

THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY

advances **WALES**

Saving the Northern White Rhino

Cardiff University researchers have discovered genes that may help save the Northern White Rhino from extinction



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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.

“Scientists have become the bearers of the torch of discovery in our quest for knowledge.”

Stephen Hawking

Advances Wales explores the latest innovations in science, engineering and technology across Wales.

This edition highlights new research from Cardiff University which could help to save the northern white rhino from extinction (page 11). Scientists at Welsh universities are also developing new drugs to fight life-threatening tropical diseases (page 12-13), creating a recycling process to turn discarded plastic into hydrogen (page 16) and researching the impact of reduced gravity in space on human health (page 6-7).

Meanwhile, Welsh companies are working on a novel device to reduce the size of tumours in the pancreas (page 8), AI-enabled diagnostic solutions for kidney disease (page 9) and an energy storage system to prolong the life of lithium-ion batteries (page 14-15).

Digital innovations in this edition include a VR experience depicting dementia (page 17), software to speed up the process of property development (page 20) and a digital tool to identify false police statements (page 18).

This edition, and previous editions, of Advances Wales can also be found online.

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.

Editorial Board: Lucas Brown, Nadine Payne, Simon Cooper, Gareth Browning, Marcia Jones, Clive Thomas, Richard Johnston.

For information on how to contribute features contact the editor,
Sophie Davies tel 029 2047 3456
email: advances@teamworkdesign.com

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Bees pioneer new honey tea blend



"Innovation in tea production, and the search for new ideas and tastes, led us to set up the company twenty years ago, and is still its driving force today. This project is a good example of the university working with Welsh industry to develop a product based on the natural bounty of Wales, supporting the wellbeing of the people of Wales."

Alan Wenden
 Managing Director and Founder
 Welsh Brew Tea

A new healthy beverage consisting of tea, honey and botanicals is being developed in Wales.

After water, tea is the most commonly consumed beverage in the world and is thought to carry a range of health benefits, such as helping to reduce the risk of cancer, cardiovascular disease and arthritis. In laboratory studies, tea has also revealed its ability to kill hospital superbugs like MRSA. Similarly, honey has been used for thousands of years to treat a range of conditions, including the common cold.

Cardiff University, Welsh Brew Tea and Cardiff & Vale University Health Board have now joined forces to combine natural honey with the health boosting properties of tea.

The bees producing the honey are part of Cardiff University's Pharmabees project for a bee-friendly campus, which is helping the School of Pharmacy and Pharmaceutical Sciences to develop a Manuka-style honey that can treat antibiotic resistant hospital pathogens.



www.cardiff.ac.uk

Clinical trial for new depression treatment

An NHS trial to treat depression is underway, using transcranial magnetic stimulation (TMS) technology pioneered by Welsh company Magstim.

In patients with depression, electrical activity in certain areas of the brain is reduced. TMS therapy uses a series of repetitive, brief and highly focused magnetic pulses to stimulate brain cells. Practitioners are increasingly deploying it in cases of treatment resistant depression, where antidepressant medication is proving ineffective and before invasive treatments are considered. Magstim's Horizon Performance system, which is being used in the new study, makes use of a focused electromagnetic coil to rapidly pulse a magnetic field to the targeted area of the brain. This induces a small electrical current which stimulates the targeted brain cells into activity, increasing it back to a normal level.

The £2m study will involve carrying out a scan of each patient's brain to pinpoint their exact area of reduced activity, which can vary by patient, prior to treatment. Half of the participants will then have a 'personalised' therapy session, targeting the exact area of their brain identified as being under-active, using theta burst TMS – a newer form



that can be delivered in as little as three minutes, versus 37.5 minutes for a standard treatment session. The other half will have a standard therapy session and the two groups will not be aware of which treatment they are receiving.

