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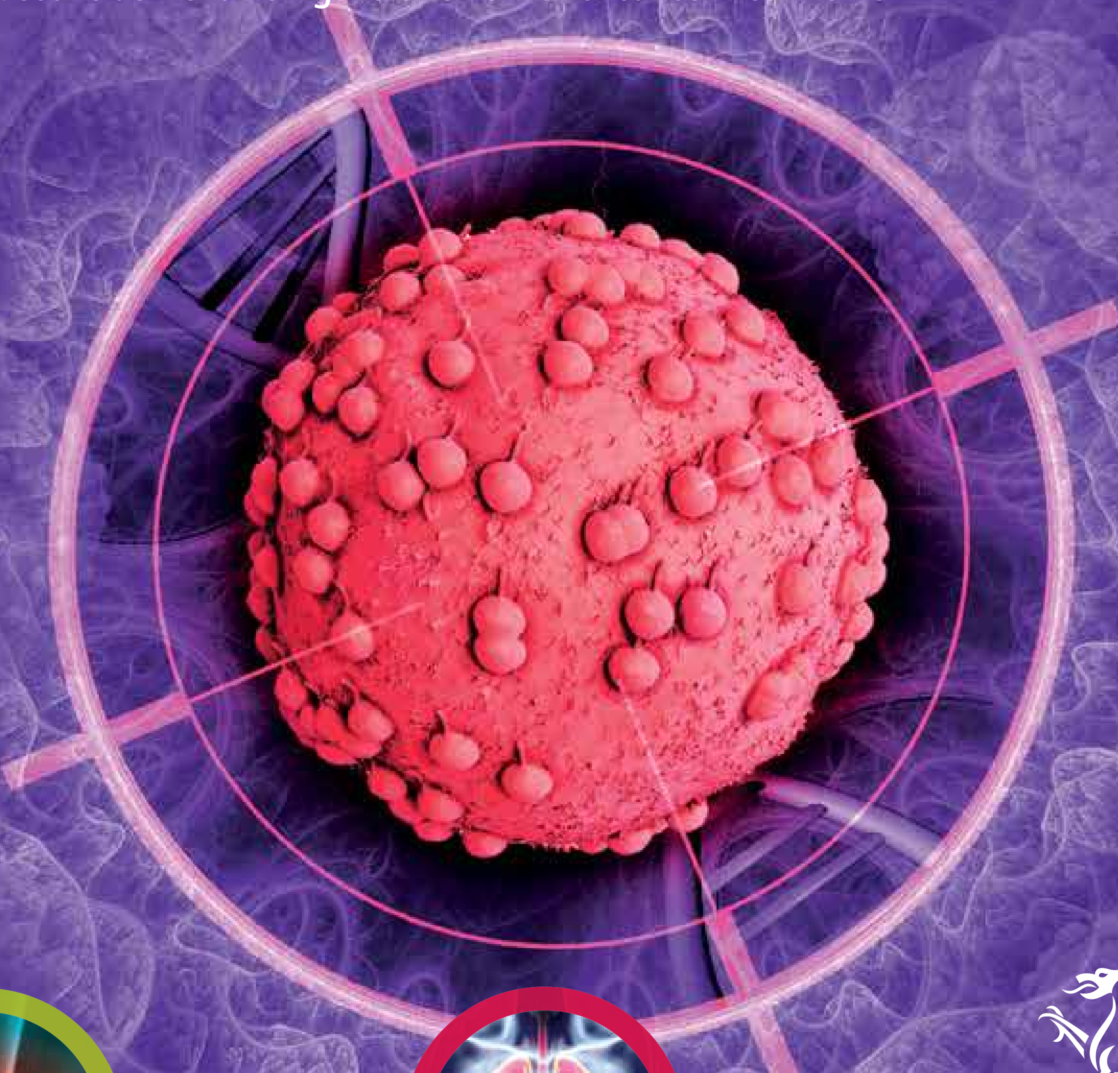
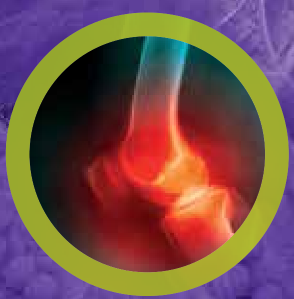
advances WALES

Salmonella targets cancer

Welsh based scientists discovered that a harmless strain of the bacteria Salmonella could be used to deliver a new generation of better cancer treatments





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Llywodraeth Cymru
Welsh Government

THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY
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Contents & Editorial

"Every great advance in science has issued from a new audacity of imagination."

John Dewey, philosopher

This edition of Advances Wales has a focus on life sciences, with news and articles on developments in Welsh medical research, health technology and biotechnology.

Scientists at Welsh universities are finding innovations for healthcare in unexpected places. Harmless strains of Salmonella are being used to reprogramme cancer cells (page 6) and damage-detecting sensors, typically used in aeroplanes, are being incorporated into a smart patch to detect osteoarthritis (page 7). Wales-based scientists are also developing a unique technology for the diagnosis of lung disease (page 8) and a natural compound that could improve quality of life for people with cystic fibrosis (page 10).

Meanwhile, a first-of-its-kind recycling machine is reducing hospital waste (page 14) and an app is working to empower brain injury sufferers (page 18). There is also university research into increasing the potential of microscopes with spider silk (page 9) and analysing microbial communities found inside cattle (page 13).

As well as these developments in the Welsh life sciences landscape, this edition features two innovations in roofing. A technology has been developed to integrate solar cells directly into roofs, avoiding the need for bulky solar panels (page 15), and waste slate from North Wales is being recycled to produce sustainable roof tiles that save installation time (page 16).

Advances Wales is also available online, where you can find previous editions that feature key developments in research and innovation in Wales.

Sophie Davies
Editor

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

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75% wedi'i ailgylchu recycled

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MATERIALS	FOOD	ELECTRONICS	PHYSICS
AGRICULTURE	ENGINEERING	COMMUNICATIONS	CHEMISTRY
ENVIRONMENT	MANUFACTURING	INFORMATION TECHNOLOGY	MEDICINE
ENERGY	EARTH SCIENCES	OPTO-ELECTRONICS	BIOTECHNOLOGY

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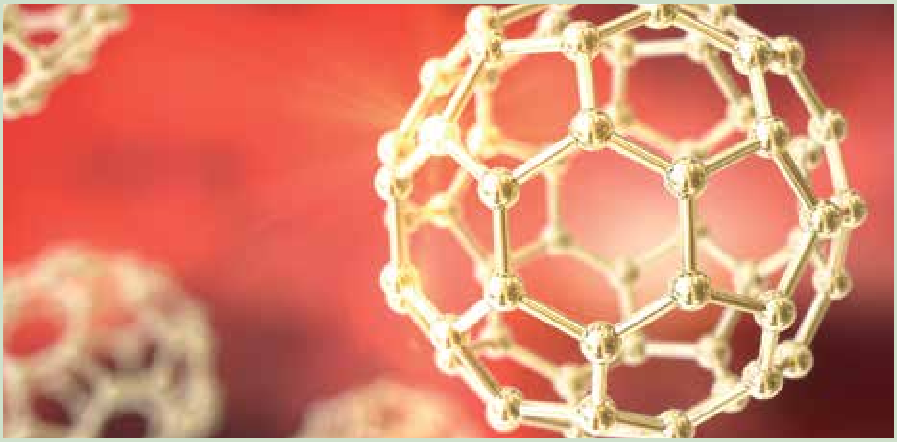
Going for gold against type 1 diabetes



A partnership between Cardiff University and pharmaceutical company Midatech Pharma has secured funding for a project using gold nanoparticles to develop treatments for autoimmune diseases such as type 1 diabetes.

