectivity or prohibitive costs.

www.csa.catapult.org.uk

IN BRIEF

Investment in legal innovation lab

Swansea University has announced £5.6 million investment for Legal Innovation Lab Wales, a unique research and innovation facility housed in the university's School of Law. A core focus of the project will be to help law firms innovate at the intersection of law and technology, whether that means making better use of data, improving the design of legal processes, or applying machine learning to legal matters. It will also involve working with law enforcement, security agencies and technology companies to advance understanding of how terrorists and criminals exploit digital platforms and emerging technologies, and to develop new tools and safeguards. Facilities will include a cyber threats research suite, a 'legal AI' laboratory, a Legal Innovation Centre where law firms and technology companies can work with researchers and software developers, and a Law Clinic where new innovations can be piloted.

Pupil coding numbers hit record high

The number of Welsh schoolchildren taking part in coding workshops at Sony UK Technology Centre hit a record high in 2019, according to figures from the Pencoed-based manufacturing facility. In the summer, the team celebrated welcoming 4,159 students through Sony UK TEC's doors. In the specialist 'Learn 2 Code' Workshops, led by a qualified coding instructor, children are encouraged to use their creativity across a variety of digital platforms in a bid to boost STEM learning. The factory, which produces the industry-leading Raspberry Pi computer, has spoken out about the importance of coding and incorporating it into early education.

Development of sustainable sequins

Bangor University's BioComposites Centre has been helping The Sustainable Sequin Company to provide the fashion industry with biodegradable sequins. Unlike ordinary plastics, which are derived from petroleum, the sequins will be made of naturally sourced renewable materials. They will have a lower impact on the planet, as they are made from readily available plant materials which can decompose at the end of their useful life. The BioComposites Centre has already contributed to the development of green innovations from compostable pizza bases, recyclable coffee cup lids and grass-based egg boxes, to bio-based building materials and car parts. Graham Ormondroyd from the BioComposites Centre commented: "It's interesting to be resolving a fashion problem for a change, but actually, this is no different to other challenges we have resolved. What we're currently testing is whether the dyes and fillers that provide the colour and iridescence don't affect the degradation process at the end of use."

Expansion plans for software firm

Aforza, a cloud software provider for the consumer goods industry, has opened a research and development lab in Cardiff. Whilst initial investment is supporting the early-stage R&D team, the company plans to expand to as many as 300 employees globally over the coming years, with Cardiff tipped as the location to drive R&D growth. Aforza utilises artificial intelligence, machine learning and mobile technology to give its customers differentiated improvements in revenue, employee efficiency, market reach and field effectiveness. It has established a base at Cardiff's Tramshed Tech, the co-working hub focused on the tech and cyber industries. Cardiff University alumnus and chief product officer at Aforza, Nick Eales, said: "It's a source of great personal pride to me to return to Cardiff; to bring investment here and play our part in boosting the knowledge economy."

Award for electric classic car converter

Newtown-based company Electric Classic Cars Ltd has won the award for Technology & Innovation at the Powys Business Awards. The company has been carrying out electric conversions and full restorations of classic cars since 2016, specialising in cars from the 1950s to the early 80s. Following support from an external investor in 2019, the company (which started as a hobby for director Richard Morgan in Llandinam) relocated from a home workshop to a 12,000 sq ft industrial unit. New developments include a custom-built electric motorcycle, The Photon, which was designed to fill a gap in the market and fits in with a retro-styled modern technology.

Growth for North Wales garden rooms

A company that uses aviation technology to create outdoor offices, gyms and studios has recently celebrated its fifth anniversary and is reportedly on track for a record turnover of £1 million in 2020. Rubicon Garden Rooms, based in Shotton, makes zero maintenance garden rooms using aircraft technology learned by the managing director when he previously worked as an engineer at Airbus. Managing director John Lyon said: "The fact that our garden rooms require zero maintenance and last for 30 years has been an important factor in our success. The uses are limited only by people's imaginations and we can install kitchens, toilets, bathrooms and showers – in fact, anything you would expect to see in a small house."

Funding boost for cancer-killing viruses

Scientists at Cardiff University have been awarded nearly £1.4 million funding to support the development of cancer-killing viruses. 'Oncolytic' viruses are widely seen as the next breakthrough in cancer treatment, as they destroy cancer cells but leave healthy cells unaffected. Dr Alan Parker, from the university's School of Medicine, said the funding would help towards moving the research "from bench to bedside". He explained: "Viruses haven't evolved to infect and kill cancer cells – unfortunately they infect healthy cells, making us ill in the process. Our research has focused on generating 'smart viruses' that can discriminate between cancerous and healthy cells. Our next challenge is to engineer the virus to make it even more potent and deliver this to clinical trials. The funding will accelerate this process and help us to deliver these exciting new therapies to cancer patients sooner."

