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THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY

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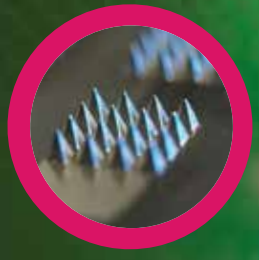
Repelling pests with nature's chemicals

Scientists at Cardiff University have discovered a new, sustainable approach to creating pest control agents in the ongoing global drive to replace pesticides.



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

THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY

advances WALES

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

This edition of Advances Wales features the development of a groundbreaking urine test for diet tracking (page 7), a sustainable manufacturing process for a sugar substitute (page 13) and a device that turns standard beer kegs into digitised smart containers (page 20).

Scientists at Welsh universities are also working to create a novel way of eradicating crop pests (page 16), convert hazardous medical waste into clean hydrogen fuel (page 14) and improve the efficiency of motors used in electric vehicles (page 15).

As efforts to fight Covid-19 continue, innovations in this edition include a world-first smart device that can both deliver the vaccine and monitor its effectiveness (page 6), as well as AI software that can detect the virus in chest X-rays and evaluate its severity (page 8). Meanwhile, researchers have been exploring the possibility of using microwave ovens to decontaminate PPE on the frontline (page 10) and a Welsh tech start-up has developed apps that help vulnerable people to understand the pandemic guidelines (page 19).

This edition of Advances Wales can be viewed online, along with past editions.

Sophie Davies
Editor

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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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Ocean scientists help to position giant wind farm

Scientists at Bangor University are playing a critical role in paving the way for one of the world's biggest wind farms off the coast of North Wales.

They are working with German renewable energy giant RWE on the siting of the Awel y Môr extension, which will more than double the size of the Gwynt y Môr wind farm. The university's expertise in 3D mapping the seabed is crucial in plotting the location of the giant turbines and in helping to plan for the next generation of deep water wind farms. Much of the data and resultant imagery used by RWE has been gathered from the university's survey ship Prince Madog, based at Menai Bridge, which spends 40 days a year on expeditions around the Welsh coastline to map the seabed. This activity will play a key role in the UK Government's green ambitions to power every home in the country with wind energy by 2030.

"Awel y Môr is a huge development, but for the Government to reach its renewable energy targets we will need many more wind farms, including into deeper waters. We need to ensure these developments are cost-effective yet sustainable for the seabed and the animals it supports. Offshore wind is going to be vital in this accelerated schedule to provide low-cost clean power because it is tried and tested – we know the technology works."

Dr Katrien Van Landeghem
Bangor University

The Gwynt y Môr wind farm's turbines stand 150 metres above the sea and generate 576 megawatts of electricity. Awel y Môr will add a further 200 turbines.

www.bangor.ac.uk

Insect-based food on the research menu

Aberystwyth University and BIC Innovation are contributing to an international project, ValuSect, which aims to improve the sustainable production and processing techniques of insect-based food products.

Insects are a common feature of people's everyday diets in countries around the world such as Mexico, China and Ghana. These insect-based foods offer a more environmentally-friendly source of protein than many other foods, and could be used to help feed the world's growing population.

ValuSect seeks to increase the number of consumers willing to eat insect-based food by improving the quality of insect production and processing, carrying out consumer tests, and reducing its environmental impact. Research will focus on the emission of greenhouse gases, the impact of substrates, food safety, and the shelf life of insect-based food products.

Aberystwyth University and Pencoed-based BIC Innovation are working with partners from six other countries in the North West region of Europe. The project will use species that already have an application running for authorisation under the EU novel food regulation.

"Whilst insect-based food products are still a niche market, there is a growing acceptance that insects will be part of a future sustainable diet, capable of feeding the world's growing population at a time of increasingly scarce agricultural resources. This project will help Welsh small and medium-sized businesses collaborate with leading experts from across North West Europe, and innovate and commercialise new products ensuring access to this new market."

Linda Grant
Director of Food Projects, BIC Innovation

www.aber.ac.uk

Six-figure investment for health tech firm

Health & Her has received a six-figure investment to revolutionise the way in which women manage symptoms associated with the menopause.

The Cardiff company's menopause health hub provides women with cutting-edge products, leading expert advice and clinically novel insights via an ecommerce website, a telehealth service and an app. It also offers a free online menopause symptom tool and tracker, along with qualified information on the menopause from UK experts.

"Menopause can be life-changing for so many. By empowering women to consider body, mind and lifestyle – and giving them the tools to improve their experience – we hope to really change millions of lives for the better. In fact, the research we've done has helped us understand just how complex menopause experiences and symptoms can be. It is really important that we constantly change and improve Health & Her by listening to the women we serve. It's about finding the best ways to reach all women and making products and services more accessible. In a world of ever-changing communication methods and media trends, we need to make it really easy for women to find, use and feel supported by what we have to offer."

Kate Bache
Co-founder and Chief Executive
Health & Her

www.healthandher.com

IN BRIEF

Investment boost for medtech firm

Cardiff-based Bond Digital Health has received £1 million investment from Wealth Club and £200,000 from the Development Bank of Wales. This will help to fund further business growth, product development and expansion into new global markets for the medical technology specialist. Bond's connectivity and data platform, Transform (which featured in Advances Issue 93), collects and stores data from lateral flow diagnostic tests. A version of Transform is currently in-market, digitising and powering a Canadian client's Covid-19 rapid antigen test. Dave Taylor, chief operations officer of Bond Digital Health, said: "Our purpose has always been to help people be better with data. This funding is a fantastic recognition of our hard work and shows a strong belief and confidence in our forward mission as a business."