An autoimmune disease develops when a person's immune system, which defends the body against disease, mistakenly decides that healthy cells are unwelcome and starts attacking them. In the case of type 1 diabetes, the immune system destroys the insulin-producing cells in the pancreas that regulate blood sugar levels. Sufferers of type 1 diabetes must carefully monitor their blood sugar levels, to stop them from going too low or too high, and get the insulin they need to survive from injections or an insulin pump. The condition is unpreventable, has no cure and requires round-the-clock self-management to avoid complications.

The £370,000 two-year grant from the Juvenile Diabetes Research Foundation will help scientists at Cardiff University and Midatech to explore how gold nanoparticle technology can dampen unwanted autoimmune responses to healthy cells in the pancreas.

"Cardiff University looks forward to this continued collaboration using Midatech's gold nanoparticle (GNP) technology. It has shown great potential to preferentially target specific immune cells, distribute rapidly to lymphoid tissues around the body, and modify the body's immune responses. This will be an important project for autoimmune diseases generally and type 1 diabetes specifically, and we are looking forward to developing this platform."

Professor Colin Dayan
School of Medicine
Cardiff University

The research is led by Professor Colin Dayan of Cardiff University's School of Medicine, who has a longstanding interest in the study of type 1 diabetes.

In addition, a first-in-human Phase I study of an innovative type 1 diabetes vaccine (MTX102) using the gold nanoparticle technology commenced in 2016 in Cardiff and Sweden. The trial will examine the general safety and tolerability of the new treatment, with results expected later this year.

www.cardiff.ac.uk

Creating a machine to fight antibiotic resistance

Two scientists from the University of South Wales have received a £14,000 grant from the Longitude Prize Discovery Awards to create a revolutionary machine that will improve the accuracy and speed of diagnosing infectious diseases.

The team, consisting of microbiologist Dr Emma Hayhurst and molecular geneticist Dr Jeroen Nieuwland, has been selected as one of 12 teams – five from the UK, five from India and two from the US – to develop technologies that fight the growing threat of antibiotic resistance.

In partnership with the university's Centre for Electronic Product Engineering, the two scientists have developed a prototype machine which uses a sophisticated technique to detect specific fragments of bacterial DNA. The ultimate goal of the technology is to determine whether a patient is in need of antibiotics and which type would be the most effective. The answer could be given within half an hour directly from the patient's sample, in contrast with the current system which takes days to provide test results and can result in the patient being wrongly prescribed medicine.

The team now intends to further develop and test the machine to ensure specificity and accuracy. The application of this technology is not limited to clinical samples, and the team is also working with an international organisation towards developing the device for detecting pathogens in drinking water supplies. A major advantage of the technology is its speed, cost and portability. Dr Hayhurst envisages something that could be used globally, even in resource-poor settings, to tackle the major challenges of antibiotic resistance and water sanitation.

"The rise of antibiotic-resistant bacteria is a huge challenge facing global health. If we don't tackle the problem we are facing a future in which 10 million people a year die of bacterial infections that we cannot treat. Inappropriate prescribing of antibiotics is bringing that future ever closer. A lack of cheap and fast diagnostic tools is an inherent part of the problem. The time to do something about this is now."

Dr Emma Hayhurst
Microbiologist
University of South Wales

www.southwales.ac.uk

New technology enhances diagnostic tests

Scientists at BBI Solutions have developed a novel signal enhancement technology that improves the performance of lateral flow tests.

Lateral flow tests are simple diagnostic tests that can be used by almost anyone in any setting, in contrast to more traditional lab-based tests that can only be performed by skilled laboratory staff. They are often used for home or point-of-care testing due to their ease of use, low cost and fast time to results. The most widely known example of a lateral flow test is the home pregnancy test.

The performance of lateral flow tests can be improved through the use of a blocking agent. In a process known as conjugate blocking, this agent reduces or eliminates free binding sites on the reporter label, preventing non-specific binding. Bovine serum albumin (BSA) is the blocking agent most commonly used in lateral flow tests, but there are known problems with using BSA, such as cross-reactivity and batch-to-batch inconsistencies causing results to vary. Its relatively large size can also cause issues, making it more difficult for

the binding partner to detect the target analyte – the substance being detected and measured for diagnostic purposes.

BBI Solutions' newly developed technology, Morffi, is designed to improve the performance of lateral flow tests while avoiding the shortcomings of the most commonly used blocking agents. It uses a synthetic biological blocking agent that is significantly smaller in size than BSA, increasing opportunities for the binding partner and the target analyte to interact.

This new blocking technology was evaluated in a lateral flow test for the detection of brain natriuretic peptide, a marker for the diagnosis of heart failure, and the results demonstrated that it outperformed BSA in several areas. The limit of detection was 0.08 ng/ml, compared to 0.8 ng/ml for BSA, showing a ten-fold increase in sensitivity, and signal intensity at all analyte concentrations also improved. This result can be attributed to the size of the new blocking agent, which makes it easier for the analyte to access the antibody.

The technology is showing great potential for a variety of applications, which include lowering the limit of detection of existing tests, improving tests where cross-reactivity with BSA is an issue – for example, veterinary tests – and reducing the time to result in tests where a rapid diagnostic result is critical. In addition, removing the inconsistency of BSA would be a significant benefit for diagnostic manufacturers.

www.bbisolutions.com

IN BRIEF

CALIN funding for life sciences

More than €9m of EU funding is being invested in a new two-nation project to expand the life sciences sector in Wales and Ireland. The funding will support research and development programmes at more than 240 small and medium sized businesses in the two countries over the next four years. These programmes will form part of the new Celtic Advanced Life Sciences Innovation Network (CALIN), which will be led by Swansea University in partnership with other Welsh and Irish universities. The network aims to support the development of new technologies, products, processes and services, leading to new jobs and further investment in the Welsh and Irish life science sectors.

Funding for life-saving study

Researchers at Swansea's Morriston Hospital have been awarded £230,000 to advance a study that could potentially save lives. The study focuses on patients with chest injuries which, although relatively minor, can lead to serious complications. These complications often do not emerge for several days, meaning that people are released from hospital and then return as emergency cases. Over ten years of research led by Dr Ceri Battle has resulted in the creation of a risk factor based diagnostic tool that can identify from the start which patients are most at risk of developing complications. The additional funding will allow a feasibility study, in which the screening tool will be trialled in four hospitals on hundreds of patients.

FDA approval for surgical smoke clearing system

Medical technology company Alesi Surgical has secured FDA approval for its Ultravision system, allowing it to enter the US market. The technology, which featured in Advances Issue 71, dispels the vapour and particulate matter generated by surgical cutting instruments during abdominal keyhole surgery. By getting rid of this smoke, the system improves visibility for surgeons and also benefits patients as it minimises the amount of cold, dry carbon dioxide gas to which they are exposed. Dr Dominic Griffiths, Managing Director, said: "This is the next step after launching our new Ultravision Trocar product in Europe which integrates the benefits of Ultravision into a pen-like access device, used in over seven million abdominal keyhole procedures performed annually worldwide. The combination of these two major achievements places us in a strong position for 2017."

AIM listing for biotech company

Creo Medical has made its stock market debut after raising £20 million from investors. The small Chepstow-based company is developing a range of surgical devices that can dissect tissue while using special microwaves to staunch the blood flow. The devices are designed for use with an endoscope - a flexible tube, with a light and camera attached to it, which is inserted into the body through an existing opening. This enables doctors to carry out certain surgical procedures without needing to puncture the skin. Steve Smith of Finance Wales, an investor in the company, said: "Creo is an emerging med-tech leader and its CROMA electrosurgical platform is groundbreaking and has significant potential to improve the outcomes of a range of medical procedures."

