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THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY

advances WALES

Improving the accuracy of global weather forecasts

Researchers at the University of South Wales have been helping NASA to increase the accuracy of their weather predictions

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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 continues to shine a light on innovative technologies and groundbreaking research across Wales.

This edition of Advances Wales explores how Welsh universities are helping NASA to improve the accuracy of their weather forecasts (page 14), undertaking a significant seagrass restoration project (page 10) and creating a system to detect cyber-attacks on smart devices (page 18).

Medical innovations in this edition include the development of a new test for urinary tract infections (page 6) and a new drug for treatment of inflammatory bowel disease (page 8), as well as research into the causes of schizophrenia (page 7) and into how the human brain behaves following a limb amputation (page 9).

Meanwhile, the news section highlights some of the novel ways that Welsh companies and universities have responded to the Covid-19 pandemic, and more of these will feature in our summer edition.

This edition of Advances Wales can be viewed online, alongside 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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Welsh universities respond to pandemic

Welsh universities have been using their expertise, experience and resources to support the local and national response to Coronavirus.

Contributions to the supply of medical equipment, facilities and resources include:

Cardiff Metropolitan University has established a Blood Centre at its Llandaff campus in partnership with the Welsh Blood Service, and loaned two Thermo Fisher 7500 ABI Fast platform machines to support enhanced testing of Covid-19.

Swansea University's on-campus clinical skills training suite and clinical skills lab at Morriston Hospital have both been freed up for NHS use. 3D facilities at the university are also being used to print ventilator parts, while midwifery and paramedic students are supporting frontline NHS colleagues in the fight against the coronavirus pandemic.

Aberystwyth University and Cardiff University are providing building space to local health boards, in order to increase their emergency case handling capacity. Cardiff University is also converting one of its buildings into a training facility for NHS staff.

In consultation with NHS Wales, Cardiff University is also fast-tracking final-year medical and healthcare students to be available to support frontline NHS teams, and 300 Year 3 and Year 4 year medical students have signed up for a 'volunteering bank' to support the NHS.

Cardiff Metropolitan University, Swansea University, Bangor University and the University of South Wales have all donated Personal Protective Equipment, such as aprons, masks and goggles, for use by frontline NHS staff. Bangor University and Swansea University are producing hand sanitiser to distribute to the NHS.

Welsh universities are also making significant contributions in the areas of training, research and community support.

www.uniswales.ac.uk

New diabetes technology in development

Afon Technology has patented the technology for the first real-time, non-invasive blood glucose monitor, which would provide a major breakthrough in the management of diabetes.

Currently, people with diabetes can monitor their blood glucose levels via invasive finger pricks, or using minimally invasive devices that work by taking samples of interstitial fluid from under the skin and can give a delay on readings. Non-invasive blood glucose monitoring has long been considered the holy grail of diabetes management.

The Chepstow-based company's solution is a wristwatch style device, designed to be discrete, wearable, non-invasive and pain-free. It will give a real-time indication of high (hyper) or low (hypo) glycemia. The aim is to free diabetics from the pain and inconvenience of finger pricks, whilst giving them the confidence that comes with knowing that their blood sugar is maintained within safe parameters.

Good control of blood glucose levels minimises the risk of long-term complications such as heart attack, stroke, blindness and kidney failure. Therefore by enabling them to more effectively monitor their condition, the Afon device could improve the lives of of diabetics and help them to avoid such devastating long-term effects. The device could also save money for the NHS by reducing hospital treatments caused by poor diabetes control.

Following recent clinical trials, the company is now moving into a product development phase, with the intention of having a product on the market within two years.

www.afontechnology.com

Rapid sanitising technology for ambulances

Swansea University has won funding in a challenge seeking innovative or novel approaches to get ambulances cleaner quicker, thereby helping to combat Coronavirus.

The aim of the Small Business Research Initiative (SBRI) challenge is to reduce the turnaround time that an ambulance requires after each journey with a suspected Covid-19 passenger.

It currently takes an average of 45 minutes to deep clean an ambulance before it can get back on the road. Some ambulance cleaning centres can also be some distance away from their base, adding strain and delay on an already busy and pressurised service, as the vehicles cannot be used until cleaning is completed.

Devised and developed in less than two weeks, over 200 proposed rapid sanitising technology solutions were submitted to the challenge from across the UK. Solutions needed to be demonstrable in a live trial on an ambulance and suitable for rapid deployment in order to help in the national effort against Coronavirus and save lives.

Twelve proposals, including one from Swansea University, scored highly enough to win funding. The university will test a novel rapid release gas treatment for the rear compartment of ambulances, which should remove contamination from surfaces and the air handling unit in around 20 minutes, without requiring any human cleaning intervention.

www.swansea.ac.uk

Welsh firms recognised in Queen's Awards

Eight companies from Wales have been recognised in the latest Queen's Awards, which are given annually for the "highest levels of excellence" demonstrated in various categories.

Welsh recipients of Queen's Awards in the International Trade category are: Air Covers Ltd, based in Wrexham, which designs and manufactures environmental protective helicopter covers; CPR Global Tech Ltd, based in Swansea, which produces a range of security, telecare and telehealth products for vulnerable people; Ruth Lee Ltd, based in Denbighshire, which is a supplier of manikins and other fire and safety equipment; and Wales Interactive, based in Bridgend, which is a developer and publisher of video games and interactive independent films.

Newport-based SPTS Technologies Ltd received an award in the Innovation category for developing a novel method of dicing silicon wafers using plasma cutting techniques, while Ammanford-based Cyfle Building Skills Ltd won an award for Promoting Opportunity (through social mobility) due to its programme that employs apprentices across key construction trades.

Awards for Sustainable Development went to Clynfyw Community Interest Company, based in Pembrokeshire, for their work with disabled and vulnerable people, and Dresd Ltd, based in St Athan, for their work reclaiming and reusing film and TV sets.