Sewage-to-fuel project gets green light

A project to convert sewage into a zero-emission fuel has been awarded £60,000 by Innovate UK and is set to go ahead in Wales. The project will involve converting biogas waste into hydrogen fuel, which can then be used to power zero-emission vehicles. Biogas is produced through bacteria breaking down sewage sludge in large tanks. Welsh Water is running the project in collaboration with technology company Costain and local authorities in south Wales. In addition to producing clean energy, it is hoped that the technology could be used to power the water company's entire fleet of vehicles with hydrogen fuel, which would save around 9,000 tonnes of carbon being released into the environment. The project will also explore demand for hydrogen vehicles, particularly for council waste collection vehicles, HGV tractors and buses.

Funding granted to develop in-space manufacturing

Newport-based company Space Forge Ltd has been awarded Welsh Government EU funding to to develop in-space manufacturing via Chemical Vapor Deposition. The start-up intends to harness the unique environment of low Earth orbit, including ultra-high vacuum, low external temperatures and high quality microgravity, to create new and better materials than those which can be made on Earth. Back on Earth, these new materials could increase the efficiency of technology and significantly reduce CO_2 output in energy intensive sectors. With the funding, Space Forge Ltd will undertake an early prototyping and space qualification phase of its in-orbit manufacturing payload for creating next generation electronics in space. If the initial industrial research phase is successfully completed, then an experimental development phase may begin.

Researchers to explore personal data ethics

Bangor University is working with Cufflink, a start-up based at the M-SParc Science Park which aims to revolutionise how people store and share personal data. The university team seeks to understand the ethical issues around personal information management systems, and find ways to empower users to easily and safely manage their own personal data and info. The researchers will investigate the role that personal data storage apps could play in rebalancing the data economy back in favour of citizens. Professor Andrew McStay from Bangor University explained: "With the modern world being based on personal data about people, it's time we made sure that personal data works for people, not against them. We're looking forward to finding out what Cufflink's app can mean for the average citizen who has better things to do than read lengthy T&Cs."

Wearable tech in development for railway workers

Lab by Transport for Wales, the rail-dedicated innovation programme, has seen a second cohort of start-ups bring new ideas to enhance the railway customer experience in Wales. After a day of pitching to TfW decision-makers, Spatial Cortex was chosen as the winner and awarded £25,000 to develop their product further. The proposed product, MOVA, is a wearable technology for railway staff to help reduce manual handling injuries when undertaking tasks such as lifting and carrying. Barry Lloyd, Head of Customer Experience and Innovation at TfW, commented: "Demo day was a fantastic showcase of the talented companies we have been working with. Judging all eleven was a tough task, but we felt that Spatial Cortex have the potential to be a real innovation in rail and have a huge impact, not just for us, but for the whole industry. Emu Analytics and Route Konnect (which featured in Advances 89) also fully deserve to be highly commended for all their hard work in the development of some brilliant solutions for us."

Boost for lighting technology to grow crops indoors

Experts in photonics at the University of South Wales are working with indoor horticulture business Nutralight to help improve the efficiency of its systems.

Nutralight is a Pencoed-based LED manufacturer which specialises in smart lighting, sensing and control solutions for the indoor horticultural market. Smart horticultural lighting is integral to self-sustaining vertical farms, which are expected to revolutionise the indoor horticulture industry. The company designs and manufactures lighting strips that illuminate crops, enabling them to grow in indoor environments.

As part of the Centre for Photonics Expertise (CPE), a project involving several Welsh universities, research fellows at the University of South Wales are helping to develop Nutralight's systems. Using knowledge of photonics (light-based technology) and modelling, they are specifically looking at ways to minimise the loss of light, in order to ensure the systems are as efficient as possible.

Peter Rees from the University of South Wales explained: "When you're looking at indoor horticulture, every little percentage point of power matters. The lights are running for many hours each day and are quite energy consuming, so there is a lot of benefit to be gained even by small improvements in the efficiency."

CPE aims to accelerate business growth by working together with industry to support the development of processes, products and systems. Its team draws on leading academic capabilities, offering light-based technological solutions to businesses across Wales at no cash cost to the company.

www.southwales.ac.uk

Farming research to address climate challenges

Researchers at Aberystwyth University are collaborating on an international project to help farmers adopt more innovative agricultural approaches that will make them resilient and adaptable to external challenges. Throughout the four year project, researchers will work with European farmers to help them implement a mixed farming approach, which is more efficient and mitigates the impact of climate change. Academics from the Institute of Biological, Environmental and Rural Sciences (IBERS) and the Department of Psychology at Aberystwyth University are collaborating with 19 academic and industry partners from 10 European countries on the project. Its objective is to drive the development and implementation of European Mixed Farming and Agroforestry Systems (MiFAS) which optimise productivity and resource use. The project will consider the impacts on crop and livestock production, livestock health and welfare, soil structure and fertility, carbon sequestration and biodiversity.

New service to support health tech developers

Health Technology Wales has launched the new HTW Scientific Advice Service. The expert consultancy service will support technology developers in Wales to demonstrate value that meets the needs of care commissioners, care providers, patients and service users. Matthew Prettyjohns, Principal Researcher at Health Technology Wales, said: "We're really pleased to start providing the HTW Scientific Advice Service to developers. We know from speaking to tech developers that this is an area where they would appreciate more support. We aim to support them to overcome barriers to market access by helping them to consider the best types of evidence, identify gaps in their existing evidence, and take the next steps to bring a product to market. This could be useful for companies at various stages of their development. Crucially, our input will help them to save time and resources, too."

Cardiff academics to tackle Covid-19 challenges

Cardiff University has won £1 million in Sêr Cymru research grants to tackle the challenges of Covid-19. The fourteen awards span the university's three colleges and focus on a range of solutions, from using novel catalysis for the disinfection of surfaces to the continuity of digital learning in Wales. The largest awards include funding to explore novel technologies for point-of-care genetic testing for SARS-CoV-2 and work to develop Active Virus Filtration Membranes. Education Minister, Kirsty Williams, commented: "Welsh universities have been at the forefront of the response to Covid-19, developing solutions to the myriad challenges the pandemic has presented. Cardiff University's projects are founded on expertise across a broad spectrum disciplines, from virology and immunology to diagnostics and behavioural science, offering real potential in the fight against virus."