Celebrating achievements in Welsh life sciences

Winners have been crowned at the annual MediWales Innovation Awards, which celebrate outstanding achievements in Welsh life sciences and health technology, including NHS and industry. Cardiff & Vale University Health Board won the Innovation within NHS Wales award for its work with heart failure patients who are towards the end of their lives, while the All Wales Medical Genomics Service received the High Impact award for developing a new, non-invasive prenatal test. NHS awards for collaboration went to Aneurin Bevan University Health Board, working with SEWAHSP and Orchard Media to create VR experiences, and Velindre University NHS Trust's FAKTION trial involving patients with incurable breast cancer. Winners in the industry award categories included Magstim, CanSense, CellPath and Creo Medical.

Grant to develop AI systems

Professor Andrew Ware from the University of South Wales has won a £46,000 grant, which will enable development of an AI-based system for reviewing method statements and risk assessments in the construction industry. The project is a collaboration between the university and Port Talbot-based Aurora International Consulting, with support from IBM Watson. Professor Ware explained: "In order to make the construction industry as safe as possible, a very significant amount of work goes into carrying out risk assessments for each new build or refurbishment. Along with each risk assessment, a set of procedures (method statement) designed to minimise the likelihood of an accident occurring is compiled. Once completed, risk assessments and method statements are checked to ensure that nothing has been overlooked, so the entire process is lengthy and expensive. What's more, there is a shortage of skilled people who can perform these checks. Using AI to complete these processes will therefore result in a significant reduction in time, cost and error rates."

Award for electronics innovation

Blaenavon-based company Super Rod has received an award for its innovative combination inspection camera and cable-pulling tool. The manufacturing firm won the Best New Product award at a ceremony hosted by Scotland's Electrical Trade Association (SELECT). Super Rod, which has been designing and building cable rods since 2001, was acclaimed for its Ferret WiFi Cable Pulling Tool, which uses the latest electronics technology to stream high resolution video to a smart device in real time. Dave Forrester, head of technical services at SELECT, commented: "It's a good design that will save time on site and also improve safety when pulling cables. It makes great use of technology to provide a simple but effective tool, making it easy to actually see where the cable is. Electricians will love it."

Advances

HUG for people with dementia

A team from Cardiff Metropolitan University has designed a sensory device to bring pleasure and comfort to people with dementia.

Over 40,000 people in Wales are living with dementia and there is currently no cure. People with advanced dementia can often become withdrawn, depressed and 'locked in'.

The LAUGH (Ludic Artefacts Using Gesture and Haptics) project aims to create a series of playful devices that amuse, distract, comfort, engage and bring joy for people with late stage dementia. As part of this project, a team led by Professor Cathy Treadaway at Cardiff Metropolitan University's Centre for Applied Research in Inclusive Arts and Design (CARIAD) has developed an innovative sensory device called HUG.

After researchers visited a care home in Port Talbot, they decided to create something for Thelma, whose carers said she was in need of a hug. In her late 90s, Thelma suffered from advanced dementia and was considered to be coming to the end of her life. When the team met her, she was largely bedridden, barely opened her eyes and rarely spoke.

Thelma holding HUG - the innovative sensory device

> *"Finding something for people with dementia to do that connects them with who they are and the people around them is very important. That's what our products aim to do: provide fun, joy and pleasure and re-connection. We focus very much on engaging the senses. Most people in the late stages of the disease are chair- or bed-bound, so we have designed hand-held or wearable things that support their wellbeing. If you can improve someone's wellbeing, it often impacts on their health in a really positive way."*
>
> **Professor Cathy Treadaway**
> Cardiff Metropolitan University

Professor Treadaway elaborated on the 'hug' idea: "We involved a lot of dementia experts in our design workshops, and one of the key themes that came up in discussions was a need for nurturing. Hugs seem to fulfil two roles in this regard: they involve you in giving the hug, but they are also reciprocal. Our design was focused on creating an object that Thelma could hug and that would hug her too. We settled on a soft baby-type shape, with weighted limbs. It was a very experiential thing and more about what it feels like than looks like."

HUG looks like a soft toy on the outside, but it has electronics inside that simulate a beating heart and can play a selected playlist of music and sounds. It is simple to personalise HUG through the music selection, and for Thelma this was via a playlist of Vera Lynn songs.