IN BRIEF

Funding for digital marketplace

Digital marketplace Paperclip has secured £750,000 in its latest funding round, bringing its total amount raised to more than £1.5 million over four years. Its most recent round was opened publicly and included over 400 private investors by the time of its closing, achieving 126 per cent overfunding. The Paperclip platform, based in Cardiff, allows users to buy, sell, swap and give away second-hand goods with nearby and likeminded users. It is also becoming a mainstay of UK university life, with over 40 universities offering dedicated platforms for their students, and this latest funding round will enable Paperclip to more than double its university presence. CEO Rich Woolley commented: "The platform is growing very quickly, with continued user uptake and university partners increasing all the time. This fund will go a long way towards ensuring that we continue to offer a slick and easy experience for users while always moving forward with innovation."

New identity for tech network

Major changes have been announced by ESTnet as part of plans to boost the profile of the Welsh technology industry. The Cardiff-based organisation has announced it will adopt a new identity of Technology Connected, along with the addition of new board members Katy Chamberlain, Chief Executive of Business in Focus, Lee Griffin, CEO and Founder of GoCompare, and Gareth Williams, VP Secure Communications and Information Systems for Thales UK. Avril Lewis MBE, Managing Director of Technology Connected, commented: "Having worked alongside our technology industry for nearly 20 years, we have seen the sector grow into a ubiquitous and influential industry which contributes greatly to the Welsh economy and is fundamental in enabling how we all live and work. We're excited to continue to grow and evolve alongside our industry as we transition to Technology Connected and help to champion the impact of technology made in Wales both within the UK and around the world."

Scientists switch research to develop vaccine

Cardiff University scientists have switched their focus from cancer research to work that could help towards developing a vaccine for coronavirus. The team at the School of Medicine usually work on reprogramming viruses so they can target and kill cancer, but they are now focusing their efforts to help in the fight against the new virus. Dr Alan Parker commented: "There are four of us on the team who have now been granted 'essential worker status' and we're obviously having to maintain social distancing so are working apart. But thankfully for us, we're in our comfort zone when it comes to our research. Our expertise is in tinkering with viral vectors for therapeutic benefit. We've changed tack slightly – from fighting cancer to infectious disease – but we're still doing what we're good at and drawing on what we know."

First ever Welsh company to join tech programme

Vizolution, a Port Talbot-based customer experience technology provider, has become the first ever Welsh company to be selected for the annual Tech Nation Future Fifty growth programme. The company, which helps enterprises replicate the qualities of face-to-face interactions within remote channels, joins 27 other late-stage British tech companies in the programme. Future Fifty was established to champion and support British tech businesses as they scale up their operations nationally and internationally. Although Vizolution has been headquartered in South West Wales since it was founded in 2013, the company has seen significant growth in recent years, and in 2018 opened new offices in Toronto to accommodate its North American expansion.

Award for cyber security firm

Newport-based cyber company Wolfberry Cyber has been recognised as Best International Cyber Security Consultancy Firm at the Acquisition International Cyber Security Awards 2020. The award recognises Wolfberry's growth in 2019, which has seen it enter markets in Europe, Asia and the US in a year when more than half of UK businesses have reported some form of cyber-attack. The company aims to make enterprise level cyber security services accessible, understandable and affordable for businesses, regardless of their size or location. CEO Damon Rands said: "The regular cadence of global high-profile data breaches is putting pressure on companies to protect both their business and customers, especially as more and more sensitive transactions continue to move online. But it isn't just about 'Hollywood' hacks - normal businesses also get caught as well, and sometimes the effect is much more damaging."

North Wales inventions inspired by the pandemic

Two innovations to protect against coronavirus have been designed at Anglesey's Menai Science Park, a hub for start-up companies and scientific research. Virustatic Shield has been working on a novel anti-viral coating for years, and has now developed a snood incorporating this special coating in response to the pandemic. Meanwhile, Wyn Griffiths came up with the idea of a hands-free door handle, allowing people to open doors using only their arms, after his wife told him about her difficulties trying not to touch door handles during a visit to hospital. He designed a prototype arm which can attach to an existing handle, with a crook to open the door, and has now distributed the 3D design online so that anyone can download it for free. Mr Griffiths said: "Hopefully people who have a 3D printer can help out their local hospital, or anywhere the public visits, by distributing these around the country."

Rural areas to benefit from 5G testbed fund

CoCore, a 5G testbed in south east Wales, will receive £5 million funding to connect rural communities across Monmouthshire and Blaenau Gwent, by demonstrating how 5G technology can be a force for good and open up new opportunities for businesses and citizens. The project will provide solutions in areas such as immersive tourism and farming security, which are key parts of the rural economy, whilst leveraging related technologies such as Artificial Intelligence, the Internet of Things and cyber security as part of an 'innovation platform'. 5G has speeds up to ten times faster than 4G and will greatly increase mobile capacity across the UK. It uses technology that is more advanced than that of current mobile networks, so it could transform the way people interact with critical services and also drive the adoption of new technologies such as driverless cars, remote healthcare and smart devices.

Student system to improve emergency vehicle response times

A team of Swansea University students have developed a solution to improve emergency vehicle response times in a worldwide competition involving over 40 universities. The students were one of six teams at Swansea to participate in Invent for the Planet, a 48 hour intensive design experience led by Texas A&M University. Around the world, delays caused by traffic congestion increase the response times of emergency vehicles. The consequences of these delays include increased fatalities and greater financial losses, with research showing that in some countries up to 20 per cent of patients needing emergency treatment die on their way to hospital because of traffic jams. The student team's idea, which saw them named winners of the Swansea competition, was an Internet of Things system which alerts motorists to approaching emergency service vehicles ahead of time, allowing them to move out of the way.