Waste converted into bio-fuel and textiles

A biologist at Aberystwyth University has developed a new eco-friendly process to manage sanitary waste such as disposable nappies. Joe Freemantle's method involves intercepting the waste and using separation and refining technologies to allow for the recycling of valuable components. This reduces the amount of waste that goes to landfill sites and contributes to the build-up of greenhouse gas emissions. The waste is then processed to produce bio-fuel and pure cellulose fibre, which can be used to manufacture polymers. Joe's research was originally based on the concept of converting cigarette butts into biofuel and has led to the creation of start-up company Green Phoenix to commercialise the ideas.

Body farm experiments advance forensic science

New experiments at Glyndwr University's body farm are enabling forensic scientists to conduct research into how animal remains decompose.

The carcasses of pigs and other smaller animals have been placed in the facility, which is the first of its kind in Wales and located in a wooded area near the university campus. Some of the carcasses are buried in shallow graves, while others are inside bags or hung up from trees, and students are monitoring how they decay in these different settings and also in a variety of temperatures.

In the UK forensic scientists are not allowed to use human remains for these type of experiments, in contrast to the USA, and animals are a suitable alternative. Pigs were chosen because they are anatomically similar to humans, so the findings provided by the study will be comparable to human remains. As a result, they will be valuable to the police, helping them in criminal investigations and in other cases where bodies have been found.

The research currently being conducted offers forensic science students the opportunity to gain valuable practical experience and has also helped the university to establish links with other experts in the field. They work closely with a team of dog handlers who provide training for dogs in security and in forensic searches for explosives, drugs and human remains. Any data collected from the research will not only help improve reliability in searches for human remains but will also make the recovery and subsequent identification process a much swifter one.

"The research focuses on an area called forensic taphonomy which is essentially all about decomposition. It's about trying to learn what has happened to a body from the point of death to the point of recovery. This helps us determine something called post mortem interval - how long somebody has been dead for. It's really important for the police in terms of their investigation, because if we can say that a person has been dead for six weeks and somebody who is a main suspect has an alibi for six weeks ago, then we know they can be ruled out of the investigation."

Amy Rattenbury
Forensic science lecturer
Glyndwr University

www.glyndwr.ac.uk

New initiative supports aspiring neuroscientists

Neuroscience solutions provider Rogue Resolutions has launched the BrainBox Initiative to support the next generation of neuroscientists. Its purpose is to provide young researchers with a wide range of opportunities including hands-on, practical experience of neuroscience techniques, speaking at conferences, presenting posters, gaining recognition for their research achievements and getting support for new ideas. Andrew Thomas, Managing Director, said: "In 2016 we piloted a number of workshops and ran the first of our research challenge prizes. The feedback and response we got was overwhelmingly positive. The BrainBox Initiative builds on this success and represents a significant opportunity for the early-stage neuroscientist."

UK's first proton therapy centre to open in Newport

Work is underway on the UK's first proton beam therapy centre for cancer treatment, which will be located at Celtic Springs Business Park in Newport. Proton beam therapy is a more targeted form of radiotherapy, which can reduce damage to surrounding tissue and treat certain hard-to-reach cancers more effectively. It is estimated that around 10% of patients who receive traditional radiotherapy would be better treated with protons. South Wales-based Proton Partners International intend to build seven proton therapy centres (which will be called Rutherford Cancer Centres) in the UK and five internationally, with two currently being built in Newport and Northumberland and a third planned for Reading. In addition to proton beam therapy, each centre will offer traditional radiotherapy, chemotherapy, imaging and wellbeing services.

Awards for innovation in the Welsh NHS

At the most recent MediWales Innovation Awards, an annual event to celebrate success in the Welsh life science community, the organisers saw more applications from NHS organisations than ever before. The award for research excellence was won by Abertawe Bro Morgannwg University Health Board, who are working to establish an accurate blood based biomarker for diagnosis of colorectal cancer. Meanwhile the efficiency through technology award went to Lymphoedema Network Wales, who have acquired lymphatic scanning equipment to facilitate a unique type of plastic surgery. An award was given to the Bevan Health Technology Exemplars scheme, in which clinicians and companies are working together to bring new technologies into the NHS. Another collaboration award went to Rocialle and Cwm Taf University Health Board, who have created a single-use box that equips nurses to rapidly treat sepsis. The All Wales Genetics Laboratory received the judges' award for their new technology that enables non-invasive sampling of tumour DNA through the bloodstream.

FLEXIS energy project underway

The £24m Flexible Integrated Energy Systems (FLEXIS) project is led by Cardiff University, with Swansea University and the University of South Wales as principal sponsors. Aberystwyth University, Bangor University and the British Geological Survey are also involved. The five-year EU-backed project will look to solve a wide range of challenges, from energy storage to decarbonisation and fuel poverty. It will also explore how new, low-carbon energy sources can be integrated into the energy grid and how the grid itself can cope with extreme flows of energy into the system in numerous places and at random times. As part of the project, a demonstration site has been identified in the Swansea Bay area, centred at the TATA Steel Works in Port Talbot, to act as a test bed for new ideas and to showcase the new technology and energy solutions being developed.

Innovation Hub announced for new Swansea Bay campus

Swansea University has unveiled plans to collaborate with biopharmaceutical company Pfizer on an Innovation Hub at their new Bay Campus. The partnership will see Pfizer collaborate with Swansea University and other relevant partners on initiatives aimed at tackling challenges in the health sector. Erik Nordkamp, Manager Director of Pfizer UK, said: "Partnership working between the pharmaceutical industry, academia and the NHS is essential for tackling today's demands on the health system. Through sharing our different skills and expertise we really can make a difference to improving health outcomes for patients, developing new ways of supporting the provision of healthcare."

Salmonella succeeds in attacking cancer cells

Pioneering research from Swansea University Medical School has discovered that a harmless strain of the bacteria Salmonella could be used to deliver a new generation of better cancer treatments.

The mechanism at the heart of this new approach to fighting cancer is called RNAi, or RNA interference, which is a natural biological process that cells use to switch off or 'silence' the activity of specific genes.

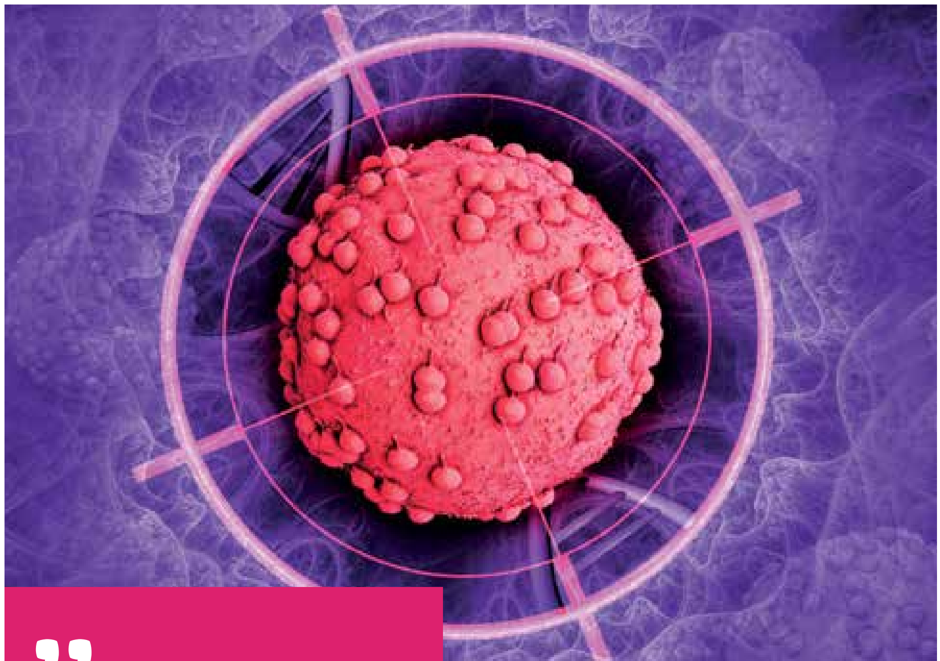
Swansea University's Professor Paul Dyson, who is leading the research, has previously harnessed this technology to create a pesticide-free weapon against insects that cause sleeping sickness and damage crops.