Four NHS Trusts are taking part in the two-year study, which will examine how taking a

personalised approach and targeting individually identified areas of under-activity in a patient's brain with theta burst TMS affects efficiency and long-term remission.



www.magstim.com

Virtual factory to speed up alloy development



Swansea University is creating a virtual factory that will allow the development and testing of new steel alloys to become significantly faster.

In the modern steel industry, it is crucial to keep up with changing technologies and customer requirements. However, developing new steel

alloys is currently a slow process with lots of different stages. It requires expensive trials on hundreds of tonnes of material, much of which has to be remade into new steel products at a cost to the business involved.

Swansea University, Tata Steel and WMG at the University of Warwick, which have a long history of collaboration on steel research, have won £7 million

of funding to tackle this problem. Their solution is to combine physical testing and computational modelling in order to rapidly assess hundreds of small-scale samples, covering areas such as strength, electrical and mechanical properties, as well as durability and resistance to corrosion. Test data can be fed into computational models, further refining their accuracy and allowing for better predictions on the final material properties. Alloys that show promise can then be investigated at a larger scale and in more detail.

The process is called Rapid Alloy Prototyping. Effectively, it means that a lot of the testing can be carried out in research labs and imaging suites – a virtual factory – rather than in an actual steel plant. This new approach will enable 100 samples to be tested in the time it usually takes to test just one. The samples can also be tiny (only a few grams) whereas current testing can require up to 900 tonnes of material. As a result of this innovation, new steel products will be able to reach the market more quickly.



www.swansea.ac.uk

IN BRIEF

Self-powering homes construction

Construction has begun in Neath on the first major housing development in the UK to use the 'Active Buildings' solar power concept. The sixteen homes, on the site of a former care home, have been designed to maximise solar gain and will use a combination of innovative technologies to allow the homes to generate, store and release their own energy. The Active Homes Neath project is a partnership between housing organisation Pobl Group, Neath Port Talbot Borough Council and Swansea University's SPECIFIC Innovation & Knowledge Centre. The 'Active Buildings' concept, developed by SPECIFIC, includes integrated photovoltaic panels on the roofs and a solar heat collector on south-facing walls for water heating. Batteries will store excess energy for subsequent use, while waste heat will be captured and recycled within the home's ventilation system.

Award for sustainable company

After becoming a zero waste to landfill manufacturing company, Biocatalysts, a Cardiff-based developer and manufacturer of speciality enzymes, won the Sustainable/Ethical Manufacturer award at the 2018 Made in Wales Awards. Historically as a site, Biocatalysts generated 30 tonnes of waste per year, of which 10 tonnes were sent to landfill. The company resolved to set a target of sending no waste to landfill by March 2019 and managed to meet this target nine months early. Their 'zero to landfill' journey began four years ago when they introduced the BioBox, a 100 per cent recyclable blue box, to customers as their new enzyme packaging. This move to fully recyclable packaging was well received and sparked a drive for the company to continue reducing its impact on the environment.

Funding for diabetic footcare system

Thermetrix has secured £500,000 investment for the development of its diabetic footcare system. The company, established in 2018 and based in Abercynon, is working with a team of experts to produce Podium, designed to give people with diabetes an easy and fast way to check the soles of their feet and seek earlier intervention to prevent complications. People with diabetes can suffer from a loss of feeling in their feet, so foot problems may go unnoticed and there is an increased risk of amputation. For this reason, it is crucial to detect any potential complications as early as possible. Using thermal imaging technology, the system can be used to take a daily image of the patient's feet, which can then be shared with their podiatrist or GP through a cloud-based dashboard app. The funding will also support the launch of Podium for both home and professional use, working with nursing homes, podiatrists and other medical professionals.