Innovative coronavirus treatment in Welsh hospital

The University Hospital of Wales in Cardiff has become the first hospital in the UK to use a potentially groundbreaking antibody transfusion treatment on coronavirus patients. The treatment uses blood plasma from people who have already recovered from Covid-19, because their plasma will contain antibodies that their immune system has produced to fight the virus. This plasma is then transfused into other patients with the virus to help them fight the infection more quickly. Recovered patients are being invited by letter, if eligible, by Public Health Wales to donate blood to the scheme. Scientists at the Welsh Blood Service, the Department of Immunology at University Hospital of Wales, critical care consultants and Public Health Wales have all worked to launch this innovative scheme. In the absence of any current vaccine or antiviral therapy, the treatment has potential to aid the recovery of patients.

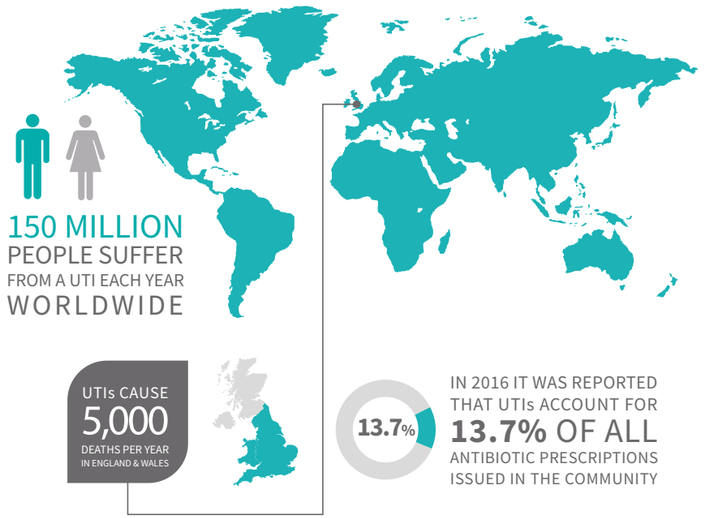
Electric transport centre of excellence for Newport

It has been announced that £36.7 million will go towards designing, testing and manufacturing electric machines in some of the UK's most polluting industries. Of this amount, £30 million will be used to create a network of industrial centres specialising in the research and development of electric transport. The CSA Catapult Innovation Centre in Newport will use a share of the investment to become one of four Driving the Electric Revolution Centres for Excellence. These centres will bring together climate change pioneers to research and develop green electric machines, including planes, ships and cars. Each centre will seek to propel UK manufacturing to the forefront of global efforts to tackle climate change and ensure the UK can reach net zero emissions by 2050.

Developing new testing for UTIs

Researchers at University of South Wales are developing a diagnostic test capable of detecting the bacteria causing urinary tract infections.

Urinary tract infections (UTIs) are one of the most common types of bacterial infection worldwide. It is estimated that 150 million people suffer from a UTI each year, and they are responsible for around 5,000 deaths per year in England and Wales alone.



It was reported in 2016 that UTIs account for 13.7 per cent of all antibiotic prescriptions issued in the community. The current 'gold standard' for diagnosing patients with UTI symptoms is microscopy and culture analysis of a urine sample, taking 24-72 hours. In primary care, most UTIs are treated empirically with antibiotics on the basis of symptoms and/or a positive dipstick result. This results in large numbers of inappropriate prescriptions, which is known to contribute to the antimicrobial resistance burden.

There is a need for a test that will allow clinicians to make point of care decisions in order to tailor or reduce UTI-associated prescriptions appropriately. For this reason, Dr Emma Hayhurst, a molecular microbiologist who specialises in antibiotic resistance, teamed up with Dr Jeroen Nieuwland, a molecular geneticist, and a team of biomedical engineers at the University of South Wales.

Their new test is designed to be a combination of an affordable, portable device and an assay which is fast, cheap and easy to carry out.

The test uses a molecular assay, opto-electronics and machine-learning algorithms to determine within 20 minutes whether there are clinically relevant numbers of disease-causing bacteria in urine. It can also pinpoint which bacterial species is causing the infection.

The device aims to revolutionise UTI treatment by providing a cheaper and more accurate diagnosis at point of care, compared to what is available now. This will reduce the large numbers of unnecessary antibiotic prescriptions associated with UTIs, which in turn will help relieve the burden of antibiotic resistance.

The innovative platform technology can easily be adapted to detect almost any pathogen from any sample, in a similar way to how the polymerase chain reaction is used now. In addition to other human clinical applications, the device could also find applications in animal health and veterinary diagnostics, as well as in water testing.

Dr Nieuwland explains: “The test will provide health practitioners with immediate information on whether there are clinically relevant numbers of bacteria in a urine sample, and whether the causative agent is Escherichia coli (responsible for the majority of UTIs). This will give increased confidence in any decision to withhold prescriptions, without increasing the risk of a missed infection. The NHS will benefit from reduced direct costs, and a reduction in antimicrobial resistance."

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Pontypridd

New genetic link to schizophrenia discovered

Cardiff University researchers have identified new mutations in a gene that provides novel insights into the causes of schizophrenia.

Dr Elliott Rees, a research fellow at Cardiff University's Medical Research Council Centre for Neuropsychiatric Genetics and Genomics, has analysed genetic data from 3,444 families affected by schizophrenia in the largest study of its kind.

Scientists have already pinpointed specific genes that can predispose people to neuropsychiatric disorders, such as autism and developmental delay. This new research looked specifically at those high-risk genes, and found that one in particular, SLC6A1, had significantly more new mutations than expected by chance. The mutations were very rare - found in around 3 in 3,000 individuals diagnosed with schizophrenia.

The importance lies not in how common the mutations are but in the area of biology highlighted. Namely, one of the main chemical transmitters of the central nervous system, known as GABA. This points towards alterations in how brain cells communicate as a potential cause of schizophrenia. These mutations also appear to substantially increase the risk of developing the condition, suggesting that treatments developed to target this system could potentially have large therapeutic effects.