Welsh tech start-ups named rising stars

Five start-ups have been named regional winners for Wales in Tech Nation's Rising Stars 3.0, a scale-up competition for early-stage tech companies across the UK. The Welsh regional winners are: Immersity, which designs realistic V-learning and V-experience scenarios to train people faster, more effectively and at a lower cost; Iungo Solutions, which connects employers, training providers and policy makers to democratise excellent careers for everyone; Nightingale, which is building a marketplace of data and AI services for manufacturers; Tendertec (featured in Advances Issue 90), which is creating the next generation of personalised safety and care technologies for the post Covid-19 era; and Yoello, which is an app-less hospitality payment platform that allows customers to simply scan, order and pay. The 10 overall winners will be announced at the Rising Stars 3.0 Final which will be held on 25 February 2021.

Awards for innovation in life sciences

Winners have been named at the fifteenth annual MediWales Innovation Awards, which celebrate outstanding achievements in the Welsh life science and health technology communities. Many organisations received recognition for their work in response to the pandemic. NHS awards were given to the teams behind the NHS Wales Video Consulting Service, the Welsh Clinical Portal mobile app and the national Covid-19 hospital guidelines, as well as the team that set up the Oxford vaccine study in Wales. Industry awards went to companies including CanSense (which featured in Advances Issue 91) for creating a diagnostic that can detect cancer using a simple blood sample, Llusern Scientific for developing a rapid Covid-19 test (which featured in Advances Issue 93), and Hybrisan (which also featured in Advances Issue 93) for developing a novel surface and hand sanitiser.

Smart device to deliver vaccine and monitor response

Researchers at Swansea University are developing the world's first smart device able to both deliver the Covid-19 vaccine and measure its effectiveness.

The research from Swansea University's Institute for Innovative Materials, Processing and Numerical Technologies will produce the vaccine through the use of microneedles to create a 'smart-patch'. This device will simultaneously measure a patient's inflammatory response to the vaccination by monitoring biomarkers in the skin.

Microneedles are tiny needles designed to break the skin barrier and deliver medicines in a minimally invasive manner. A classic example is the transdermal nicotine patch, which delivers nicotine through the skin to help people give up smoking. They provide a safe and effective method to deliver vaccines, with additional advantages such as requiring lower vaccine doses, permitting low-cost manufacturing, and enabling simple distribution and administration. A microneedle delivery patch is easy to apply, allowing for a personalised vaccination approach.

The project is led by a team of researchers with expertise in the use of microneedle arrays for transdermal therapeutic drug delivery and diagnostic applications. They will build on these distinct technologies by developing the first dual functionality microneedle-based Covid-19 smart-patch. Skin vaccination using microneedles has been described as a superior immunisation approach due to, for example, its potential to overcome immune tolerance observed in pregnancy. There are also lower vaccination costs through antigen dose-sparing, which is especially relevant in underserved countries.

The goal is to create a smart vaccine delivery device that can not only deliver the Covid-19 vaccine transdermally, but also monitor biomarkers in the skin compartment in a minimally invasive way, offering real-time information on the efficacy of the vaccination. This new method would change the way in which vaccine efficacy trials are performed, from a statistical assessment to a scientific measurement of patient inflammatory response to vaccination.

The real-time nature of the platform will mean rapid results, allowing faster containment of the Covid-19 virus. It could help to ensure a safe return to work and effective management of subsequent outbreak waves.

"Beyond the pandemic, the scope of this work could be expanded to apply to other infectious diseases, as the nature of the platform allows for quick adaptation. We are currently getting the platform ready and we hope to do human clinical studies on transdermal delivery with our existing partners at Imperial College London, in preparation for final implementation."

Dr Sanjiv Sharma
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Swansea

Simple urine test improves diet tracking

Scientists at Aberystwyth University have developed a groundbreaking urine test which can detect more than 50 different types of foods in a person's diet, as well as consumption levels of alcohol and nicotine.

The test works by measuring chemicals known as biomarkers in urine, which are created by the digestion of individual foods or from the breakdown of nicotine or alcohol in the body. It allows clinicians to check the quality of a patient's diet, without relying on the patient to accurately record everything they have consumed.

Foods currently targeted include red meats, poultry, fish, cheese, fruit, vegetables, wholegrains and pulses which are highlighted in the 'Eatwell Guide' used by health organisations across the UK. The test can also monitor exposure to foods which should be consumed in moderation, such as chocolate, sugar-rich confectionery, baked goods and coffee, and can give a general picture of the amount of protein eaten.

The original prototype laboratory test was developed for clinical trials by researchers from Aberystwyth University, Newcastle University and Imperial College London. The team at Aberystwyth's Institute of Biological Environmental and Rural Sciences (IBERS) has now expanded the test to include the simultaneous measurement of more than 50 biomarkers for specific foods and for smoking (including vaping) and alcohol consumption.

Monitoring examples include older people who often lack sufficient protein in their diet, patients convalescing after surgery, malnutrition in developing countries and in the homeless in the UK, individuals at risk of developing Type 2 diabetes, or diet quality during pregnancy that affects childhood obesity.

For the general population, the test could be used as part of health improvement programmes to monitor dietary intake, as well as smoking and drinking behaviour. Evidence suggests that people often inaccurately record their own diets, and under-report unhealthy food while over-reporting fruit and vegetable intake.

The test will make it easier to collect reliable information on what people eat without the need for laborious, time-consuming questionnaires or diaries. It will create a better understanding of the links between food and health, so that better healthy eating advice for the public can be developed.