Developing smart factories of the future

Swansea University is collaborating with packaging manufacturer Crown Holdings to develop the next generation of smart factories, which use advanced technology to improve efficiency. Dr Cinzia Giannetti, from the College of Engineering, is working with Crown's R&D centre in the UK to explore how new data analytics techniques and digital technologies can have an impact. Drawing on Crown's expertise in the high-speed manufacture of metal packaging, the three-year study will focus on improving the rapid decision-making capabilities of machines to optimise production processes. With unique access to Crown's plant data, the project will develop robust computational models that can be used in the company's smart factories to make predictions about machine failures and optimise operational efficiencies, with the ultimate aim of decreasing waste and reducing downtime.

Digital start-up selected for accelerator

Caerphilly based start-up Signum Health has been selected for a prestigious accelerator scheme to help the NHS meet the challenges of an ageing population and scarce resources. This is the first year that the accelerator has been launched outside London. The scheme, which has already saved in excess of £50 million for the NHS, is designed to work intensively with digital companies to refine, develop and scale their innovations across the NHS and social care sector. Signum Health's i-navigator is a social prescribing tool that supports people in need of non-clinical care. By allowing patients to access non-clinical support from home and at a time and place convenient to them, the tool has the potential to reduce unnecessary GP appointments. The company's core goal is to enable patients, pharmacies, GPs and other alternative healthcare services to work more efficiently and share health information in a way that benefits everyone.

New uses for waste from sugarcane production

A collaborative research project between the UK and India, led by Aberystwyth University, aims to transform waste streams from the Indian sugarcane industry into valuable new products.

India is the world's second largest producer and largest consumer of sugar. The Indian sugarcane industry generates waste in the form of spent wash, which is unwanted residual liquid from bioethanol production, and bagasse, which is dry pulpy residue left after the extraction of juice from sugar cane.

Dr David Bryant from Aberystwyth University's Institute of Biological, Environmental and Rural Sciences is leading the BIOREVIEW project, working with India to develop innovative, economically viable, industrial biotechnology processes that will create value added products from the sugarcane industry waste.

It has been predicted that products worth over £12bn could be produced from the spent wash, and that xylitol, a diabetic compatible



sweetener that prevents tooth decay, produced from bagasse could be worth £1bn by 2025. Microcrystalline cellulose that has uses in food and pharmaceuticals will also be produced from residual bagasse. Other applications include production of depth filters that can help to clean up polluted or contaminated water sources.

The overall BIOREVIEW vision involves integrating advanced bio-refining processes into Indian sugar mills to result in economic, environmental and societal benefit to both industry and the wider Indian society.



Opening of world-class biobank

Cardiff University has opened a new facility with the capacity to hold up to a million biological samples for medical research. The Cardiff University Biobank will give researchers quick and easy access to samples that can be used in research for the prevention, diagnosis and treatment of a wide range of serious and life-threatening illnesses. Samples collected by the biobank, which is based at the University Hospital of Wales, will include blood, urine, tissue and saliva. They will be made available to academic and commercial organisations undertaking vital scientific and health research. Prior to the creation of the new biobank, the university hosted eight separate tissue banking facilities, with several others in preparation, and the new facility will provide an umbrella support structure for each of these. When the biobank opened in October 2018, some of its first new donors were rugby players from the Cardiff Blues squad.

New biotechnology research centre

Bangor University has opened a research centre that will discover new enzymes with the potential to transform the efficiency of biotechnology industries. The Centre for Environmental Biotechnology (CEB) places the university at the cutting edge of research into how unusual microorganisms that live in extreme environments, called extremophiles, can be used to make industrial processes and products 'greener'. The facility will provide state-of-the-art equipment and world-leading expertise for identifying and isolating enzymes from extremophiles. Many industrial sectors currently use inefficient chemical synthesis processes, which require high energy consumption and use of organic solvents that are damaging to health and the environment. To replace chemical synthesis with environmentally friendly processes, CEB will identify, develop and test enzymes from extremophiles. These enzymes are very well suited to work in the extreme conditions of an industrial process and could reduce energy use, pollution and costs.