Professor Sir Michael Owen, former director of the MRC Centre and one of the study's authors, said: “As well as implicating a specific gene, SLC6A1, for the first time in schizophrenia, our findings suggest that new mutations in genes that are important in brain development can be a major factor in some cases, and that these mutations can also increase the risk of other disorders such as autism and developmental delay. In addition to understanding how the mutations impact on brain function, it will be important to understand what factors modify their effects as these may also be possible targets for new treatments.”

The findings offer further insight into the underlying causes of schizophrenia, a frequently severe mental health condition that can cause hallucinations and delusions. The ultimate goal is to develop new therapies for the condition, which affects about 1 per cent of the world's population and 600,000 people in the UK.

> *“This work increases our understanding of the biological causes of schizophrenia, which we hope will lead to the development of new and more effective treatments - because identifying the key genes involved provides molecular targets for the development of novel drugs.”*
>
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Cardiff

Discovering a new drug to treat inflammatory bowel disease

Compton Developments, part of the Compton Group of companies, have discovered a drug which has successfully reduced inflammation in laboratory models of inflammatory bowel disease.

Inflammatory bowel disease (IBD) is a combination of two diseases: ulcerative colitis and Crohn's disease. Millions of people around the world suffer from bowel disease and there is currently no cure.

The potent anti-inflammatory drug discovered by the Swansea-based company is based on Boswellia frereana (Somali frankincense). In preliminary testing, using an in vivo model of IBD, the drug significantly reduced clinical symptoms of IBD such as body weight loss, incidences of diarrhoea and colon inflammation. It was also found to reduce the blood biomarkers of inflammation. Current drugs only manage the symptoms of the disease, some of which come with serious, unwanted side effects. This new botanically derived drug represents a safer alternative for treating the clinical symptoms associated with IBD.

Boswellia frereana is a little-researched species of frankincense, indigenous to Somaliland in North East Africa. There are over 20 species of Boswellia trees in Africa and the Arabian Peninsula, yielding oleoresin extracts, which have therapeutic properties commonly attributed to chemicals known as Boswellic acids. The company's innovation stems from the fact that B. frereana is the only species of Boswellia in the world that does not contain these acids, but instead contains a bouquet of different chemicals.

The company's Research Director has a background in analytical and pharmaceutical chemistry and family links to Somaliland. He initiated an academic collaboration with a Senior Lecturer at Cardiff University's School of Biosciences, who tested the bioactivity of several Somali botanical extracts in her laboratory models of inflammation, while Compton chemically characterised the drug.

To the research team's surprise, B. frereana was the only botanical extract to significantly inhibit an inflammatory protein known as MMP-9, as well as nitric oxide and other biomarkers of inflammation such as TNF alpha. Realising the importance of its novel chemistry and its ability to inhibit the MMP-9 inflammatory protein, Compton patented the botanical drug, internationally, for treating inflammatory conditions.

The company will now conduct full preclinical testing of the new anti-inflammatory drug. This will involve a study to determine the lowest pharmacological drug dose that can be administered without it losing its efficacy. Preclinical testing will also yield vital information on the drug's absorption profile in the blood and establish how the drug behaves in the body.

A drug based on B. frereana could improve on current standards of care through a better balance of efficacy and safety for IBD patients. It has the potential to encourage both the induction and prolongation of remission, which is particularly important as repeated episodes of IBD can require surgical intervention. This would also help to alleviate the socio-economic burden associated with IBD disease, because sufferers often have to take sick leave and/or early retirement due to their condition.

If the preclinical tests are successful, Compton Developments will be a significant step closer to their aim for the drug to be clinically approved in the UK.

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Swansea

Groundbreaking research into the brain post-limb amputation

Psychologists at Bangor University have discovered how limb amputation drives changes in the way that both sides of the human brain work together.

As advances in technology and brain science speed ahead, one of the most important things now understood about the human brain is its remarkable capacity for change. It is known that our experiences are capable of reshaping the functions of our brains, and that this extraordinary flexibility, or "plasticity", lasts throughout our lifespan.

A dramatic example of this capacity for change follows the loss of a limb. When this happens, the part of the brain that was previously devoted to feeling and moving the now missing limb changes to take on new functions. Available evidence suggested that these new functions appeared to reflect what the neighbouring parts of the brain normally did.

Now, researchers from the Hand and Brain Lab at Bangor University's School of Psychology have, for the first time, revealed brain changes after limb amputation that extend across the two sides of the brain. Functional MRI scans demonstrate that in people who have lost one hand, the functions controlling the surviving hand extend across both brain hemispheres.

Dr Ken Valyear, Senior Lecturer from the Hand and Brain Lab and lead-author of the study, explains: "Different parts of our brain are devoted to feeling and moving different parts of our body, and normally, the left side of our brain responds when we feel something with our right hand, while the right side of our brain responds when we feel something with our left hand.

Our new findings reveal a startling change in this relationship. What we discovered is that when someone loses a hand, both sides of the brain respond when the remaining hand is touched. This apparent transfer of function happens at greater distances than we knew were possible, and this motivates a change in the way we think about the limits of brain plasticity."

This new understanding could help to develop new therapies for individuals who have lost or injured a limb. It could also have implications for developing prosthetic limbs to restore touch and feeling to the user.

Moving forward, the team at Bangor University have started new work with patients who have suffered serious injuries to the nerves of the hand. Their primary goals are to better understand the brain changes that accompany hand nerve injuries, and how these changes influence functional recovery. They then hope to use this knowledge to improve future recovery outcomes for those who have suffered similar injuries.

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Bangor

Restoring seagrass in the fight against climate change

A significant seagrass restoration project has marked a major milestone by planting over 750,000 seagrass seeds in Wales.

Seagrass is a flowering marine plant that captures carbon from the environment up to 35 times faster than tropical rainforests, making it a key weapon in the battle against climate change. It often grows in large underwater meadows, which absorb carbon and release oxygen. Globally, it is estimated to account for 10 per cent of annual ocean carbon storage, despite occupying only 0.2 per cent of the seafloor.