Once the prototype was given to Thelma at the care home, she quickly took to hugging it and soon began to show improvement. Within a week she was more alert, her appetite returned, and she began to speak and socialise with other residents. Care home staff commented that after three months she seemed like a different woman, her quality of life had improved, and her falls (which had previously been frequent) had stopped completely. She unexpectedly went on to live for a further nine months.

As a result of the positive evaluation of HUG with Thelma, the study has now been scaled up via the LAUGH EMPOWERED PSCI project. This is a collaboration between Cardiff Metropolitan University, Sunrise Senior Living (residential dementia care) and Cardiff and Vale University Health Board. 20 HUGs are currently being evaluated with people who are living with dementia in Sunrise Cardiff, and there are a further 20 with patients who have been admitted to the Stroke Rehabilitation Centre at Llandough Hospital in Cardiff. In addition, a number of them have been placed in the community in different parts of Wales, with people who are affected by dementia but are still living at home. Early results from the research show that using HUG relieves anxiety and distress, provides comfort and helps communication with carers and loved ones. The design team at Cardiff Metropolitan University are now exploring ways to produce the device commercially.

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Cardiff

Blood coagulation profiler in development

Benson Viscometers Ltd is developing a novel device that determines the 'clotting profile' of a blood sample.

Coagulopathy is one of the most preventable causes of death following trauma. It is present at the time of admission to the emergency department in up to 25-35 per cent of trauma patients and has been implicated as the cause of almost half of haemorrhagic deaths in these patients. These patients are associated with higher transfusion requirements, as well as longer stays in intensive care and in hospital generally. In comparison to patients without a coagulopathy, those with it have a three to fourfold greater risk of mortality, and up to eight times higher mortality within the initial 24 hours of injury.

The correct treatment within the 'golden' first hour following trauma greatly reduces the demand for blood products and also reduces mortality and recovery time. However, blood analysis to ensure correct blood component therapy can currently only be undertaken once the patient arrives at the hospital.

In order to reduce the time delay to commence blood component therapy, Benson Viscometers Ltd is in the late stages of developing a mobile Coagulation Profiler which monitors the clotting of fresh whole blood in real time. The instrument is small, lightweight, battery operated and mobile, enabling it to be used at the scene of the incident both in outdoor areas such as the roadside, major trauma incident or for military use on the battlefield, next to the injured patient. It will operate beside the patient, but is not connected to the patient, in clinical environments such as hospital A&E for trauma centres, ambulances (including air ambulances for trauma patients prior to and during transport to hospitals), obstetric departments, neonatal units, front line military situations, field military hospitals and anti-coagulant monitoring in GP practices.

The profiler is designed to be always 'ready for use', maintained in a low battery consumption standby mode. It will require no calibration fluids or reagents. There will be no set up required and it can therefore be operated with minimal personnel training. Insertion of a test capsule automatically activates the analyser ready for the test. The introduction the fresh blood sample by syringe automatically starts the analysis and produces the clotting profile without any further operator actions. A 500µl sample of fresh whole blood is all that is required.

Aiding selection of correct blood component therapy, the coagulation profiler will have algorithms developed to identify normal and frequently encountered abnormal profiles. Test results are displayed graphically in real time with critical patient clotting information, including time to commence clotting, rate of clotting and maximum clot strength. These results are numerically displayed for clarity and there is grey background plot which is indicative of a normal healthy clot profile.

The profiler has had laboratory proof of concept testing where it has been demonstrated that the system is sensitive to detect abnormalities caused by low platelets, coagulation factor deficiency and for patients on New Oral Anticoagulants (Rivaroxaban). After discussions with several clinical teams the original concept, for use at trauma sites with haemorrhaging patients in both civilian and military environments, has been expanded to include obstetric haemorrhage and the monitoring of patients taking 'New Oral Anticoagulants' (NOACS).

The experimental development phase is continuing in order to complete development of the prototype hardware, associated software, peripherals and disposable, single use blood test capsules. The coagulation profiler is designed and being produced to provide a "step change" improvement to the Trauma care pathway.

Several potential areas of future development are under consideration including a solar powered version for use in developing countries and disposables with reagents for specialist analysis.

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Haverfordwest

Zebrafish discovery sheds new light on hearing disorders

By studying the genetic make-up of zebrafish, scientists from Cardiff University have gained new insights into the cause of human hearing disorders.

Genetic factors are thought to cause more than 50 per cent of all congenital hearing loss cases. Many are attributed to the misalignment or damage of tiny cells, known as hair cells, inside our ears that allow us to hear and process sounds.

There are thousands of hair cells within the inner ear which are tuned to respond to different sounds based on pitch or frequency. This is due to the orientation in which the tiny hairs are laid out. When sound enters the ear, the hairs change the sound vibrations into an electrical signal that is then sent to the brain, allowing us to recognise it.