For several years, RNAi has been considered a high priority and a major funding area for the pharmaceutical industry as a potential cancer therapy. However, a significant challenge in this process is delivering RNAi specifically to cancer cells in the body while avoiding gene silencing in healthy cells.

It has been proven that certain harmless versions of Salmonella can target and grow in tumours inside the body. This is because the tumour environment provides essential nutrients that the bacteria cannot obtain in healthy tissue and also because the body's immune system is suppressed in the tumour. Professor Dyson and his team have now repurposed these bacteria to produce RNAi, which in turn can successfully reprogramme individual cancer cells to stop them growing. In contrast to chemotherapy and radiotherapy, this new and improved cancer treatment involving Salmonella would be non-toxic and target only the tumour, leaving healthy tissue unaffected. It could also require just a single dose to take effect.

Focusing on prostate cancer initially, the team has found that the modified strains of Salmonella are capable of stopping tumour cells from multiplying. There has also been progress in research into their effects on other types of cancer, with evidence that the technology can be applied to breast and colorectal cancer cells in vitro. The results of this work demonstrated silencing of the target genes - mainly 'oncogenes' whose activity drives cancer cells to multiply. In addition to stopping the cells dividing, they also lose the ability to migrate, which prevents the cancer cells from spreading.

This means that the therapy is capable of not just reducing tumours but also of stopping the spread of cancer to other parts of the body.



> "One dose of this treatment could be enough: that is the real breakthrough from the first phase of our research. We found that the bacteria multiply and continuously produce the therapeutic molecules which keep targeting cancer cells. This is very different from existing approaches to cancer, where repeated rounds of treatment are necessary."
>
> **Professor Paul Dyson**
> **Medical School**
> **Swansea University**

Profile

Product
Harmless strain of Salmonella bacteria

Applications
Reprogramming cancer cells to stop them growing and multiplying

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Creating a smart patch for osteoarthritis

A team from Cardiff University's School of Engineering are using aerospace technology to develop a 'smart patch' that will detect the early onset of osteoarthritis in knees.

When people suffer from osteoarthritis (OA) their damaged joints often make an audible clicking sound during movement, which is known as crepitus. However in the early stages of the disease, these rubbing noises are confined to higher frequencies that we are physically unable to hear.

Biomechanical and structural engineers at Cardiff University believe that sensors used in aeroplanes to detect damage could hold the key to capturing these noises and improving early diagnosis of OA.

The team are incorporating acoustic emission sensors, which are usually used to detect cracking sounds caused by damage in structures such as aircraft wings, into a thin patch to be worn on the skin. The smart patch will be able to pick up the specific sound signature of early stage OA, catching subsonic noises in joints before the disease fully develops. This could allow detection in a GP surgery or even at home through a self-monitoring app on a mobile phone or tablet.

As the structure being analysed (i.e. the knee) is much smaller and located in a less noisy environment than an aeroplane wing, significantly cheaper sensors can be used. The team are currently evaluating different low-cost sensors and determining the materials that will form the patch itself. They are also finding the best patch layout for detecting even the faintest signals coming from a joint. To decide whether it will be more suitable to have a fully disposable patch or a sterile single-use layer with ultrasound gel, they are now testing the sensors on an 'artificial skin' made of a particular gel formulation which will simulate how the sound is affected by different skin thicknesses. This will enable them to try different sensors and patch designs quickly and easily, before the patient trial stage.

Once the smart patch design is complete, it will be trialled with volunteers at Cardiff University's Arthritis Research UK Biomechanics and Bioengineering Centre. Here, state-of-the-art motion capture, MRI and dynamic fluoroscopy facilities allow researchers to fully understand how and at which point of the joint motion a particular sound is made and to determine whether it is correlated to disease. It is estimated that a patch prototype will be ready within a year, with the realistic possibility of a commercial product being available for use in seven or eight years.

Arthritis Research UK estimates that 8.75 million people in the UK have sought treatment for OA. A smart patch has the potential to save millions of pounds spent on diagnosis via X-ray and MRI scans, in addition to improving the lives of patients through targeted, bespoke treatments.

> "The idea has got huge potential to change the way we diagnose osteoarthritis. If we're able to separate the sound signature of a healthy knee from a knee with disease, we will be able to lower the diagnostic cost on society by a large amount."
>
> **Dr Davide Crivelli**
> **School of Engineering**
> **Cardiff University**

Profile

Product
Smart patch

Applications
Detecting and monitoring osteoarthritis in knees

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New technology detects lung disease

PulmonIR, a spin-out-company from Swansea University, has developed a new technology to better diagnose and monitor the common lung condition Chronic Obstructive Pulmonary Disease (COPD).

The primary cause of COPD is cigarette smoking or exposure to tobacco smoke, but can also occur as a result of inhaling other noxious materials. The lungs of people with COPD have narrowed airways due to damaged tissue and inflammation. Consequently it becomes more difficult to move air in and out, so symptoms include breathlessness, wheezing, a persistent cough and frequent chest infections.

Although COPD is irreversible, its progression can be slowed down by treating its symptoms. Methods of managing the condition include quitting smoking and using an inhaler or medication to make breathing easier. If left untreated it can become exacerbated, leading to hospitalisation. Nearly 60,000 Welsh people are affected by COPD and in 2015 there were 1,920 COPD related deaths in Wales – an increase from 1,614 in the previous year. To put this into perspective, there were more than double the number of deaths from COPD across Wales in 2015 than there were from breast cancer and from prostate cancer. Some regions of Wales also have a higher than average prevalence of COPD compared to the rest of the UK. The burden to the patient and NHS Wales is significant with over 10,000 hospital admissions per year and an average hospital stay of nine days.

Research from Professor Paul Lewis at Swansea University Medical School and the School of Management has found that by shining beams of infrared light onto a sample of sputum (coughed up mucus), COPD can be detected. This newly developed technology has the potential to speed up diagnosis and improve monitoring of the condition, thereby saving lives, lowering the number of hospital admissions and reducing treatment costs in the NHS.

> ”
>
> “Where COPD is present, the surface of molecules within a sample of sputum contains a specific configuration of sugars. We discovered that by shining beams of infrared light onto a sample, you could detect COPD from the unique frequencies of light bouncing off these sugars. We found that if a patient has COPD or if their condition exacerbates then the molecular structures of these sugars change and absorb different frequencies of light. This provides unique biomarker profiles for patients in a non-invasive way. This technology could allow health professionals to test and diagnose COPD patients in as little as ten minutes.”
>
> **Professor Paul Lewis**
> **Swansea University**

The technology is being taken forward commercially through the recently formed spin-out company PulmonIR and clinical trials in collaboration with Cwm Taf University Health Board are almost complete. These trials are being used to validate high-throughput testing of patient samples in the laboratory, to field test portable infrared spectrometers and to compare the clinical results obtained against spirometry, which is the currently accepted clinical ‘gold standard’. Following completion of the clinical trials, PulmonIR will seek the necessary approval to launch commercial products.

Profile

Product
Infrared technology

Applications
Detecting and monitoring Chronic Obstructive Pulmonary Disease

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Spider silk enhances microscope

Scientists from Bangor University have achieved a world first by using spider silk as a superlens to increase the potential of a microscope.