A project involving Sky Ocean Rescue, the World Wildlife Fund (WWF) and Swansea University aims to restore 20,000m^2 of the marine plant, following the disappearance of up to 92 per cent of the UK's seagrass in the last century. The huge decline has been caused by pollution, coastal development, and damage from boat propellers and chain moorings.

As part of the project, which is the biggest seagrass restoration initiative ever undertaken in the UK, over 750,000 seagrass seeds have recently been planted in Dale Bay in Pembrokeshire. The planting will continue later in 2020, with over a million seeds due to be planted in total this year.

This process of restoring seagrass started in summer 2019, when a team of volunteer snorkellers and divers began collecting the seeds from existing meadows around the country. The seeds were then processed at Swansea University.

Around 2,000 volunteers, including many school children from West Wales, then helped by preparing small sand-filled hessian bags. Each of these bags were tied at metre intervals to a length of rope, securing them to the seafloor. Just before planting, each bag had one scoop of seeds added to it. In total, 15km of seed bag rope was carefully dropped into Dale Bay by a team on board a small boat. Over time, all of the natural materials used in the planting process will safely disintegrate, leaving the seagrass seedlings to take root and grow.

The site in Dale Bay was chosen because this area has lost seagrass historically, but it has the right features for the plant to survive in terms of water depth and sufficient light levels. The project aims to establish a local Seagrass Community Group to advise on the future management of the restored seagrass.

Once it matures, the seagrass meadow could support 160,000 fish and 200 million invertebrates. Between 30 and 40 times more sea life is typically found in seagrass than on a patch of seafloor that doesn't have any vegetation. Therefore when ecosystems are protected and restored, they can ensure biodiversity and continue to support human life, while also lessening the climate risks. Not only does it directly absorb carbon, but it also creates a valuable underwater ecosystem of marine life. This ecosystem will in turn provide valuable services, from providing food to helping regulate climate.

Further benefits of seagrass are that it provides a crucial habitat for many fish, such as cod, plaice and pollock. It also helps to protect our coasts from erosion, as it absorbs wave energy and cleans the ocean by absorbing polluting nutrients produced on land by humans. Seagrass removes nitrogen at 20 times the rate of bare sediment.

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Swansea

Innovative technology to treat water

Hydro Industries has developed technology to purify dirty water, making it safer and cleaner.

Water is a precious natural resource and many countries around the world don't have enough of it. With the global population expected to double in the next twenty years, together with environmental consents becoming stricter, this problem will only get worse.

Hydro Industries is using innovative technology, at the heart of its system designs, to provide safe drinking water in some of those countries. It is also cleaning up agricultural and industrial effluent in order to salvage much needed clean water and valuable minerals.

Water purification is often approached with chemicals and additional water, diluting the effluent and treating it with decontaminant or detergents. These chemicals are often harmful in themselves and the dilution process uses up more water, exacerbating the problem of its scarcity.

The Llanelli-based company has a different approach, deploying electro-chemistry and disinfection to remove and in some cases salvage the contaminants. These are often valuable, such as oil, iron, or the agricultural organic to make fertiliser that can be recovered from farm slurry. Critically, the water left behind from the process can be safely returned to the land or sea, or improved further so that it meets the World Health Organisation requirements for safe drinking water.

Applying electricity to a sacrificial electrode, while pumping dirty water through it, causes particles which normally repel each other to congeal. The process, known as electrocoagulation, then allows the particles to be filtered out. Although this method of electro chemistry has been around for centuries, the company was able to design software and electrodes that make the system efficient, reliable and environmentally friendly. Their soft-ware enables them to be very specific in targeting the impurities in the water.

Hydro has recently begun a project to clean up the Red Sea in Egypt, which involves targeting Boron as well as oil. The team will be targeting and removing Boron from the industrial effluent produced by oil refineries, which will be hugely beneficial to marine life in the Red Sea.

> *"Hydro has a humanitarian and environmental impact. In some cases, we allow companies to meet stricter climate change regulations, often ending historical practices that could be deeply harmful. When we do so, we also help them to recover the impurities we remove, which can be valuable to them. In other cases, we are saving lives by producing safe drinking water in communities that cannot get it otherwise. We have done this in Sudan, Somalia and India, and are now working with the world's largest NGO to remove arsenic from drinking water in Bangladesh."*
>
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Llanelli

Digital platform to manage energy consumption

Surple has developed energy management software to help organisations make smarter energy decisions.

The Newport-based company has built a platform that imports energy data, visualises it and derives insights from it. As a result, organisations can more accurately assess their energy usage and make changes for the future.

It allows users to import all types of utility data – electricity, gas and water – as well as generation data from renewables such as solar panels. In addition to this, Surple does not have links to any particular energy supplier. This means that large organisations, who may have hundreds of meters spread between several suppliers, can still see all of their data in one place.