Using zebrafish as a proxy, a team including scientists from Cardiff University has shed light on how changes to specific genes can alter the coordinated direction that hair cells inside the ear are laid out. Due to the inaccessibility of the inner ear, studying the alignment of hair cells in humans is extremely challenging.

Zebrafish have very similar hair cells along their body, within the so-called lateral line organ, which they use to read pressure differences in water. Critically, zebrafish can regenerate these hairs when they are damaged, providing scientists with an ideal test bed to understand when things may go wrong.

The study involved scientists from Cardiff University, the Stowers Institute for Medical Research and the Fred Hutchinson Cancer Research Centre. They investigated the genes underlining two signalling pathways (PCP and Wnt) which are present in both humans and zebrafish and are known to affect the way in which hair cells coordinate their orientations.

By systematically switching these genes off in the zebrafish, the team was able to study the many possible effects on hair cell direction. This was achieved using new statistical characterisations developed at Cardiff University, enabling the scientists to measure the types of hair cell patterns that would be created by, for instance, being highly aligned in rows, not aligned or aligned in circular structures.

Results showed that not only could the regularity of the hair cell pattern be destroyed, producing a random hair cell direction, but also that certain alterations to the genes could lead to the hair cells having circular or spiral patterns.

"The big result is that we now better understand what influences hair cell directionality and, equally, what may be going wrong in humans. These insights provide new directions through which we can tackle congenital hearing problems."

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Cardiff

Transforming detection of bowel cancer

CanSense is developing an accurate, fast, non-invasive diagnostic test for early detection of cancer using a simple blood sample.

Bowel cancer is the second most common type of cancer globally and it is predicted to rise by 60 per cent over the next ten years. When it is detected at an early stage, bowel cancer has a high survival rate, but many patients are not diagnosed until the disease is at a later stage, with a much higher risk of mortality. There is low patient uptake for the current 'FIT' test, which involves sending faeces away for analysis, and this results in needless colonoscopies which take up NHS time, money and resources, not to mention an unpleasant experience for the patient.

Swansea University spin-out company CanSense has combined Raman Spectroscopy with AI technology to develop a test for the early detection of cancer using a blood sample, i.e. a liquid biopsy. The test is initially focused on bowel cancer and aims to diagnose more patients earlier, when the disease is significantly more likely to be treatable and curable.

By allowing patients to have a simple, non-invasive blood test, as opposed to the FIT test or a colonoscopy, the new innovation is expected to substantially improve patient compliance, while also reducing patient anxiety and discomfort. It will enable GPs to make quicker, more informed decisions for their patients, reducing the time taken for diagnosis and ensuring patients receive the right treatment pathway sooner. The ultimate goal is to save more lives through earlier cancer detection.

The test also has the potential to save NHS money and resources, because patients who definitely do not have bowel cancer can learn this at an earlier stage, after a visit to their GP for a blood test. Consequently, there will be more of a focus on priority treatment for urgent suspected cancer patients and a reduction in the number of unnecessary colonoscopies, which are costly, invasive procedures.

CanSense was built on a foundation of extensive academic research and clinical trials, with over 2000 NHS patient samples analysed to date. The company recently won the Best Start-up award at the MediWales Innovation Awards 2019 in recognition of its societal impact potential.

Dr Adam Bryant, CEO of CanSense, commented on the future of the technology: "To give you some insight into our ambition, we are looking to establish a Centre of Cancer Innovation in Swansea – putting Wales itself at the forefront of the cancer early detection market. The roadmap includes creating a large clinical laboratory, employing a considerable number of people with a varied skill set. Furthermore, we will obtain global reach with the establishment of regional diagnostic hubs in undeveloped countries and will create diagnostics for all cancer types. Our longer-term vision, after technical and regulatory development, is to establish our blood test as the test of choice in general population screening for all cancer, globally."

> *"Thousands of bowel cancer deaths could be prevented every year through earlier diagnosis of this disease. This is a potentially game changing innovation in terms of population-based access to a cheap, convenient and acceptable test. This innovative test will mean subjecting less patients to invasive endoscopic examinations. This is an important step in the development of precision medicine undertaking the right test for the right patient at the right time."*
>
> **Professor Tom Crosby OBE**
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Swansea

Turning food waste into new proteins and ingredients

Tate & Lyle and Bangor University are taking part in a project to develop more plant-based ingredients that increase environmental sustainability and provide an alternative for animal products in foods and cosmetics.

Agricultural and food manufacturing processes produce a substantial amount of by-products that go to waste. Therefore, experts are investigating whether these by-products can be put to better use and turned into valuable proteins and ingredients. They are also exploring the possibility that these plant-based proteins can provide cheaper and more sustainable alternatives to the animal proteins that are currently used in a wide range of food and cosmetics products.