> Modern diets are so complex, with many people frequently consuming meals they have not prepared themselves. With thousands of different products available on supermarket shelves, it is not surprising that most people have difficulty reporting accurately what they eat. The use of food intake biomarkers to measure exposure to key dietary components takes away much of the guesswork."
>
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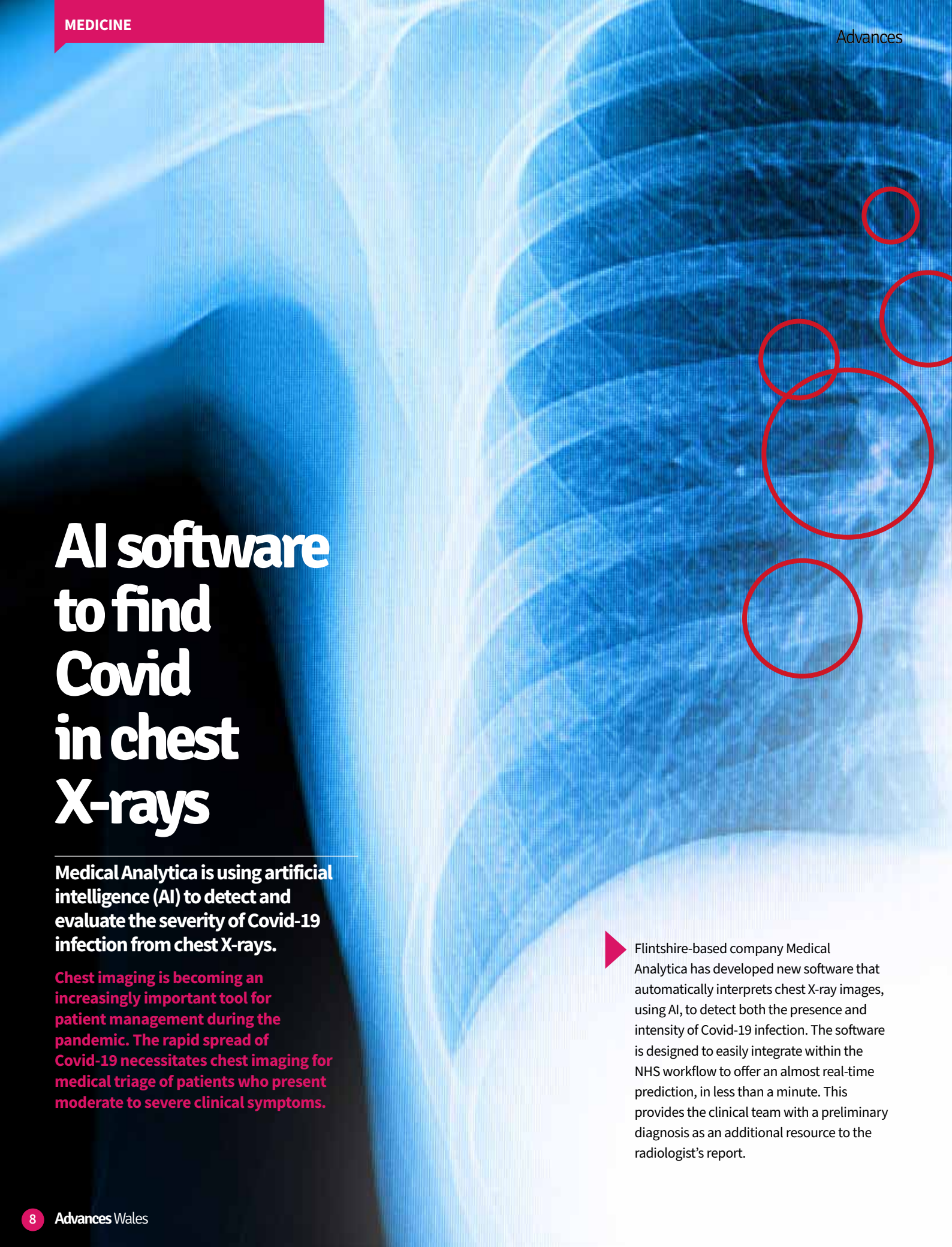
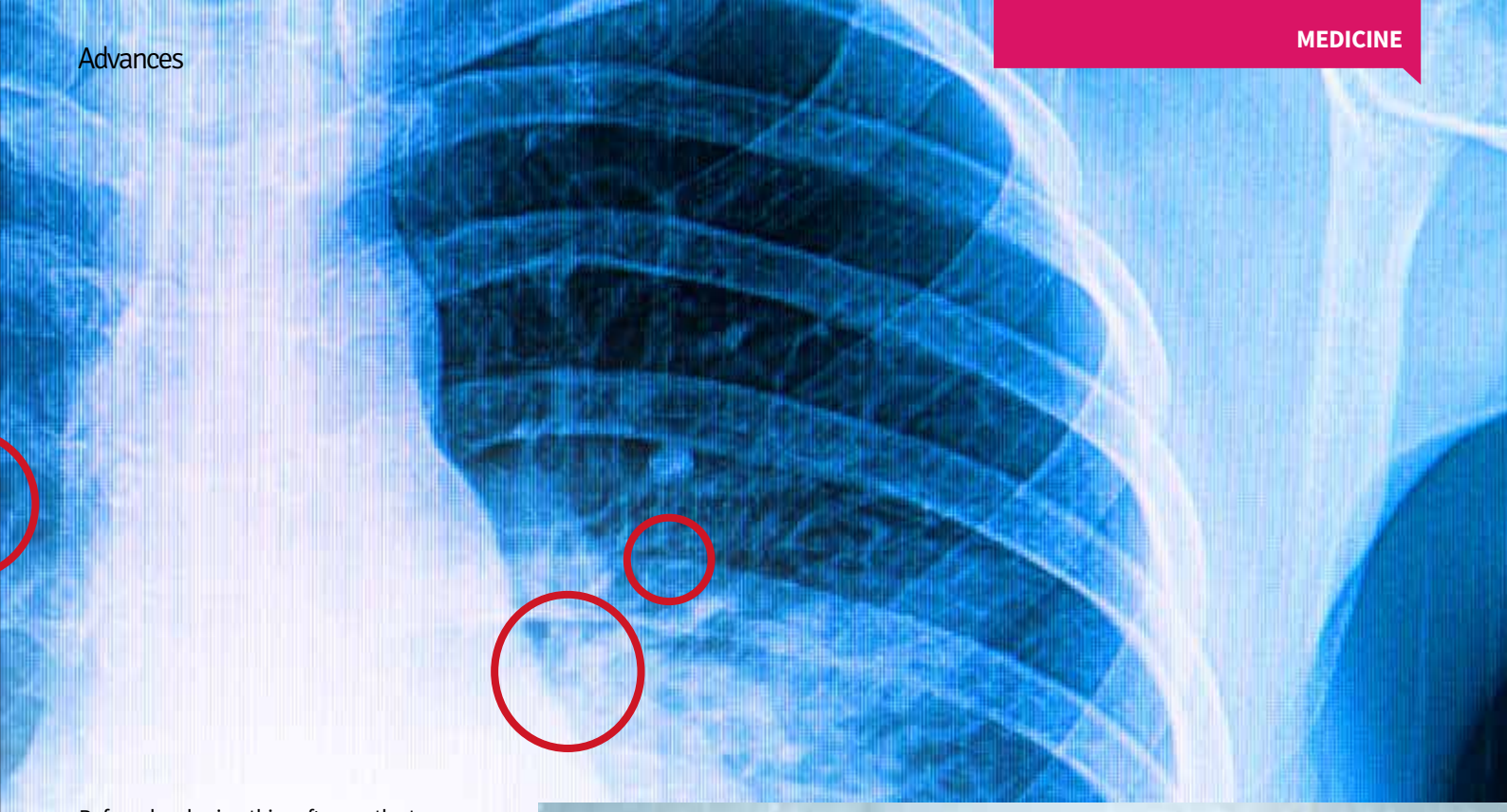