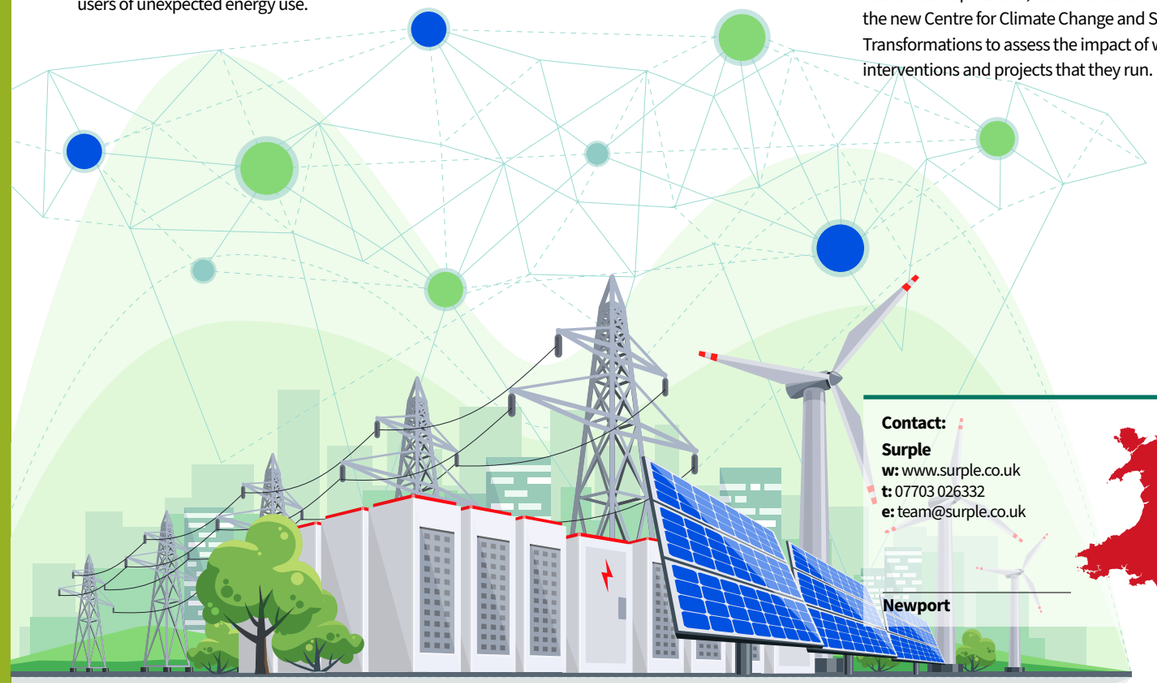
The cloud-hosted web application can be accessed on any device with access to the internet. It is powered by an innovative machine-learning algorithm which calculates expected energy consumption and automatically informs users of unexpected energy use.

Utility data gets automatically imported from the user's registered energy supplier or data collector. Once the data is in the system, users can visualise and assess their energy usage, and there are features specifically designed to speed up and simplify energy management processes

Reports can be generated, and alarms can be used to help users keep on top of their energy usage and set targets for longer-term consumption, spend or carbon goals. Within the system, users can also monitor the success of energy-saving projects and run degree-day regressions to determine how effectively they are heating their buildings.

The company was inspired to build the software after learning that Newport City Council's energy manager had to use several different platforms in order to get a full picture of energy use. In a pilot project with the council over six weeks, involving five schools, the new software helped to enable significant energy savings. The identification of multiple water leaks in the schools resulted in Newport making significant savings, and the council was also able to identify inefficient heating controls and broken equipment which could then be fixed.

Surple is now working with Newport Council as their principal analytics partner and is hoping to roll out across more of the council's buildings. The team is also helping organisations including Celtic Manor Resort, International Convention Centre Wales and Ty Hotels to monitor their energy consumption and identify savings. The company recently won the Green Start-Up award at the Wales Start-Up Awards, and is collaborating with the new Centre for Climate Change and Social Transformations to assess the impact of workplace interventions and projects that they run.



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Newport

Advances

Improving the accuracy of global weather forecasts

Researchers at the University of South Wales have been helping NASA to increase the accuracy of their weather predictions.

In the first few months of 2020, the UK saw unprecedented weather patterns. In February, it experienced the highest amount of rainfall in any month since records began in the 1800s, and widespread flooding devastated local communities.

Combined with the growing concerns around climate change, the importance of being able to accurately predict the weather, in order to prepare and potentially save communities and to plan for the impact on the environment and the economy, has never been clearer.

Researchers at the University of South Wales have been working with NASA to refine their atmospheric model, which is needed to make weather and climate predictions. As a United States Government agency, their research is used to influence policy decisions, and is one of several agencies in the US that undertake climate modelling.

NASA's atmospheric model, based on a series of mathematical equations, is separated into many components. One is the Linear Model, for data assimilation. This is used to input atmospheric data, such as temperature, wind speed or humidity, into the models. Another component is the Dynamical Core. This solves the governing equations to predict the state of the atmosphere in the future.

Although it is beneficial to use the same numerical methods in both, it is not always possible in practice. For example, the use of non-linear limiters for weather and climate prediction models is considered paramount for obtaining accurate forecasts. Although these limiters work very well in the Dynamical Core, they are not well suited to being linearised for the Linear Model.

To help improve the prediction models currently being used, Dr James Kent, a mathematician at the University of South Wales, worked with NASA to take a different approach.

> *"Instead of taking the numerical methods from the Dynamical Core and linearising them, we looked at what they needed the Linear Model to do in order to achieve as accurate a prediction as possible. We then worked backwards to identify what methods would help to produce this. This change of viewpoint led to a breakthrough and a change in the way that NASA's model functioned."*
>
> **Dr James Kent**
> University of South Wales

During initial testing, researchers applied the new model to tracer transport, such as predicting the movement of clouds as well as quantities such as specific humidity. When testing this against the full Dynamical Core, they found that the predictions had a greater correlation, i.e. they were more accurate.

The updated model has also been used to look at the sensitivity to different parameters within weather predictions, including changes to the wind, temperature and water vapour, and what effect this could have. The same model can also be used to look at the concentration of gasses in the atmosphere, helping to monitor climate changes and giving scientists more accurate predictions for the future.