The Pro-Enrich project, a collaboration between 13 companies and three research organisations across seven European countries, is looking to find a cost-effective and efficient way of producing alternative proteins and other ingredients from agricultural processing residues. The project will run for three years and is led by the Danish Technological Institute and supported by the Bio-Based Industries Joint Undertaking. The two Welsh partners involved are Tate & Lyle (which has a large facility in Mold) and Bangor University's BioComposites Centre.

For many years, the food ingredients sector has used products derived from animal protein (like dairy, eggs and gelatin) in a range of applications, such as thickeners and stabilisers, and to provide texture in a range of foods. However, there are now growing concerns about the environmental sustainability and ethical implications linked to the use of animal-derived proteins for specific functions in the food industry. Identifying cheaper alternatives for these materials not only responds to these concerns but also holds great commercial potential. More and more people across the world are becoming interested in plant-based diets, and many consumers are making room for non-meat and non-dairy products as part of a 'flexitarian' diet.

Products derived from plants offer a potential alternative source of functional proteins and are being used in the food industry as gel, foam and emulsion stabilisers in many foods, including sauces, cakes, ice creams and food dressings. Plant proteins such as soy and pea can be isolated and modified for different food applications. The Pro-Enrich project is looking in particular at extracting proteins and phenolic compounds from what is left over when processing rapeseed, citrus, olives and tomatoes.

At its facilities located on the Island of Anglesey, the BioComposites Centre is investigating methods to selectively isolate these functional proteins and bio-active ingredients for applications in food, pet food and adhesives. Meanwhile, at its plant in Mold, Tate & Lyle is looking at ways to use these proteins in different types of food. Having moved away from sugars some years ago, the company now produces a range of ingredients designed to reduce the calorie, fat and sugar content in food, and increase the amount of fibre.

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Bangor

Breeding success for vulnerable lobster species

A project led by RAS Aquaculture Research Ltd (RASAR) has managed to breed juvenile spiny lobsters, which is a first for this species in Europe.

The European spiny lobster (Palinurus elephas) was once a commercially important species in Wales. However, in the 1980s, it declined 90-95 per cent throughout Europe due to overfishing. North Wales, a former stronghold of the spiny lobster, currently produces fewer than five animals each year.

Since the fishery collapsed, it has shown few signs of recovery. The species is now classed as vulnerable by the International Union for Conservation of Nature and has been identified for priority conservation action in the UK Biodiversity Action Plan. The spiny lobster is particularly sensitive to fishing pressure, with a reproductive cycle that involves a planktonic phase of nearly n ine months.

Gwynedd-based RASAR, which develops water treatment technology for high value seafood species, is researching culture of the spiny lobster with a view to farming the species in land-based farms. This involves the design and operation of sea water treatment technology, specially designed larval culture tanks and artificial feeds to support the survival and growth of the planktonic lobster larvae through several complex stages until they become a juvenile lobster.

The culture techniques were developed over a period of five years, slowly improving understanding of the feed and environmental requirements of the lobster larvae as they progress to the juvenile stage. In July 2019, the company succeeded in producing the first juvenile spiny lobsters. Closing the larval cycle of spiny lobsters to produce juveniles is considered one of the holy grails of aquaculture, because of the extreme difficulty that all global spiny lobster species present during culture attempts. The successful production of juveniles in Wales represents a European first for this species. In Japan, juveniles were produced during the 90s using broodstock lobsters imported from Ireland. However, this work depended on the regular use of antibiotics – an approach not taken during the new study. RASAR was also able to secure juvenile lobsters in just 28 per cent of the time taken under wild conditions.

Further improvements to the feed and hardware technology are currently in progress to firmly establish the larval culture protocol for the species. This work could eventually result in construction of a commercial scale hatchery in Wales to supply farms for ongrowing the lobsters to market size. Farming spiny lobsters could assist with coastal fishery diversification opportunities in Wales, producing a high value seafood product while also assisting with restoration initiatives along the Wales coastline.

The project is already generating interest from other countries who have also tried to close the cycle but without success. While there is interest in culturing the species for the seafood trade, there is also significant potential in lobster processing by-products. These are rich in a range of high-value bioactive compounds which are useful for numerous applications in water treatment, agriculture, food, nutraceutical, pharmaceutical products and biomedicine. In the longer term, farmed spiny lobster production could be a source of high-quality raw material for bioactive compounds, while also producing a high value seafood product to meet growing market demand when wild lobster fisheries are in serious decline globally.