Equipment donated for coral research

Skye Instruments, a Powys-based designer and manufacturer of instruments for environmental monitoring, plant growth and agricultural research, has celebrated 35 years of trading by donating equipment to coral reef research projects. The company launched a competition allowing researchers to apply for their required equipment and explain their intentions. The first selected winner is undertaking a project that looks at the effect of light pollution on fish that live within the reef, while the second winner is exploring the impact of irradiance on coral bleaching and if shading could help reduce the effects. The third winner is looking at the impact of sediment runoff on coral and if this can be reduced with plants native to Hawaii. Skye Instruments donated equipment including underwater light sensors, data loggers and GPRS weather stations.

Award for connected lighting tech

A smart lighting solution developed by Chepstow-based company EnModus has been named the Industrial and Transport Lighting Project of the Year at the 2018 Lux Awards for the lighting industry. The firm has been recognised for fitting more than 950 smart lights at Volvo's production facility in Scotland. With high-efficacy LED luminaires and ambient light sensors, the solution uses wiring infrastructure to power a communications network across the building. The technology provides automated control of individual luminaires and emergency light testing. Using the EnModus Cloud Platform, the car manufacturer is able to measure energy savings and view occupancy levels in the building. Paul Hudson, Operations Director at Volvo, commented that: "With the smart connected lighting solution in place, we are another few steps closer to reaching our goal of becoming a carbon neutral site."

Start-up closes funding round

Customer experience technology provider Vizolution has closed a £10 million investment round backed by three of the world's largest banks. Working across the financial services, insurance, energy and telecoms sectors, the Swansea-based company streamlines complex customer processes for a range of businesses. It plans to use the new funds to expand its product range and push into new markets. Since launching in 2013, the company has opened new offices in Port Talbot, Toronto and Boston, and it has also won a range of awards. Ian McLaughlin, managing director of home buying and ownership at RBS (which is a customer of the Welsh company and also an investor), said: "Last year, Vizolution technology enabled us to introduce the UK's first ever completely paperless mortgage process and the results have been transformational in helping us to make the home buying journey much simpler and easier for our customers."

A composite image featuring a close-up of an astronaut's helmet on the left, with a glowing, multi-colored brain (orange, yellow, and red) superimposed over it. The background is a dark space scene with a view of Earth from space, showing blue oceans and green continents. The overall lighting is a mix of cool blues and warm oranges, creating a futuristic and scientific atmosphere.

Protecting the brains of space travellers

A scientist from the University of South Wales is researching the impact that reduced gravity has on human health.

NASA has made a commitment to send astronauts to Mars by the 2030s. This is an ambitious goal, since a typical 'round trip' can take anywhere between three to six months, with crews expected to stay on the Red Planet for up to two years before planetary alignment allows for the return journey home. It means that crews would have to live in reduced (micro) gravity for about three years, which is far beyond the current record of 438 continuous days in space.



In the early days of space travel, scientists worked hard to figure out how to overcome the force of gravity, so that a rocket could catapult free of Earth's pull in order to land humans on the Moon and rovers on Mars. Today, scientists are interested in learning how reduced gravity affects the health of astronauts, with a particular focus on their brains. Humans have evolved to exist within Earth's gravity (1 g) but not in the weightlessness of space (0 g) or the microgravity of Mars (0.3 g).

Professor Damian Bailey from the University of South Wales believes that in reduced gravity, certain parts of the brain end up receiving too much blood due to the build-up of an invisible molecule floating around in the bloodstream called nitric oxide. This causes the arteries supplying the brain with blood to relax and open up too much. As a consequence of this surge in blood flow, the blood-brain barrier can become overwhelmed, allowing water (called oedema) to slowly build up, and causing brain swelling and an increase in pressure. The end result is that there is insufficient oxygen getting to parts of the brain quickly enough. This is a big problem that could explain not just issues with blurred vision, but also issues with other skills including

cognitive agility such as how the astronauts think, concentrate and move.