AI software to find Covid in chest X-rays

Medical Analytica is using artificial intelligence (AI) to detect and evaluate the severity of Covid-19 infection from chest X-rays.

Chest imaging is becoming an increasingly important tool for patient management during the pandemic. The rapid spread of Covid-19 necessitates chest imaging for medical triage of patients who present moderate to severe clinical symptoms.

Flintshire-based company Medical Analytica has developed new software that automatically interprets chest X-ray images, using AI, to detect both the presence and intensity of Covid-19 infection. The software is designed to easily integrate within the NHS workflow to offer an almost real-time prediction, in less than a minute. This provides the clinical team with a preliminary diagnosis as an additional resource to the radiologist's report.



Before developing this software, the team was working on AI-based solutions to differentiate between malignant and benign tumours in Ultrasound and CT scans, as well as X-ray images. The new tool for Covid-19 detection is also able to identify other chest conditions at the same time, such as pneumonia, COPD and cardiomegaly.

During the pandemic so far, chest X-ray images have rarely been a reliable tool for detecting Covid-19 infection. A key feature of the new software is its dependency on a supervised training approach, which requires specialised skills and a wide range of mathematical models capable of extracting the unique feature of each condition. It is a labour-intensive approach, but it leads to more reliable predictions and a minimum level of false results. Early tests examining images from the National Covid-19 Chest Image Database (NCCID) have demonstrated significant accuracy in differentiating Covid-19 infection from other chest conditions.

Chest X-ray interpreted by the software can provide a preliminary indication to the most likely cause of a patient complaint. Therefore, it has the potential to be a vital tool in speeding up patient triage to the relevant specialist management pathway. This would improve the patient experience and enable the NHS to more efficiently direct its resources.

The company's goal is to provide extra support for the thinly stretched healthcare professionals working through the pandemic. They aim to provide a practical, effective tool that makes maximum use of X-ray machines which are available in community hospitals and health centres around the country.

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Flint

Finding the key to reusing PPE

Researchers from Cardiff University have been testing the feasibility of using microwave ovens and dry heat to decontaminate PPE.

Shortages of adequate PPE put frontline workers and patients at risk of contracting coronavirus. Respirators and face masks are usually considered to be single-use items, so researchers from Cardiff's School of Pharmacy & Pharmaceutical Sciences and the School of Engineering are trying to find a way of safely disinfecting them for reuse.

The team has discovered that certain types of respirators can be effectively decontaminated in just 90 seconds using an industrial-grade microwave oven and a baby bottle steriliser containing water. Therefore, microwave decontamination could potentially be used in emergency situations to address PPE supply issues.

In the study, respirators were exposed to three microwave disinfection cycles and were shown to retain their ability to filter bacteria and viral-sized aerosols. However, surgical masks are known to lose effectiveness once they become moist, and the team found that microwaving them led to a complete loss of their aerosol filtering capacity.

The researchers investigated using dry heat ovens as an alternative approach. Dry heat sterilisation does not involve any water, so it is compatible with items that are damaged by moisture. Exposure to 70°C dry heat for 90 minutes was found to be effective in decontaminating both surgical masks and respirators. After three dry heat cycles, both types of mask retained their aerosol filtering properties.

Whilst microwave-generated steam and dry heat were both shown to kill coronaviruses, the team wanted to ensure that these methods were also effective against bacteria encountered in healthcare environments. For this reason, they purposely contaminated respirators and surgical masks with Staphylococcus aureus, a bacterial species highly prevalent in human airways which can cause soft tissue infections and sepsis. Staphylococcus aureus is the accepted biological indicator to test the integrity of a mask. Results demonstrated that both methods effectively reduced the number of bacteria on masks to a safe level.

As a result of the study, the team has developed a protocol to determine which types of PPE would be suitable for different treatments with dry heat incubators or microwave ovens. They warn against members of the public using a similar approach at home, because domestic microwave ovens differ in many ways.