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Gwynedd

Creating new materials from black plastic

Research at Swansea University has found that plastics commonly used in food packaging can be recycled to create new materials, such as wires for electricity, and could help to reduce the amount of plastic waste in the future.

Although plastics are made to last for a long time, many are thrown away after just one use, and this has led to a significant amount of plastic waste. For every person on earth today, there is over 100 times their body weight in plastic waste. To make matters worse, only a small proportion of the hundreds of types of plastics can be recycled with conventional technology, so researchers are developing innovative ways of reusing them. The study at Swansea University, led by Dr Alvin Orbaek White, focused on chemical recycling, which uses the constituent elements of the plastic to make new materials.

While all plastics are made of carbon, hydrogen and sometimes oxygen, the amounts and arrangements of these three elements make each plastic unique. As plastics are very pure and highly refined chemicals, they can be broken down into these elements and then bonded in different arrangements to make high value materials, such as carbon nanotubes.

Carbon nanotubes are tiny molecules with powerful physical properties. They are made of carbon-carbon bonds, giving them diamond-like strength. The structure looks like a piece of chicken wire wrapped as a cylinder, and when carbon is arranged like this it can conduct both heat and electricity. Coupled with their high strength, this makes nanotubes quite special compared to other carbon materials.

They have already been used to make conductive films for touchscreen displays, to create antennas for 5G networks and to develop fabrics that create energy from movement. Their pliability has also made them ideal for flexible electronics, and NASA has used them to prevent electric shocks on the Juno spacecraft.

During the study, the research team tested plastics, in particular black plastics, which are commonly used as packaging for ready meals and fruit and vegetables in supermarkets but can't be easily recycled. They removed the carbon and then constructed nanotube molecules from the bottom up using the carbon atoms, and then used the nanotubes to transmit electricity to a light bulb in a small demonstrator model.

Now the team plan to make high purity carbon electrical cables using waste plastic materials and to improve the electrical performance and increase the output, with the aim of making them ready for large-scale deployment in a circular economy in the next three years.

The research is significant because carbon nanotubes can be used to solve the problem of electricity cables overheating and failing, which is responsible for around an 8 per cent electricity loss during transmission and distribution globally.

> *"8 per cent may not seem like much, but the figure is low because electricity cables are short, which means that power stations have to be close to the location where electricity is used, otherwise the energy is lost in transmission. Many long range cables, which are made of metals, can't operate at full capacity because they would overheat and melt. This presents a real problem for a renewable energy future using wind or solar, as the best sites are far from where people live."*
>
> **Dr Alvin Orbaek White**
> Swansea University

With this work, the team is creating the technology to upcycle plastic waste into higher quality materials, which will bring us one step closer to a renewable energy future on a cleaner planet.

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Swansea

A step towards renewable propane and butane

Researchers at the University of South Wales are collaborating with industry to lower the carbon impact of Liquefied Petroleum Gas (LPG).

LPG is comprised of higher alkane gases, including propane and butane, and is widely used as a fuel in gas cylinders in off-grid locations. These gases are also used as propellant in the aerosol industry and as a feedstock to produce petrochemicals.

Playing a significant role in the energy system, LPG provides heat and energy to two million off-grid homes and businesses across the UK. It is currently derived through the extraction of natural gas or as a by-product from oil extraction and refining, and is either produced at one of the UK's six oil refineries or imported.

The UK is expected to fall short of its 2020 renewable energy obligation, specifying that 15 per cent of all energy consumption should come from renewable sources. Within this overall target, there are sub-targets stating that 30 per cent of electricity, 12 per cent of heat and 10 per cent of transport should come from renewable sources. The UK is expected to exceed its electricity sub-target, but it has yet to reach halfway in both heat and transport.

Although considerable effort is being made to decarbonise gas grid supplies, such as biomethane and renewable hydrogen, the options to decarbonise off-grid gas users are currently limited. Therefore, a mechanism for the sustainable production of propane and butane is required. The only existing technology uses a by-product from the manufacture of biodiesel which, in the long term, has a limited capacity to fulfil market demand.

Building on their research into the anaerobic production of methane and hydrogen gas, and more recently in power to gas conversions, scientists at the University of South Wales have been investigating the potential for producing ethane, propane and butane via microbial pathways.

The research, initiated in collaboration with Wales and West Utilities (WWU), has identified a pathway that is capable of producing low concentrations of alkane gases at this early stage, but concentrations are getting close to meeting requirements of 4-10 per cent higher alkane gases for enabling biomethane injection into the natural gas network.

The team has recently started a new collaboration with Flogas Britain Ltd, a major supplier of LPG in the UK, and over the next three years, they will be developing strategies to increase the concentrations of propane and butane that can be produced to an industrially relevant level. Higher alkane gases production will also be investigated from a wide range of feedstocks.