A special reduced gravity aircraft, based in Bordeaux, is able to simulate the feeling of weightlessness. By climbing and then dipping through the air, it can perform as many as 30 'parabolas' in a single flight, each lasting 30 seconds. With all of the equipment securely fastened down, the research team took measurements from eight volunteers over four days. They measured blood flow in different arteries that supply the brain using a portable Doppler ultrasound, which works by bouncing high-frequency sound waves off circulating red blood cells. They also took blood samples from a forearm vein to measure nitric oxide and other invisible molecules that can indicate if the blood-brain barrier has been forced open.

Initial findings showed that nitric oxide levels increased following repeated bouts of weightlessness. This was proven to coincide with increased blood flow, particularly through arteries that supply the back of the brain,

forcing the blood-brain barrier open. The scientists are planning on following up with more detailed assessments of blood and fluid shifts in the brain. This would involve using imaging techniques like magnetic resonance to confirm the findings, while exploring countermeasures such as rubber suction trousers that could help 'suck' blood away from the astronaut's brain, like a vacuum cleaner, and drugs to counteract the increase in nitric oxide.

Contact:
Prof Damian Bailey
University of South Wales
w: www.southwales.ac.uk
t: 01443 482296
e: damian.bailey@southwales.ac.uk



Pontypridd

Medical device to change pancreatic cancer treatment

Creo Medical has designed a novel device to reduce the size of tumours in the pancreas.

Pancreatic cancer is the eleventh most common type of cancer, with around 9,800 people diagnosed in the UK each year, and the sixth most common cause of cancer death. Many cases are detected at a late stage, as there are few noticeable symptoms early on.

Chepstow-based company Creo Medical has developed a new device that enables tumours in the pancreas to be reduced in size, making use of its proprietary microwave energy based needle, antenna and control system. The device is introduced into the ablation site through the

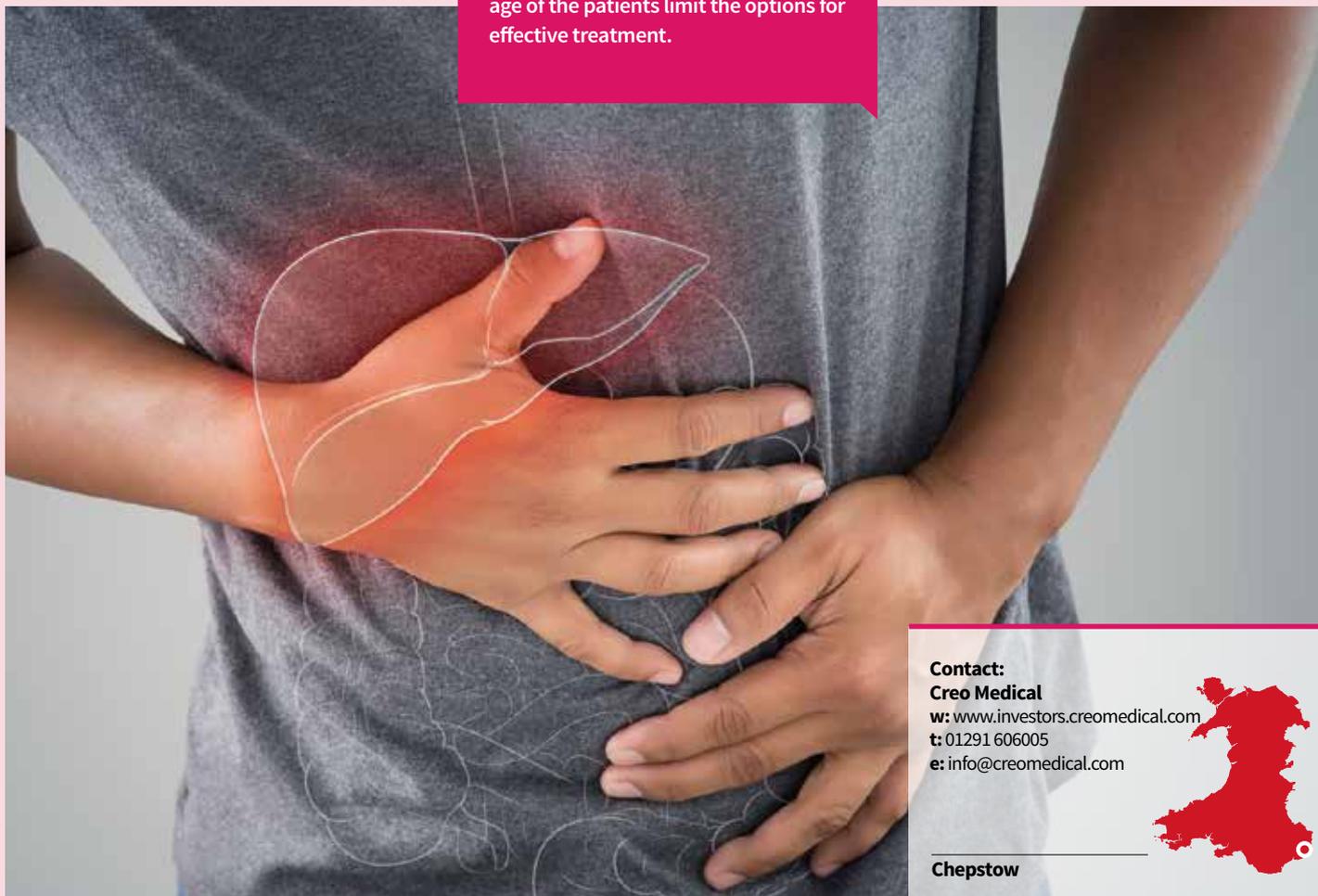
gastrointestinal tract and the tumour is located using an endoscopic ultrasound scope.