> "Mask and respirator models vary considerably and so it is important to ensure the method of decontamination does not compromise their function. Considering the advantages and disadvantages of each approach, we have proposed a reprocessing workflow that practitioners could follow in healthcare settings. Reusing existing PPE could buy vital time during emergencies and save lives."
>
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Cardiff

New sewage treatment fights antibiotic resistance

Researchers led by a University of South Wales expert have found a new way to fight the global health challenge of antibiotic resistance.

The team, led by microbiologist Dr Emma Hayhurst, has discovered that putting the remnants of sewage treatment, known as sewage sludge, through a pressure cooker-like treatment can help to remove antibiotic-resistant bacteria.

Sewage treatment is normally carried out in an anaerobic digester, which breaks down organic matter, such as sewage sludge, into methane gas and fertiliser. A drawback of this process is that it does not remove all of the antibiotic-resistant bacteria. Therefore, they can make their way back into the environment when the fertiliser is used in agricultural processes.

However, the research team found that the resistant bacteria can be killed off by first using a process called thermal hydrolysis and heating the sewage sludge to 160 degrees, in what has been compared to a giant pressure cooker. This development is vital because antibiotic resistance has been identified as one of the world's biggest health challenges. Some estimates say that the issue could lead to more than 10 million deaths across the world each year by 2050.

There are still some challenges to overcome, because in the original anaerobic digestor process, certain types of resistant bacteria and resistant genes appear to multiply and spread rather than disappearing.

Researchers are now looking into how certain conditions are allowing for this bacteria to grow and flourish, meaning they end up with more than bacteria than when they started.

Waste water treatment plants act as gateways for the release of environmental pollutants, with millions of tonnes of sewage, carrying large amounts of resistant bacteria and their DNA, all coming together in one place. By treating this sewage effectively, it is possible to effectively 'close the gate' and prevent their release.

"If sewage sludge is not treated effectively then it is released back into the environment, and from there it can transmit back into humans. Using anaerobic digestion as a stand-alone treatment does not work as efficiently as it could. Our research shows, however, that by adding thermal hydrolysis to the process, you get rid of almost all of the bacteria, including the ones that have a resistance to antibiotics."

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Pontypridd

Manufacturing a sustainable sugar substitute

ARCITEKBio has a created a new process to produce xylitol from a sustainable waste stream.

Healthy eating and nutrition are important in an increasingly health-conscious society. Refined sugar accounts for around 20 per cent of all calories consumed by people, and sugary diets are causing a myriad of health problems. Xylitol, a sugar substitute, can alleviate some of the harmful effects related to sugar use, but current methods of commercial xylitol production rely on an unsustainable, energy-intensive process.

Xylitol is a sweetener found naturally in fresh fruit. It has a like-for-like sweetness to sugar, contains 33 per cent fewer calories, inhibits tooth decay, and is metabolised independently of insulin in the body. Although it is present in some fruit and plants, the quantities are so low that it is not economically feasible to extract it commercially.

ARCITEKBio, a cleantech company formed out of Aberystwyth University, has developed a process called EcoXyL to provide a state-of-the-art, sustainable method of xylitol production. The new process utilises sugars typically associated with waste streams from multiple sectors, such as farming, forestry, paper and pulp, brewing and advanced biofuels. Using proprietary microorganisms, these waste sugars are converted into xylitol via a fermentation-based approach, followed by a series of purification steps.

Industrial production of xylitol currently relies on chemical synthesis, which requires a high temperature, high pressure and heavy metal catalysts, making the process unsustainable. It also requires extensive raw material clean-up, as well as multi-step crystallisation and purification resulting in poor product yields of less than 40 per cent sugar capture. Issues with regulatory compliance and raw material availability have often resulted in supply shortages and consequently increased prices.

Using proprietary microorganisms which are robust and have proven efficacy for industrial production, the new process requires minimal or no raw material clean-up. The process also yields high product outputs per batch and has low conversion times. This results in lower cost of manufacture for cost-effective and sustainable production.

The company has now completed industrial pilot-scale trials to generate first prototypes, evaluate process efficacy at closer-to-manufacturing scale and de-risk commercial deployment. EcoXyL is designed to work both as a stand-alone or as a bolt-on process to existent manufacturing.

By providing a more eco-friendly, reliable xylitol supply, the innovation will have a range of benefits. People would have the opportunity to purchase more sustainable products and contribute towards mitigating climate change.

Widespread availability of this sugar substitute, and increased awareness of its benefits, could help to reduce health issues such as obesity and Type 2 diabetes.

For applications such as production of chewing gum, chocolate, confectionaries and pharmaceuticals, EcoXyL-derived xylitol provides an option for sustainable sourcing with consistent product supply. Since the manufacturing process can use leftover feedstock from agriculture, there is likely to be a trickledown effect, translating into better value for farmers. There is currently no manufacture of xylitol in the UK, so a home-grown technology can circumvent import needs. Ultimately the company aims to curtail the global sugar epidemic and promote more sustainable living.

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Aberystwyth

Recycling medical waste to produce clean fuel

A team led by Swansea University is developing a new technique that uses sunlight to convert hazardous medical waste into clean hydrogen fuel.

The NHS spends around £700 million per year disposing of medical waste. The Covid-19 pandemic is creating vast amounts of additional waste, due to the need for masks and other protective equipment.

A joint Wales/India team, led by Swansea University researchers, is developing a novel process called photoreforming. This uses sunlight to simultaneously kill viruses and convert non-recyclable waste into clean hydrogen fuel. The researchers are now actively looking for industry partners to commercialise their technology.

The process works by using nanostructured semiconductors to drive the degradation of waste and pathogens with sunlight. This new research builds on the team's previous work generating hydrogen from waste plastics.

Currently, medical waste is disposed of via incineration. In contrast, photoreforming does not generate greenhouse gases and works at ambient temperature. In addition to producing hydrogen fuel, the process can also generate organic feedstocks for the chemical industry.