This research has the potential to revolutionise a number of industry sectors. The future of the LPG industry and continuation of the mechanism for providing off-grid fuel gas is dependent on finding sustainable alternatives to fossil-based propane and butane. Efforts to reduce the carbon impact of the aerosol industry are also based on establishing sustainable sources of propane and butane gas.

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Pontypridd

Treating harmful concrete washwater

Siltbuster is using innovative technology to deal with polluting concrete washwater in the construction industry.

Concrete washwater arises on most construction sites, and its impact on the environment is often underestimated. It looks clean to the naked eye but has a pH of 12-13 (the equivalent of oven cleaner), making it highly damaging to vegetation and ecosystems. It can also kill fish and other aquatic life if discharged into the natural environment.

Siltbuster is a leading specialist in water treatment, developing equipment to prevent waterborne pollution. The company has created a range of systems capable of neutralising this dangerous water, for use on construction projects of any size or scale. Their technology takes the pH of the water down to a neutral pH7, meaning it is safe to be released to a watercourse or be disposed of down a drain with the appropriate permitting.

The Monmouth-based company has pioneered an innovative process that uses carbon dioxide to neutralise highly alkaline water. It is safer, easier to control and more cost-effective to use than acids. It is also a more practical method than dilution with water, as it would take 10,000 litres of water to neutralise just one litre of concrete water with a pH of 12.

The Roadside Concrete Washout (RCW) was the company's original solution, designed to capture and treat water generated by washing truck mixer chutes on concrete delivery lorries. Running off a 12V battery, the system can be used in remote locations to allow safe, contained washing down anywhere required. When the RCW system was first developed, concrete washwater was not considered to be a pressing issue. Promotion of this technology has raised awareness of its environmental impact, with the Environment Agency producing a statement on how concrete washwater is to be dealt with.

Since developing the RCW system, the company has created other complementary solutions to treat different concrete washwater scenarios and to fit with various onsite space requirements. For example, one is designed to cater for larger projects and column skips (used with tower cranes), while another is for use with either plastic lined skips or in combination with the firm's primary reception units. Most recently, they created the Micro Concrete Washout (MCW) system in order to provide a more compact, versatile system which smaller building firms can use to capture, treat and store the water used to wash their mixer truck chutes and clean their small tools, such as wheelbarrows, buckets and trowels. This unit is a self-contained treatment system which enables water to be reused for subsequent washing via the integrated pump and hose.

Siltbuster's technology has now been used in projects including: Crossrail, to neutralise high pH water produced during concreting; Airbus Manufacturing Facility, to control and treat the washwater generated during construction; M1 Junction 19, to handle the concrete washout and ensure any water discharged would not harm the local wildlife during construction of a bridleway via the River Avon. The company recently won the award for Manufacturing Innovation at the Made In Wales Awards 2019.

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Monmouth

Harnessing the power of biological catalysts

Scientists at Cardiff University's Catalysis Institute have made a breakthrough that could allow day-to-day materials such as paints, cosmetics and pharmaceuticals to be created in a more environmentally friendly way.

Catalysis is the process of increasing the rate of a chemical reaction by adding a substance known as a catalyst. They are widely used in industry to produce products in a much quicker and more efficient way. Scientists are constantly seeking potential new catalysts and often look to nature for inspiration.

Enzymes, which are known to catalyse numerous biochemical reaction types, are unrivalled when it comes to speeding up chemical reactions with mild conditions. Of particular interest to scientists are enzymes known as peroxygenases, which are derived from fungi, among other organisms.

A team including scientists at the Cardiff Catalysis Institute has successfully unlocked the catalytic abilities of enzymes taken from fungi by creating the perfect conditions needed for them to function. This could potentially lead to new ways of creating a whole host of industrial chemicals.

To function effectively, enzymes need a steady supply of oxidant, which for peroxygenases is usually provided by hydrogen peroxide (H_2O_2). This is often provided by another supporting catalyst. Current approaches use additional enzyme systems, but this can result in complicated reaction mixtures.

A new approach has been to combine hydrogen and oxygen directly to produce the H_2O_2. However, the specific catalysts used for this type of reaction work with very harsh conditions that enzymes do not like. Therefore this has provided a major hurdle for scientists trying to maximise the catalytic potential of enzymes. They have found it difficult to develop supporting catalysts that can operate in an enzyme's ideal environment without causing damage to the enzyme itself.