The physical laws of light make it impossible to view objects smaller than 200 nanometres, which is the smallest size of bacteria, using a normal microscope. Nevertheless, scientists have long been looking for superlenses that enable us to see beyond this level of magnification.

Following recent work in which they broke the perceived resolution barrier using a nano-bead-derived superlens, a team at Bangor University's School of Electronic Engineering has now found a way of doing the same with spider silk. This marks the first time that a naturally occurring biological material has ever been used as a superlens. Led by Dr Zengbo Wang, the team discovered that when dragline silk of a golden web spider is applied to the surface of the material to be viewed, it provides an additional two-three times magnification. The work was completed in partnership with Oxford University's Department of Zoology.

> "We have proved that the resolution barrier of a microscope can be broken using a superlens, but production of manufactured superlenses involves some complex engineering processes which are not widely accessible to researchers. This is why we have been interested in looking for naturally occurring superlenses provided by 'Mother Nature' which may exist around us, so that everyone can access superlenses."
>
> **Dr Zengbo Wang**
> **School of Electronic Engineering**
> **Bangor University**

The natural cylindrical structure of spider silk made the material an ideal candidate for research. Compared to spherical lenses, it has advantages in the extended field-of-view along its length. In a similar way to how we look through a magnifying lens, the team looked through silk spinned from the golden web spider with a microscope and discovered that objects beneath the silk were magnified by a further two-three times.

By using the silk as a superlens, the scientists were able to view details on a micro-chip and a blu-ray disc which would have otherwise been invisible using an unmodified optical microscope. Therefore, the new superlenses could be used for seeing structures that were previously classed as invisible, such as engineered nano-structures and biological micro-structures, as well as certain native germs and viruses. For potential commercial applications, a spider silk nanoscope would be robust and economical, which in turn could provide excellent manufacturing platforms for a wide range of applications.

In addition to spider silk, the team believes there are more new superlenses to be found in nature and is currently collaborating with a biology team at Queen Mary University of London to investigate the possibility of using bacteria as an optical superlens.

Profile

Product
Golden web spider silk

Applications
Increasing the potential of microscopes

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New candidate for cystic fibrosis infection control

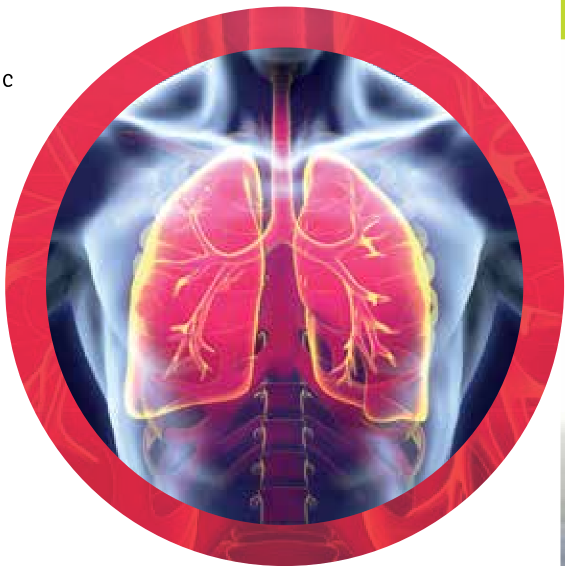
Neem Biotech has developed a natural compound to tackle the chronic lung infections that are the biggest cause of death for adults with cystic fibrosis.

Cystic fibrosis is a rare, genetically inherited disease that compromises the ability of epithelial cells to maintain an appropriate level of hydration. This results in them drying out, becoming inflamed and secreting an abnormally thick, sticky mucous.

Varying degrees of severity exist in cystic fibrosis and all epithelial layers can be affected, although the lungs and digestive tract often attract the most attention. In the respiratory system, the presence of this genetic mutation increases susceptibility to bacterial lung infections, particularly those caused by Pseudomonas aeruginosa. This opportunistic bacteria can be present to no visible effect in many otherwise healthy individuals, but becomes a problem for people with cystic fibrosis who have compromised immune systems.

There is currently no cure for cystic fibrosis and sufferers have almost every aspect of their lives affected by their condition. In particular, chronic lung infections have a significant impact on their quality of life and wellbeing. The most recent UK figures indicate that chronic lung infections occur in 54% of adults with cystic fibrosis. Once chronic (occurring more than three times within six months), P.aeruginosa-caused infections are difficult to clear and are merely maintained at a low level of activity, with intermittent flare-ups that may or may not require hospitalisation.

The current standard of care treatment for these lung infections is the prescription of antibiotics. They are prescribed to treat acute episodes of infection, also known as exacerbations, as well as preventatively in between chronic exacerbations. Consequently, someone can end up taking several kilograms of antibiotics over the

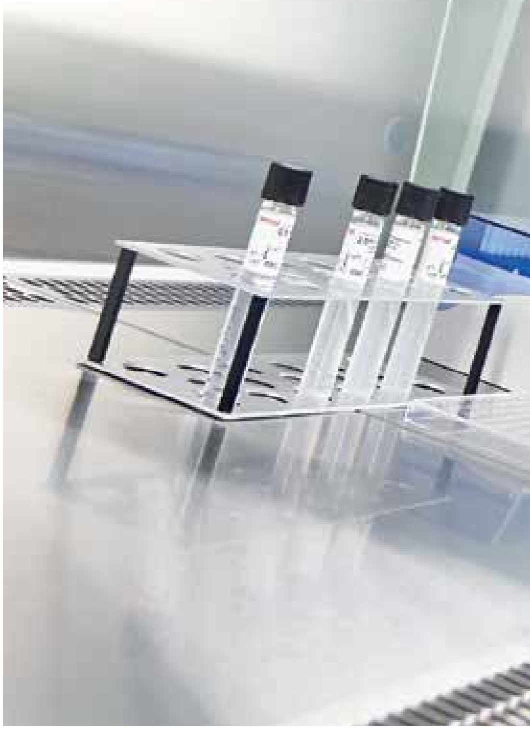


course of their life, exposing them to side effects and contributing to the ongoing development of antimicrobial resistance. The rise of 'superbugs' can be attributed to this phenomenon, as bacterial infections are becoming increasingly impervious to the drugs prescribed against them.

Neem Biotech's NX-AS-401 is a small molecule sulphur compound that has proven capability to aid in the treatment of chronic lung infections caused by the P.aeruginosa bacteria. It has the potential to improve quality of life for people with cystic fibrosis, in addition to countering antimicrobial resistance, and is effective when used in combination with existing antibiotics.

A range of antibiotics are conventionally used in an attempt to cure bacterial infections. They have different mechanisms of action on bacterial cells and their success depends on the match between their mechanism of action and the bacterial

Epithelial cells make up the outside layer of tissue that lines every open surface of the body, inside and out, including the various tunnels and cavities in the lungs and liver.



> "To explain how our lead compound works, I would make an analogy between the trench warfare of World War I, where heavy artillery was used and destroyed everything in the vicinity of where it landed, and more modern combat where more selective targeting is possible, disrupting the enemy's communications and bringing about the destruction of their protective barriers. In combination with routinely used antibiotics, NX-AS-401 can lengthen the effective life of these antibiotics for treating chronic P.aeruginosa lung infections in cystic fibrosis."
>
> **Michael Graz**
> **Managing Director**
> **Neem Biotech**

strain's susceptibility to them. Over time, however, bacteria have developed ways of blocking these mechanisms of action through changes to their genetic structure. This means that the bacteria become resistant to the antibiotics used against them, with the antibiotics becoming less effective at best or sometimes not effective at all.

The novel compound developed by Neem Biotech is able to increase the potential impact and effectiveness of existing antibiotics that are of relevance to cystic fibrosis.