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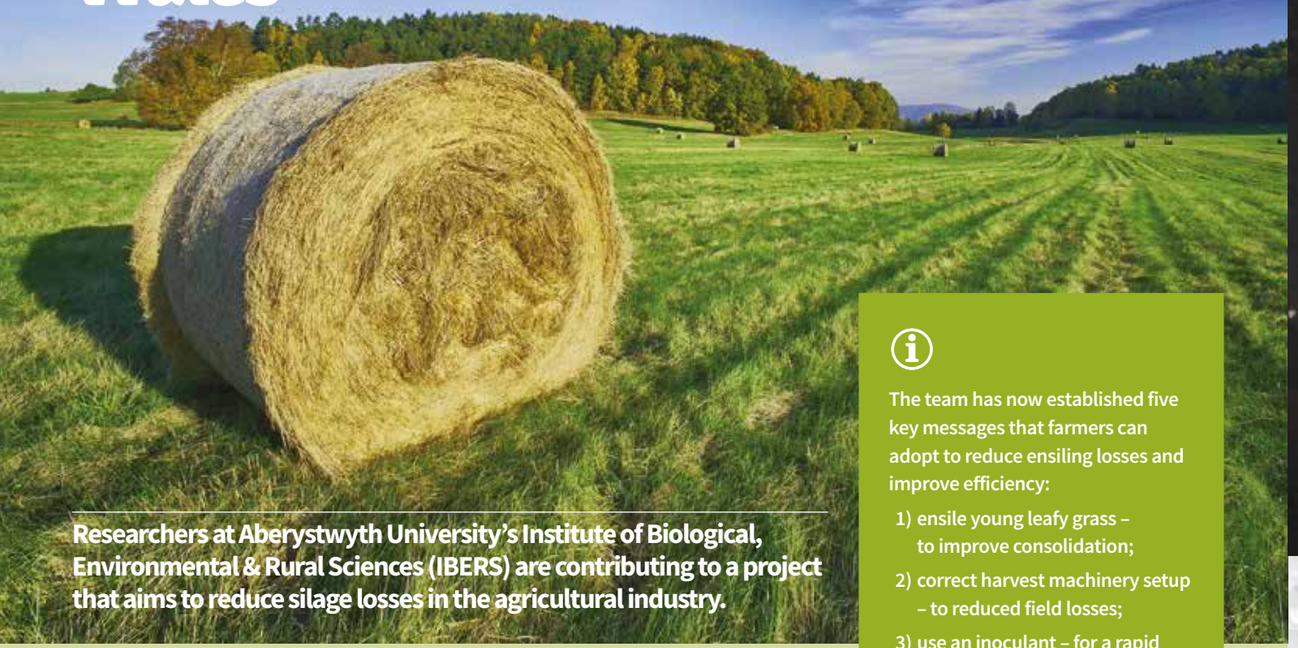
Pontypridd

Improving silage efficiency in Wales



Researchers at Aberystwyth University's Institute of Biological, Environmental & Rural Sciences (IBERS) are contributing to a project that aims to reduce silage losses in the agricultural industry.

Silage production is vital for the profitability of Welsh livestock farms, with 5.4million tonnes of grass ensiled annually. However, research has shown that current ensiling processes are inefficient, with calculated losses of around 25 per cent.

Losses occur at each stage of the process, including during wilting and harvesting operations, respiration losses during silo filling, fermentation and storage losses within the sealed silo, and feed-out losses when the silo is open to the elements during emptying over winter. Most of these losses are 'invisible', with quality feed material broken down to water, CO2 and other (often undesirable) products that reduce intake and palatability of the silage. Often, farmers are unaware that these 'invisible' losses occur.

In addition to representing a financial loss and compromising the quality of the resultant silage, reducing these silage losses will lessen environmental risk from volatile carbon compounds and effluent.

The SMARTsilage project was established to develop ways to reduce this loss of valuable feed, thereby providing both economic and environmental benefits for the Welsh agricultural industry. It will also provide farmers with the tools needed to future-proof their industry against the challenges posed by global food security. By following good practices and reducing losses, farmers will have more silage, of a higher quality, available on their farms, reducing their reliance on bought-in feed and improving the health of their animals.

This project brings together a collaborative team of experts, including researchers from Aberystwyth University's Institute of Biological, Environmental & Rural Sciences (IBERS) with companies Pöttinger, Volac and Genus, utilising the latest agricultural technologies targeted at key stages of the ensiling process. The intended outcome of the research is to reduce overall silage losses by at least 5 percent.

The team has now established five key messages that farmers can adopt to reduce ensiling losses and improve efficiency:

1) ensile young leafy grass – to improve consolidation;
2) correct harvest machinery setup – to reduced field losses;
3) use an inoculant – for a rapid and efficient fermentation;
4) maximising silage density – to reduce air ingress and movement ;
5) efficient sealing – to maintain anaerobic conditions.

By following these guidelines, it is estimated that losses can be reduced from 25 per cent to 20 per cent or below. This reduction in losses will result in an extra 270,000 tonnes of silage being available for feeding, as well as leading to improved silage quality and increased production efficiency on Welsh livestock farms.

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Aberystwyth

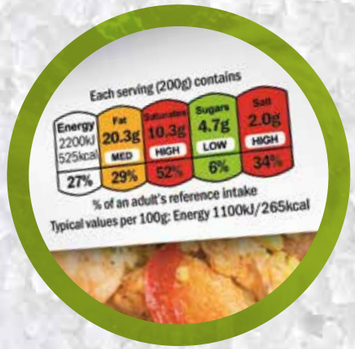
Natural flavour enhancer for salt reduction in foods

Scientists at Aberystwyth University have developed a flavour enhancing food product which can be used to significantly reduce the salt content of pre-packaged meals and snacks.

Eating too much salt can cause high blood pressure, which leads to strokes and heart disease. In the UK we eat around 8.1g per person daily, compared to a recommended maximum of 6g. Around 80 per cent of the salt we eat is already in the foods that we buy, rather than salt we add to it ourselves.

Limiting the amount of salt in pre-packaged foods is considered essential in reducing conditions like heart disease. Such conditions place a significant burden on health services and cause long-term debilitating problems, which affect the lives of millions of people worldwide.

Scientists have developed an innovative food product at the BEACON Biorefining Centre at Aberystwyth University's Institute of Biological, Environmental and Rural Sciences (IBERS). The work was carried out in partnership with Quorn Foods, as well as Waitrose & Partners, Create Flavours Ltd, Amano Enzyme Europe, Membranology and Harper Adams University.