The team includes epidemiology experts from India's King Institute of Preventive Medicine & Research and Thiruvalluvar University, who are helping to examine the photocatalysts' antiviral activity against different pathogens, including SARS-CoV-2, the virus that causes COVID-19.

The simplicity and low cost of photoreforming make it easier to implement in countries that do not have an established recycling system. By turning this hazardous waste into a resource, the technology could provide a commercial incentive to collect waste and prevent littering in the first place.

"Since the outbreak of the Covid-19 pandemic, we have witnessed a global surge in single-use medical waste and PPE polluting the environment, such as disposable face masks littering beaches. Applying our technology to reprocess just 1 per cent of this waste would save millions and mitigate pollution at the same time."

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Swansea

Advancing the design and development of electric motors

Engineers at the University of South Wales are working to improve the efficiency of motors used in electric vehicles.

With 27 per cent of UK greenhouse gas emissions currently coming from road transportation, the challenge of finding alternative, electric solutions has never been more urgent in the race to address climate change. As well as the benefit to public health, there is an increasing need to improve the air quality in many towns and cities, where road transport emissions are one of the biggest contributors to localised pollution.

In the UK, there are ambitious targets to stop the sale of fuel-based cars and vans, and to only allow electric vehicles to be sold from 2030 onwards. It is hoped that this will help the UK to achieve net zero carbon emissions by 2050.

Electric vehicles have advanced greatly in recent years. The core component of an electric vehicle is the electric motor, but it needs to be highly efficient and lightweight, and to generate low amounts of heat and noise. Achieving this is not straightforward, and there are a number of challenges in the manufacturing process that still need to be addressed in order to optimise the efficiency of an electric motor.

The University of South Wales is leading a £1.44 million project with six industrial partners to design and develop a high-performance motor, using various novel techniques, that will also create a revolutionary supply chain for electric vehicle motor manufacturing in Wales and the UK. Working with TATA Steel, Motor Design Limited, Dragon Laser Limited, Wiltan Limited, Batten and Allen Ltd and the Welsh Automotive Forum, the i-CORE project is investigating new materials, manufacturing processes and techniques for novel designs.

Engineers are exploring the manufacturing of ultra-thin electrical steel, material handling and novel laser cutting technology, and new bonding material and interlocking methods for laminations. To further optimise the manufacturing process, they are also looking at additive manufactured (3D printed) lightweight polymer based motor components. With the motor that is being designed and built, the team aims to produce optimal performance with a high amount of power and torque (rotational force), whilst still being small and lightweight enough to be viable in a standard-size vehicle.

The project will also look at developing a new supply chain that covers the entire electric motor commercialisation process, from motor design and component manufacturing to performance optimisation and assessment. This novel supply chain is expected to not only strongly support the 2030 goal of full electrification, but also create a new driving platform for other applications, such as trains, buses, marine and aviation.

> “To achieve net zero carbon by 2050 will require a huge effort across the entire supply chain, as fuel-based transport is phased out and electric vehicles and motors become the new norm. The i-CORE project seeks to develop solutions that will support this aim, in addition to developing a new supply chain for electric motors in Wales.”

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Pontypridd

Repelling pests with nature's chemicals

Scientists at Cardiff University have discovered a new, sustainable approach to creating pest control agents in the ongoing global drive to replace pesticides.

Traditional pesticides currently act as broad-spectrum toxicants, meaning that both pests and non-pest insects can be affected by the treatment. There is a growing belief among scientists that semiochemicals could be key to eradicating pests of major crops around the world in a more sustainable way, because they can precisely target only the species that is causing harm.

Semiochemicals are signalling chemicals used to carry information between living organisms. The most prominent example is a pheromone, which is emitted by members of a species to modify the behaviour of other members of the same species.

Pest insects mostly use their sense of smell to recognise the presence of pheromones, as they detect and avoid unsuitable ecosystems. This sense of smell is extremely specific in detecting semiochemicals amongst a range of other chemicals present in the environment. Consequently, the current approaches to designing pesticide alternatives are not successful when applied to them.

The team from Cardiff University's School of Chemistry has developed a novel approach to create variations of semiochemicals in the lab using naturally occurring chemicals, and done so in a way that makes the process more predictable and suitable for large-scale production. The approach is based on fermentation, which takes natural products produced by an organism to make products that are useful to humans. It is currently being scaled up for production to protect high-value lettuce crops from aphids in Spain, through a commercial collaboration based in Cardiff.

So far, the team has produced an aphid repellent derived from pest-damaged plants which has been shown to successfully repel a range of pests. They were also able to modify the repellent so that the activity was reversed, resulting in a powerful aphid attractant. This idea of being able to both 'push' and 'pull' a pest away from the crop holds massive potential, as it means that pests can not only be repelled but also guided away to target other areas such as crop waste.

In addition to applying the novel process across Europe, the approach is also set to expand into research against major crop pests worldwide. These include whitefly and sand flies, which are vectors associated with human disease in South America, Asia and sub-Saharan Africa.

“Natural products have traditionally been obtained by extraction or by chemical synthesis in the laboratory, but such methods can be operationally difficult and expensive. Our new method uses enzymes produced naturally by fermentation.”

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Cardiff

Harnessing data to optimise agriculture

Agxio has created a machine learning platform using artificial intelligence (AI) to make big changes in agriculture.

In recent years, many industries have been transformed through the availability of large volumes of data, which can provide valuable insight and inform better decisions. However, processing and making sense of this data can take a huge amount of time, expertise and effort, so there is a need for digital systems to make it quicker, easier and more intuitive.

Exploring real-world applications of AI in agriculture, Aberystwyth-based startup Agxio has developed a fully automated, AI-driven machine learning platform called Apollo. The platform is able to deploy 'automated data science robots', which can evaluate data to produce predictive models that solve real-world problems. These models are then optimised to look for patterns or configurations of parameters that human modellers may not even consider or have the patience to develop. The platform is data agnostic, which means it has a broad range of uses, and it is being deployed in areas including animal and plant disease detection, market surveillance, parasitology analytics, and Controlled Environment Agriculture.