It works by increasing opportunity for these antibiotics to act on the P.aeruginosa cells that are prevalent in chronic lung infections. NX-AS-401 has been shown to have a significant effect on reducing the harmfulness of these cells, working against the process that is allowing infections to establish and maintain themselves in the lungs of cystic fibrosis sufferers. It has received Orphan Drug Designation from the United States FDA and preparations are underway for a first-in-human clinical trial.

Profile

Product
Small molecule sulphur compound

Applications
Aiding in the treatment of chronic lung infections suffered by people with cystic fibrosis

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World first 3D mammary gland

Researchers from Cardiff University's School of Biosciences have created a three-dimensional mammary gland model that will pave the way for a better understanding of breast cancer.

A detailed knowledge of normal mammary gland development, as well as the mechanisms that drive its molecular, cellular and hormonal regulation, is fundamental to an understanding of how breast cancer starts and progresses.

In-vitro culture systems involving breast cells and tissues have contributed significantly to research into mammary gland biology. However, they have thus far been unsuitable for long-term, ongoing research as scientists have been unable to maintain them for more than 14-21 days. A team of scientists from Cardiff University and the Monash Biomedicine Discovery Institute in Melbourne, Australia, have now found a way of creating a more life-like, long-lasting organoid for use in breast cancer research.

The team grew mouse mammary cells in a scaffold material to generate 3D mammary tissue. The resultant organoids mimic the structure and function of a real mammary gland. This enables further exploration of how breast tissue develops, including the roles played by hormones and genetic influences. Although scientists have been able to experiment on breast cells and tissues at a 2D level, hormone regulation – a crucial aspect of breast tumor development – cannot be reliably captured with cells on a dish.

"Much of how breast tissues respond to external stimuli such as hormones is, as yet, unknown. In order to fully tackle the mechanisms that lie behind breast cancer we first need to understand how healthy breast tissue develops. As such, developing a model of a normal breast with the actual architecture of a mammary gland has long been a 'Holy Grail' for cancer researchers."

Professor Trevor Dale
School of Biosciences
Cardiff University

In addition to growing these realistic mammary glands, the team also discovered how to maintain them for several months. This enables more detailed, long-term studies and analysis to be conducted. It is hoped that the organoid will ultimately provide an active model for the study of disease and drug screening, which could help scientists to get quicker approval for new breast cancer drug treatments.

Organoid = an artificially grown mass of cells or tissue that resembles an organ.

Profile

Product
3D mammary gland model

Applications
Understanding mammary gland biology and breast cancer

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Microbes carve out a niche for themselves

Researchers at Aberystwyth University's Institute of Biological, Environmental and Rural Sciences (IBERS) have developed a new way of identifying how different types of microbes can survive when competing for resources in the same environment.

Niche specialisation is the process by which, through natural selection, a species becomes better adapted to the specific characteristics of a particular habitat.

Understanding niche specialisation in microbial communities could enable scientists to engineer them in order to achieve desired outcomes. However, while processes such as competition are known to occur among microbes in these communities when resources are limited, identifying the signatures of niche specialisation has always been a challenge.

Dr Francesco Rubino and Dr Chris Creevey from IBERS worked with the Agriculture and Food Development Authority in Ireland on a study to identify the genes and functions that play an important role in maintaining niche specialisation. This involved examining the microbial community found inside the rumen of cattle. The rumen is a forestomach evolved by certain animals, such as cows and sheep, that allows partial microbial digestion of food before it enters the main stomach.

Microbes inside the rumen of cattle are vital to the agricultural industry as they allow the conversion of grass into meat and milk. However, they are also a major source of methane, the second most significant greenhouse gas in the UK, so researchers are keen to understand how this complex microbial community works and to find ways of reducing its environmental impact.

The rumen microbial community is a highly competitive, anaerobic environment for microbes, with limited nutrient availability determined by the biomass consumed by the cattle. In the new study, genomic information was taken from the microbes in the rumen of 14 cattle that were part of the same herd, living on the same unrestricted diet of grass silage. The researchers used novel computational biology techniques to look for signatures of specialisation in the microbial community.

Through the study, the scientists were able to identify the specific functions that are important for each microbe to maintain its niche within the rumen microbial community. For example, they identified the genes that have allowed the two largest groups of bacteria in the rumen (the Prevotella and Clostridia) to undergo specialisation to the extent that they no longer compete for the same resources. This specialisation has resulted in a co-operative process where both are necessary to fully degrade the grass consumed by the host.

> "We were looking to identify what resources different microbes compete over when they are present in the same environment. Developing such an understanding is essential to meet many of the major challenges facing human society today, such as management of natural ecosystems and mitigation of climate change. Despite the large numbers of studies that had been generated from the microbial populations found in the gut, the soil, the sea and human skin, we were still lacking a clear understanding of the ecology of the micro-organisms that have an essential role to play in everything from human health to earth system processes."
>
> **Dr Chris Creevey**
> **IBERS**

Microbes (or micro-organisms) are living things that are too small to be seen by the human eye without the use of a microscope. There are various types with different characteristics and they can be put into groups including fungi, bacteria and viruses.

These findings have opened new avenues for research into manipulating the rumen microbial community to achieve desirable outputs, such as increasing efficiency and reducing the amount of greenhouse gases emitted by cattle. They will also allow researchers to identify niche specialisation, as well as the microbes needed for specific functions, in any other microbial community.

Profile

Product
Novel computational biology techniques

Applications
Examining niche specialisation in microbial communities

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Game-changer recycling machine for hospital waste

Engineers at Thermal Compaction Group have created a new technology for the management of clinical wrap waste generated by hospitals. The recycling system, called Sterimelt, is the first of its kind for the healthcare industry.

Clinical wrap is a non-woven polypropylene wrap used to maintain the sterility of medical instruments and equipment. The material can also be used as bed sheets (and as curtains) on wards and as covers in the operating theatre.

A significant amount of hospital waste from operating theatres is clinical wrap. The majority of it is uncontaminated and therefore non-hazardous, however, it is currently co-mingled with contaminated wrap which then puts it into the category of hazardous waste. This means that it requires specialist handling, is significantly more expensive to remove than non-hazardous waste and usually gets disposed of by incineration or landfill.

Sterimelt allows hospitals to deal with clinical wrap waste on site with a more efficient, compliant and sustainable system. In the process of manufacturing clinical wrap, dense beads or pellets of plastic are melted to make the finished product. The innovative machine, which is comparable to a large oven, reverses the manufacturing process by applying carefully controlled heat to re-melt the clinical wrap. It becomes a liquid that can flow into a mould cavity, creating a dense block of plastic. As a result, the size of the waste is reduced by up to 90 per cent.

The plastic blocks produced by the machine are sterile, so they can be categorised as non-hazardous waste and are consequently easier and cheaper to recycle. They even have commercial value, due to the fact that they can be granulated for reuse in the manufacturing of new products such as furniture. Therefore in addition to reducing the amount of money that needs to be spent on specialist waste disposal, the system opens up a new revenue stream for the NHS who can sell the product for profit.

In effect, the system works like an electric skip. After one button is pressed manually, it then processes the waste automatically. At the end of the cycle, the solidified material is removed and the machine is refilled to start the process again. It does not release any harmful gases during operation and a comprehensive filtration system is used to reduce polyaromatic odours, which are harmless but could be a source of complaint for people who work or live in its vicinity if left unfiltered.

The technology has undergone a successful year-long trial in collaboration with Aneurin Bevan University Health Board. A machine installed at St Woolos Hospital in Newport was found to be capable of a minimum of six cycles per day, and by processing clinical wrap waste from Newport's Royal Gwent Hospital alone, it produced 90-100 kg of sterile plastic blocks daily and recycled around two tonnes of wrap every month. Introduction of the machine has enabled the health board to make significant cost savings and generate extra revenue through sale of the plastic blocks. The technology won in the Success Through Innovation category at the 2016 Welsh Business Awards and the company behind Sterimelt believe it could eventually be adopted worldwide.