In their new study, the team has successfully developed a catalyst made from gold and palladium nanoparticles, which can produce a steady stream of H_2O_2 to the enzyme in much more benign conditions. This is consumed by the enzyme in the same reaction vessel to carry out the chemical transformation, resulting in only water as a by-product of the whole process.

The catalyst can produce just the right amount of hydrogen peroxide for the enzyme to drive the whole process with mild conditions. These transformations would require much harsher conditions if using just traditional catalysts. This is a significant step towards utilising the power of enzymes to create a range of molecules, from commodity to fine chemicals, in a greener and more efficient way.

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Cardiff

Springboard for gymnastics training app

FB Curves 3D Gym is using digital technology to aid training, coaching and judging in the world of gymnastics.

Founded by two ex-international gymnasts, Cardiff-based FB Curves 3D Gym has developed innovative apps to enhance understanding, learning and development in the gymnastics community. The fully animated 3D apps can be used for both men's and women's gymnastics, and are designed to help gymnasts, coaches and judges understand every element of the sport in detail, including body positions and angles.

Over seven years of research and development, the company established that the gymnastics industry was lacking the digital tools needed to help develop the sport further, and that participants were lacking the technical support with modern technology that athletes in certain other sports had. Therefore, they introduced an app for men's gymnastics in 2017, followed by a women's gymnastics app in 2019. Whilst developing the initial app, they sought expert advice from (and trialled the app with) many Olympic and world gymnasts, international coaches and judges, in order to confirm that the technology would truly add value to the sport.

The men's app includes over 800 elements and the women's app currently has over 650 elements. The 3D technology illustrates the accurate positions and angles of the body that are required to perform elements with perfect technique. This means that gymnasts and coaches are able to dissect and visualise each stage in depth during training sessions.

Coaches can use the apps to develop new coaching ideas and techniques, so that they can more effectively train their students, and judges can also use them to prepare for competitions by studying examples of ideal execution. There is also an associated library of 3D videos which explain the scoring and judging system, going through everything from basic errors to more complex faults. The apps have been made available to not only elite gymnasts, but to gymnasts, coaches, teachers and clubs at all levels.

FB Curves 3D Gym is now affiliated with a number of federations, including Welsh Gymnastics and the French Gymnastics Federation, and is making plans to work with UEG (European Union of Gymnastics) and others. The company is also beginning research and development with the aim of expanding into other sports.

> *"A lot of time and research has gone into this project, to ensure there was a market for it in the world of gymnastics. It will benefit gymnasts, coaches and judges, as well as circus artists, free runners and parkour performers. It will also be used as an educational tool in schools, colleges and universities. We are really excited to help develop this sport in terms of technical support. At present we have thousands of downloads of the app across 100 countries all over the world."*
>
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Cardiff

Innovation in microbial air monitoring

Pinpoint Scientific is developing a new system for microbial air monitoring in sterile manufacturing environments.

The pharmaceutical industry is moving increasingly towards the use of isolation working chambers, such as isolators, bio-safety cabinets and RABS (rapid access barrier systems). The aim is to perform the drug manufacturing process in sealed environments, free from any human intervention and contamination caused by human presence. These are almost always custom built and designed to be as compact as possible, which in turn limits the space available for microbial air samplers/monitors.

Pinpoint Scientific's microbial air sampler/monitor currently uses a small monitoring head inside the test area with a remotely located pump and controller unit, but it still requires significant engineering input to install in an existing chamber. The Bridgend-based company is now developing a miniature pump unit that will fit inside the monitoring head, rather than in a separate remotely located control unit, and will have power low enough to be 'Power over Ethernet'.

With this innovative integrated pump, the monitor will have no need for plumbing or welding to install, reducing the effort and cost required to implement. Another advantage of the pump being in the head itself is that the sampled air can be exhausted in a novel way, back into the same chamber environment. This is particularly useful in bio-safety cabinets where dangerous pathogens may be present.

In addition to the pharmaceutical industry's move towards more containment technologies, there has also been a move towards more monitoring and data gathering and system integration. The new monitor will be linked directly to a network-based computer system, without any additional interface hardware, in order to monitor and gather data.

Air samplers currently on the market can only sample for ten minutes, but Pinpoint Scientific is developing theirs with a four-hour capability. There will be an environmental benefit due to the unit requiring less power to operate.

New legalisation has defined what is required of pharmaceutical manufacturers in terms of continuous monitoring. One fundamental requirement is the need to prove the environment has less than 1 cfu (colony forming unit) per m^3, so monitors that can detect micro-organisms below this level are required. The Welsh company's samplers/monitors are capable of detecting particles as low as 0.5 µm. The new sampler packages this high-performance technology into a small and easy-to-install footprint, designed for the limited space found in isolation working chambers.

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