The system is designed to focus on problems that are beyond human scale in dimension or complexity. Typically a problem may have tens, or even hundreds, of millions of data points that must be analysed during the data modelling phase. In addition, there are tens of thousands of different machine learning models that may need to be considered before finalising the selection of the model. The range of permutations of these models and the inherent complexity within the data makes this a 'beyond human scale' problem. The machine learning platform automates this process and can generate what would normally take a human weeks or months to achieve in just minutes or hours. In addition, while humans naturally tend to have biases, Apollo does not have any, and it intuitively automates a number of the critical steps required in AI.

The platform enables farmers, researchers and policymakers to harness and safely share their on-farm data, in-lab results, models and best practice. It democratises data and creates a data network topology that can be shared globally, thereby advancing research opportunities and the ability to transform business and operating models.

One application is within the company's Centaur platform, to create a command centre for advanced decision making in agriculture. It allows farmers to deliver more sustainable, in-season precision agriculture for both traditional and non-traditional farming. Applications include yield optimisation, predictive disease monitoring, field mapping, crop selection, livestock health monitoring, field trials, sustainability metrics, drone analytics, regulatory surveillance, and bio-tracking.

Deployment of this system would help to boost yields for farms, reduce and manage disease, and ensure safety in the food chain. It also has potential applications outside agriculture, and could be a powerful tool in areas such as fraud analytics, disease detection, economic anomalies and bio-sequencing.

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Aberystwyth

Apps simplify Covid-19 guidance for vulnerable groups

Starfish Labs has developed a series of mobile apps that help people with Special Educational Needs and Disabilities (SEND) to understand the impact of Covid-19 on society and on their day-to-day lives.

As regional lockdowns and laws are frequently changing throughout the pandemic, it can sometimes be hard to decipher the rules for different parts of the UK. For people who have learning difficulties, who often rely on structured daily routines, these changes can be even more confusing and disruptive to daily life.

Most existing information on Covid-19, as well as generic advice on hand washing, sanitising, face coverings and social distancing, does not take into account people with SEND and how they will understand the guidance. The new apps from Aberystwyth-based Starfish Labs are designed to address Covid-19 support for people with learning difficulties. They have been developed in conjunction with SEND educationalists and a public health doctor, ensuring that the content is effectively simplified and presented.

To make the pandemic guidance easier for users to understand, custom content can be uploaded by carers, parents or teachers. It is significantly more meaningful for someone with SEND to see images of their own mask, people they know and their own environment, as opposed to seeing pictures of people or objects that are completely unfamiliar to them. After the app has been downloaded, any custom content is stored on the device, so the apps are not 'data hungry' and there is no additional expensive data usage for those who may be using pay-as-you-go connections. The content can be viewed repetitively, which is a benefit for users who are autistic, for example.

The apps are also accessible in Welsh and English. The general guidance is presented in short, simple sentences, with the option to view cartoons, photos or videos and to hear the guidance as spoken words, along with Makaton symbols, making the apps as accessible as possible to a wide range of users. The 'back end' structure of the apps has been developed so that it can be updated to release versions in different languages for other community groups, such as those who do not have English or Welsh as a first language.

Makaton is a unique language programme that uses symbols, signs and speech to help people to communicate. The apps' Makaton content was created in collaboration with experienced tutors at Derwen College, a special educational needs college. An initial test user group for the 'Covid-19: Staying Safe' app was also established at the college and garnered positive feedback.

"The ever-changing advice surrounding keeping safe during the pandemic can be confusing for all of us, but especially for people with special educational needs, autism or communication difficulties.The app simplifies the guidance and allows the user to choose pictures, cartoons, words or Makaton symbols depending on their preferred method of communication. The ability to personalise the app is particularly impressive. Showing an individual's own mask, wash basin and home environment makes it so much more engaging and relevant for them."

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Aberystwyth

Smart device to digitise beer kegs

The Smart Container Company Ltd has created a device that turns kegs into smart containers, enabling a zero-waste supply chain for the draught beer industry.

Beer is one of the most consumed beverages in the world, and there are over nine million kegs in existence in the UK alone. However, there are significant flaws and wastage associated with the way these kegs are managed.

The Smart Container Company Ltd, based in Pontypridd, has developed an Internet-of-Things (IoT) device that instantly turns beer kegs and casks into smart containers. The aim is to create a more sustainable supply chain and circular economy where less waste (beer, water, gas, carbon footprint, etc) is produced.

Currently, the draught beer industry requires a variety of technology solutions from multiple vendors in order to collect data and manage the supply chain. This method often proves to be inefficient and ineffective, without sufficient transparency.

By connecting kegs and casks to the internet, the Keg Tracker device brings real-time transparency into the draught beer supply chain. It collects valuable data from the containers using 5G and sensor technology, and uses a low-power wide area network (LPWAN) to send this data to the cloud.

The data is then visualised and used to create reports and provide insights that enable brewers, distributors and pub operators to be more efficient and operate in a more sustainable way. Larger enterprises, who already tend to have robust systems in place, can also access a portal to view real-time data feeds.

Keg Tracker is designed to be a one-size-fits-all device. Monitoring temperature and volume can help to prevent product spoilage, while tracking location can reduce the risk of losing containers and allow for better route optimisation. The system can also address the problem of wastage at a retail level, because people can understand how much beer is in each keg without having to actually open them.

In addition, the technology could help large breweries to substantially improve their environmental impact. For example, enabling transparency for product replenishment can reduce the carbon footprint of delivery trucks. A significant amount of water is used and wasted in the production of beer (it can take around eight pints of water to make one pint of beer), so even just one small change in making the supply chain more efficient could make a big difference to the environment.

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Pontypridd