Pancreatic cancer is rarely diagnosed at a time when surgical resection is feasible, because symptoms do not appear until tumours have already spread to involve critical abdominal vessels and adjacent organs, which greatly increases the risk. The location of the tumour and the often advanced age of the patients limit the options for effective treatment.

The application of the device's energy has the potential to sufficiently reduce tumour size, so that it would provide a continued quality of life for the patient. The procedure could be repeated every few years, whenever the tumour has increased in size enough to require action, and this could be repeated indefinitely.

By continuously reducing the size of tumours when necessary, the new technology could present a long-term palliative care solution for patients and change the prognosis of a short-term life span to a long-term control plan. It could therefore increase the survival rate associated with pancreatic cancer worldwide.



Contact:
Creo Medical
w: www.investors.creomedical.com
t: 01291 606005
e: info@creomedical.com



Chepstow

AI solutions for kidney disease

RenalytixAI is developing AI-enabled diagnostics to improve diagnosis and clinical management of kidney disease.

Kidney disease affects over 850 million people globally and is considered a significant unmet medical need. End-stage renal disease (ESRD), the final stage of chronic kidney disease, is known as a ‘silent killer’ because often the patient does not have any noticeable symptoms until it is too late for intervention.

With the aim of improving diagnosis and clinical management of kidney disease, Penarth-based company RenalytixAI is using artificial intelligence to analyse different sources of information, including blood-based biomarkers, genetics and large electronic health record databases. The company has developed its lead tool, KidneyIntelX, in collaboration with Mount Sinai Health System and other large academic medical centres in the US.

The digital tool uses an AI-enabled software algorithm to process input from different sources of diagnostic data, including liquid biopsy plasma biomarkers and digital metrics from patient electronic health records. These disparate data sources provide diagnostic information for patients at high risk of having accelerating kidney disease, such as patients with Type 2 diabetes and African ancestry.

Patients with accelerating kidney disease are much more likely to experience end-stage kidney failure and be admitted for costly dialysis treatment.