An additional problem for the food industry is what to do with waste streams. For instance, Quorn is made through a natural fermentation process, but results in a large volume of liquid that is treated on site before being disposed of as waste water.

The new flavour enhancer was created by taking the fermentation liquid from the production of mycoprotein, which is the main ingredient in all Quorn products, and using biorefining processes to extract and concentrate umami-rich taste compounds from that liquid. The resulting flavour enhancer was then added to foods like cheese spreads, a variety of pre-packaged meals and Quorn products, and tested with a professional tasting panel.

When added to foods instead of salt, tests show a 15-40 per cent reduction in salt content in a range of food products, without any noticeable change in the overall taste compared to the original recipe. Therefore, the BEACON team at Aberystwyth University reused a food processing liquid that would otherwise be wasted, and turned it into something that could contribute towards health and well-being.

Quorn is now investigating the business and commercial scope for treating their left-over liquid at the scale required by their manufacturing plants (500-700 million litres/year). Ultimately this could lead to widespread use of this compound within the food industry, in Wales and further afield, and Quorn estimates that if scaled up the process could generate around 10,000 tonnes of flavour enhancer.

Quorn mince

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Aberystwyth

Advances

INFORMATION TECHNOLOGY

New system to detect cyber-attacks on smart devices

Researchers at Cardiff University have developed a novel system capable of detecting and classifying cyber-attacks on smart devices in the home.

Known collectively as the Internet of Things (IoT), smart devices are becoming increasingly common and are now considered key technologies in a range of sectors, from economy and energy to transport and healthcare. In Western Europe, there are on average 5.4 smart devices per household.

A team from Cardiff University's School of Computer Science and Informatics has created a new system which can detect attacks on devices such as the Amazon Echo Dot and Apple TV with 90 per cent accuracy. It has the ability to distinguish between malicious or benign activity.

The researchers say that the lightweight tool could be used in a similar way to antivirus software and believe that its implementation is imperative in order to keep up with the rapid development of smart devices. This new development comes as the UK's Department of Digital, Culture, Media and Sport recently declared that a new law would force companies to "explicitly state" the length for which they will provide security updates when customers purchase a smart device.

In their study, the team developed a mock household environment containing eight different smart devices. They deployed several common cyber-attacks on the network and applied a three-layer intrusion detection system to detect them.

The team profiled the normal behaviour of each device connected to the network, identified malicious packets on the network when an attack was occurring and classified the type of attack that was deployed. The system was able to complete these three tasks with at least 90 per cent accuracy.

> *"This is another step forward in the early stage detection of disruptive cyber-attacks that is being integrated with our wider portfolio of research using advanced AI to predict and actively block malicious activity before it achieves major impact. The over-arching goal of our cyber research programme is to pave the way for proactive and cost saving cyber defences, maximising the potential for AI in cybersecurity in line with the objectives of the UK's industrial strategy."*
>
> **Professor Pete Burnap**
> Cardiff University

Lead author of the study, Eirini Anthi, said: "The insufficient security measures and lack of dedicated detection systems for networks of smart devices make them vulnerable to a range of attacks, such as data leakage, spoofing, disruption of service and energy bleeding. These can lead to disastrous effects, causing damage to hardware, disrupting the system availability, causing system blackouts and even physically harming individuals.

"A relatively simple and seemingly harmless deauthentication attack can cause no significant damage, but if performed on a device with critical significance, like a steering wheel in a driverless car, it can pose a threat to human life. What we've demonstrated is a system that can successfully distinguish between devices on the network, whether network activity is malicious or benign, and detect which attack was deployed on which device connected to the network automatically."

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Cardiff

Modifying wood to improve durability and sustainability

Lignia Wood Company is working with Bangor University to develop unique forms of durable, sustainable timber.

Timber modification refers to a range of treatments that change the physical and/or chemical make-up of timber, in order to improve on one or more of the timber's properties.

A wide variety of wood modification technologies exist, with some filling the cell lumen, which is the large air-filled cavity in the centre of each wood cell, and others interacting with the wood cell wall. Among these, some act by crosslinking, either internally or via grafted bifunctional reagents, to form bridges between functional groups in the wood cell wall, thus restricting movement (i.e. shrinkage and swelling). Simple grafting reactions may also occur, bonding to hydroxyl groups or other functional groups in the cell wall, whose interactions with water result in movement in wood. Modification needs to be carefully controlled, since undesirable reactions can degrade wood and have negative effects on its properties.

Lignia Wood Company moved from England to Wales in 2016 to set up the UK's first wood modification plant. By relocating to Barry, the company was offered good access to the raw materials that it needed, as well as access to wood science expertise at Bangor University. In its first six months of production in 2019, the company manufactured around 600m^3 of its innovative wood.

Resin impregnation improves the properties of timber by filling cell wall voids and lumens with a resin, which when cured forms a composite between the resin and the wood cell structure. This gives Lignia wood the properties of tropical hardwoods, with high dimensional stability, durability against decay and an increased hardness. All of these properties are delivered with a minimal effect on the environment, particularly in comparison to uncertified tropical hardwoods. The wood is suitable for exterior products such as decking, cladding, furniture and interior applications.

A recent innovation from the company is the development of Lignia Yacht. This is manufactured from quarter-sawn timber specifically for the yacht market, reducing the reliance of Burmese Teak which is often illegally logged and traded.

The Barry-based company has also been working in partnership with Bangor and Coventry Universities plus Millennium Lasers Ltd from Swansea on a project to improve the permeability of local timber species, so that they can be used within the manufacturing process. The process used lasers to 'incise' timber with sub-millimetre diameter holes that acted like the vessels found in some wood species. This allows the flow of resin to increase without the detriment to mechanical properties found with other forms of incising. The project was a success at pilot scale and the consortium are now hoping to commercialise the system.

Lignia is seeking to move away from imported timber and use locally grown Welsh timber as its raw materials. Work is being undertaken with Bangor University to investigate the applicability of Welsh timber to the company's process.

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