> "This is the first of its kind in the world. The trial has shown that we can take the wrap as waste, reduce its volume substantially, render it inert and then re-introduce it to the supply chain. The Welsh NHS is taking a close interest in what we are doing and other hospitals are very keen to embrace the technology."
> **Tim Hourahine**
> **Technical and Compliance Manager**
> **Thermal Compaction Group**

Profile

Product
Clinical wrap recycling machine

Applications
Reducing hospital waste and the cost of its disposal

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Turning roofs into solar energy generators

BIPVco, based in Deeside, is integrating solar cells into roofs with no need for heavy, bulky panels.

Large industrial, commercial and residential properties consume vast amounts of energy and emit huge quantities of CO_2, but produce no energy themselves. BIPVco has developed a technology that enables a solution to be built into the very fabric of buildings, turning them from passive, energy-consuming entities into active energy generators.

Traditional BAPV (building-applied photovoltaics) systems use relatively heavy, bulky solar panels that are mounted on top of roofs after the construction of buildings is complete. In contrast, BIPVco's technology allows solar cells to be integrated directly into the substrates that make up roofs. This means that inbuilt photovoltaic functionality can be achieved, so there is no need to resort to heavy, often unsightly mounting systems. In addition to being less obtrusive than roof mounted panels, the new solar roofing can be installed on buildings that would be otherwise unable to withstand the weight.

BIPV (or building-integrated photovoltaics) refers to photovoltaic materials, which convert light directly into electricity, being used to replace conventional materials in parts of a building such as the roof.

The company makes use of solar cells with CIGS (Copper, Indium, Gallium, Selenide) thin-film technology to convert sunlight into energy. Compared to the crystalline-based technology used in BAPV systems, CIGS is more flexible and durable. It also performs better in low light conditions, requires fewer materials and less energy to manufacture and needs very little maintenance.

The technology can be incorporated into both flat and curved roofs for new build houses, factories and commercial units or retrofitted using a 'peel and stick' product. In the manufacturing process, power-generating CIGS layers are sputtered (i.e. deposited using fast ions) on a stainless-steel foil of 50-micron thickness in a unique roll-to-roll continuous process. These layers are very thin, creating a stack which adds up to a total of 2.5 microns, with some layers in the stack being as thin as 0.8 microns. To put this into perspective, a human hair is typically 75 microns thin.

The use of a unique current pick and interconnect system, which requires no soldering, allows for a massive surface at the interconnect area to enhance energy harvesting capabilities and reduce internal resistive losses. Whereas a typical silicon-based photovolataic module has just three diodes, the new designs typically contain a minimum of 56 cells and 28 diodes, thereby improving performance in shaded conditions.

BIPVco began life as a research project run by Tata Steel, and it was through collaborative research with SPECIFIC led by Swansea University that ways of incorporating solar cells with CIGS technology into roofs were identified. The technology has now been put to the test in several pilot projects, such as Swansea University's eco-friendly Active Classroom, designed and managed by SPECIFIC, which was featured in Advances Issue 80. As its first commercial project, the integrated solar roofing has been installed on a brewery in Nigeria owned by SAB Miller, who chose the solution based on its energy-saving capabilities, simplicity to set up and resistance to theft in comparison to conventional solar panels.

In 2016, the company won Solar Technology of the Year and Clean Tech Start-up of the Year at the Business Green Technology Awards and was invited to present its technology in the BBC Royal Institution Christmas Lectures. To prepare for the future, the company has engineered its solutions to be adaptable, so that they can incorporate the next generation of emerging photovoltaic technologies such as Perovskite.

Profile

Product
Integrated solar roofing

Applications
Generating solar energy with no need for bulky roof panels

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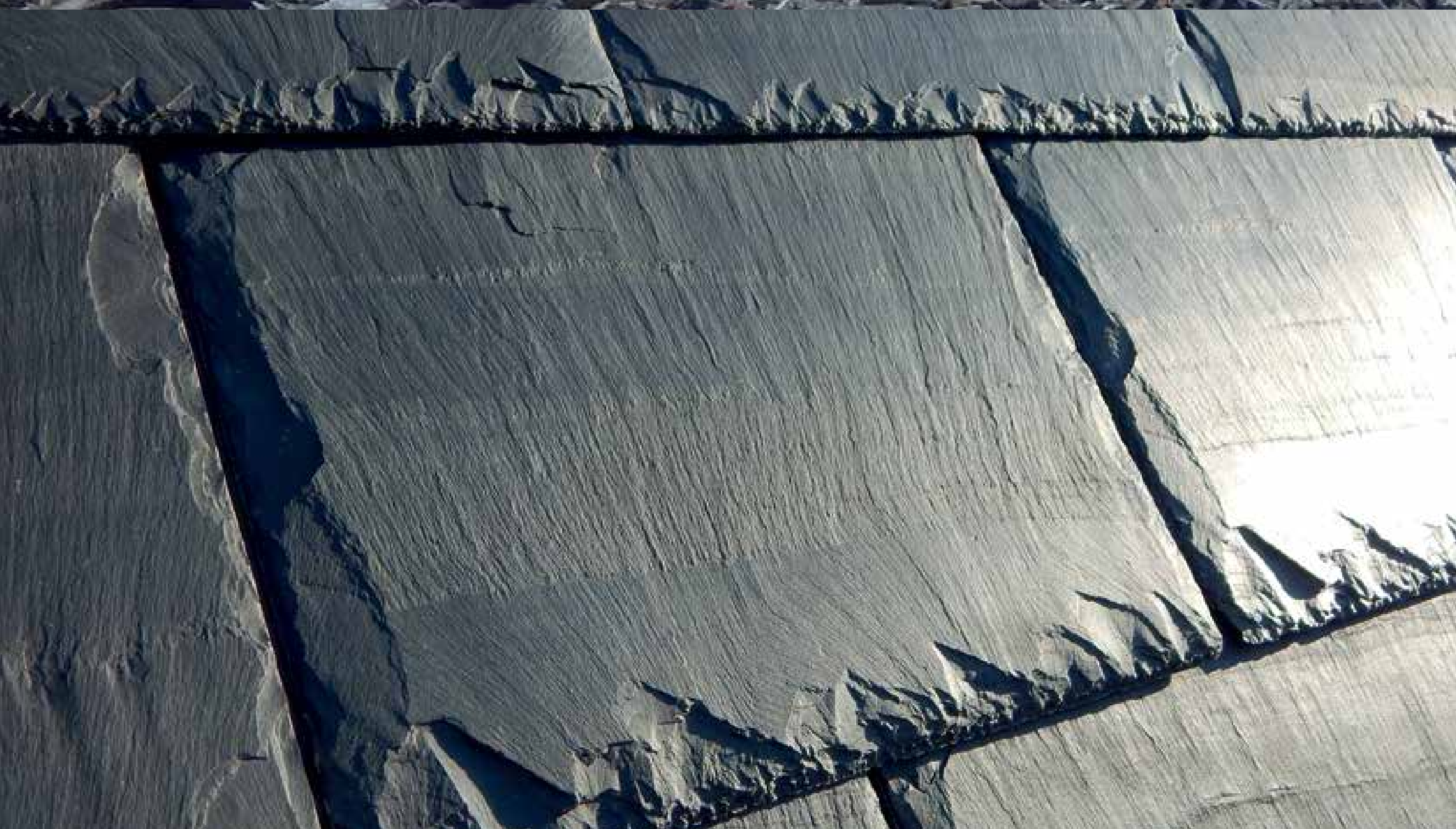
Waste slate recycled for new, snap-fit roof tiles

Carapace Slate is recycling Welsh slate to produce sustainable roof tiles with a more efficient fitting system.

The domestic construction industry is experiencing consistent growth, with output across the UK projected to increase by seven per cent each year up to 2020. However, there is a skills shortage within the industry and it is estimated that only seven per cent of roofers required to meet growing demand will be recruited and trained by the end of the decade. As a result, the sector is in need of new construction methods to improve productivity and address this skills shortage.

To help bridge the gap between the required housing output and the workforce available, Carapace Slate has designed a new system that enables general builders and labourers, who are not trained roofers, to efficiently and competently install roof tiles. It significantly reduces the installation time for non-skilled workers when compared to the traditional



materials and methods used by skilled roofing professionals, providing a significant boost in productivity.

The system involves the world's first snap-fit roof tile. Each tile self aligns and fully interlocks with a six-point nail-free fixing mechanism, lowering installation time from around 45 minutes to just one minute per square metre. This presented an initial manufacturing challenge, as a simple snap-fit fixing method requires a complicated geometry to function. Composite roof tiles are often manufactured using a polyester resin compound with DMC moulding, which is generally used for parts with uniform thickness but not suitable to create the depth and angles needed for the interlock. Another challenge was finding a material that would be strong enough to resist any weather thrown at it while also having a thin, capital grade 5.5mm thickness.

Working with an industrial chemist, the company developed a new rapid-cure epoxy resin and composite production technique that is only moderately viscous when heavily loaded with slate particles. This allowed them to use a new process, which can be described as a hybrid between RRIM and injection moulding, creating parts at high volume with advanced mechanical characteristics. The end product is identical to hand-cut Welsh slate, which the company believes will pass the strict restrictions in many of the 2,000 conservation areas across the UK.

The new type of slate is environmentally friendly, as it is made from over 80 per cent surplus slate and processed through a low-power, low-carbon manufacturing technique. An estimated 500 million tonnes of slate is currently lying discarded in North Wales slate mountains, due to the area's industrial past, and this could be recycled instead of going to waste. The new tiles can be considered a direct substitution for the low-cost roofing materials that the UK imports from countries such as Spain, China and Brazil. Consequently they could support local supply chains, as well as reducing the costs and the carbon footprint associated with transporting heavy goods across the world.

> "Although we have the ability to replicate any roof tile, we think it is important to help revive one of the world's most desirable and now elusive roofing products. Wales has played host to some of the largest slate quarries and mines in the world, with many being in almost constant operation for centuries, but only a few are now left standing. We see an opportunity to build on the legacy of Welsh slate by reforming the discarded waste material back into its intended form."
> **Martyn Lucas**
> **Managing Director**
> **Carapace Slate**

Profile

Product
Sustainable, snap-fit roof tiles

Applications
Making use of waste slate and reducing installation time

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App cooks up independence for brain injury sufferers

Healthcare technology company SymlConnect is developing an app that helps patients with brain injuries to cook independently.

People living with brain damage can find it difficult to complete tasks that they used to find straightforward before sustaining their injury. This is often evident in cooking, as they may struggle to follow recipes and lose track of what they are doing. Swansea-based SymlConnect is creating an app in partnership with Glyndwr University to support brain injury sufferers in this area. The aims of the project are to promote independence in cooking tasks and develop a solution that benefits brain injury service users and also public services.

The app called MASCOT (Mobile Analysis and Support Companion for Occupational Therapy) provides service users with step-by-step recipes which have clear, detailed instructions and visual aids. Each recipe begins with a list of necessary items to be ticked off as they are found and then guides the user through every step of the process. A task as simple as making a cup of tea can be challenging for a brain injury sufferer, so this is one of the options that it is possible to be guided through. More advanced options include cooking a spaghetti bolognaise or a chicken curry.

In contrast to recipes on paper or online, the app gives very specific instructions to limit the need for decision-making. It also allows occupational therapists to customise the steps to ensure that appropriate explanations are provided. This enables improved focus, which in turn reduces the risk of confusion. By helping people with acquired brain injuries to cook on their own, without needing others to prompt them, their feelings of self-confidence are

improved. The rehabilitation process is therefore enhanced as they regain some of their independence.

Occupational therapists are able to control the images and text that their patients view on the app, so they can tailor the content for each individual user's learning style or cognitive ability. For instance, if they feel that any of the instructions are not quite clear or descriptive enough, they can easily modify or add text. The app has an existing bank of images, but occupational therapists have the ability to add their own pictures or even insert pictures from a service user's own kitchen to support recognition. This means that in order to further prevent confusion, they can take photos of the cooking equipment that a patient actually owns and include these in the activities. They also have the option to add reminders and safety tips to recipe stages, such as '20 minutes is up so remove your food from the oven now' and 'remember to switch off the oven'.

After the service user has completed a task, they are asked to provide feedback on whether they found it easy or difficult to follow. The occupational therapists have access to this self-assessment information, so can identify which of their patients are struggling the most and plan their time accordingly. For example, if a particular patient is finding even the simplest recipes difficult, their occupational therapist will treat them as a priority, whereas patients who are finding most tasks simple will need less attention. The app enables occupational therapists to monitor their patients remotely, reducing unnecessary home visits and therefore saving valuable time.

The app currently has a library of ten recipes, which were chosen and developed by a lead occupational therapist from Glyndwr University, and this will be expanded in the future as new recipes are added by occupational therapists during their routine visits. There are also plans to pilot the app with charities, where carers and relatives would control the content of the recipes, allowing more flexibility. Furthermore, the app could be adapted for use in the future with patients suffering from other conditions such as dementia.

Profile

Product
Recipe app

Applications
Helping brain injury sufferers and their occupational therapists

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Aeroplane lighting innovation takes off

Technology developed by STG Aerospace is improving the aeroplane passenger experience, while also increasing efficiency for airlines.

The company's saf-Tglo emergency exit marking solution illuminates the floor path inside the aircraft cabin, glowing in low light or dark conditions and clearly displaying the exit ways for passenger safety.

Traditionally lighting up in neon green, the new system is the first photoluminescent floor path marking system to have a blue glow. In addition to having a calmer, more soothing quality, research has shown that the blue wavelength offers an enhanced perception of the floor path to a human eye that has adapted to the dark. This means that it improves the appearance of the cabin without compromising passenger safety. In daylight, the base colour is also whiter than in traditional systems so a wider, brighter colour palette is provided in ambient light.

The floor path marking system is designed to simultaneously store and emit light and can therefore provide a visible emergency exit path after just a short charge period during normal cabin lighting. No electric power source is required and it can be fully charged within minutes. As a result, airline maintenance and operational costs are reduced through increasing reliability and eliminating delays and cancellations due to failed electrical egress lighting (the lighting which is on at all times). The next-generation blue-glowing system won in the Best Cabin Innovation category at the 2016 APEX Awards and has received approval for use in almost all Boeing and Airbus aircraft models

Further advances for the aeroplane passenger experience are being provided through liTeMood LED reading lights, which are designed to give users more privacy. Instead of having a circular light source, their unique photometric design delivers a square light pattern that precisely defines individual passenger space, while preventing unwanted light spill onto neighbouring passengers. They reduce glare and feature a multi-phosphor LED with a high Colour Rendering Index in excess of 95. This creates a more pleasant ambience than traditional fluorescent lighting and renders colours more clearly, making inflight magazines, meals and retail products more visually appealing. The reading lights also deliver an 80% power reduction to increase aircraft electrical efficiency.

The new lighting technologies have been developed at the company's Innovation and Engineering Centre in Cwmbran, which opened in 2015.

Profile

Product
Cabin lighting for aeroplanes

Applications
Providing a better passenger experience and increasing airline efficiency

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