AI-enabled diagnostic tools are able to process much larger amounts of disparate information than is possible for the human clinician, and this information can have predictive value to better understand the current health status and future outcomes of patients. RenalytixAI technology can also introduce a new level of personalised medicine by providing diagnostic information for specific patient subtypes. For example, in patients of African ancestry, who are three times more likely to be afflicted by kidney disease than Caucasians, the standard version of the tool is enhanced by a genomic test to detect risk variants in the APOL1 gene.

The algorithms learn over time with more use and inclusion of additional longitudinal data input from each patient. In addition, by combining circulated blood proteins and genetics with large electronic health record databases, the company believes it can create more powerful models for therapy response and new druggable biomarker targets, which can have an impact on outcomes across the kidney disease spectrum.



One of the key blood biomarkers used in the diagnostic algorithms, sTNFR, was first recognised by investigators at the Joslin Diabetes Center in Boston, US, who found strong associated risk for progressive renal function decline and ESRD in patients with Type 2 diabetes. RenalytixAI is now using these biomarkers for determining whether a patient has increased risk of developing chronic kidney disease or ESRD. The company intends to submit KidneyIntelX for regulatory review following multi-centre validation trials beginning early 2019.

Contact:
RenalytixAI
w: www.renalytixai.com
t: 020 7933 8780
e: renalytix@walbrookpr.com



Penarth

Next-generation drug for rare conditions

Midatech Pharma is developing a new oncology drug, built upon a drug delivery technology designed to make sustained release drugs safer, cheaper and more effective.



Carcinoid syndrome and acromegaly are rare and debilitating hormone-based conditions, with high rates of morbidity and mortality. Scientists at Midatech Pharma's Cardiff-based R&D site have used their drug delivery technology, known as Q-Sphera, to create MTD201 Q-Octreotide. This is a once-monthly sustained release formulation of octreotide acetate, designed to serve as an alternative to the current leading treatment for these conditions.

Both conditions are caused by the excessive secretion of growth hormone in the body, often secondary to either pituitary adenoma or carcinoid tumours. The new drug reduces circulating growth hormone in the body in order to bring the life-threatening diseases under control. Having a sustained release

formulation enables patients to receive a single injection every four weeks, rather than up to three times per day with immediate release, standard octreotide. It is also easier to prepare and inject, as a result of the delivery platform providing more precise control over particle size, morphology and behaviour, so its formulations illustrate highly linear, reproducible drug release kinetics and improved physical characteristics.

Exploiting the delivery platform, the sustained release formulation used in the new drug is able to improve injectability, minimise dosing errors and enable the use of smaller needles, which reduces injection pain and injection site reactions. Similarly, quicker and simpler product reconstitution is expected to reduce both clogging and the time needed by the nurse or physician to administer the injection, addressing the common problem that current formulations are complex and slow to prepare for injection. For octreotide therapies, it reduces the typical preparation time from around 40 minutes to under 10 minutes.



MTD201 has been investigated in a 'first-in-human' clinical trial, with early data indicating that it produced a safe and effective sustained-release of octreotide supporting a one-monthly dosing regime. Building on these positive results, Midatech Pharma is now pursuing a pivotal clinical study that will support marketing approval. In doing so, the company also aims to show how Q-Sphera has the potential to improve patient outcomes and reduce direct medical costs, meaning it would benefit NHS, insurers and healthcare providers worldwide.

Contact:

Midatech Pharma Wales Ltd
w: www.midatechpharma.com
t: 02920 480180
e: info@midatechpharma.com



Cardiff

New hope for the northern white rhino

Researchers have discovered that it could be possible to rescue the critically endangered northern white rhino from extinction, using the genes of its less threatened southern cousin.

White rhinoceros distribution across Africa is divided into populations in the north and south. The southern population declined to its lowest number around the turn of the 19th century, but recovered to become the world's most numerous rhinoceros. In contrast, the northern population has declined rapidly since the 1970s, and the last male died in 2018, leaving only two remaining female rhinos who are both unable to breed.

Researchers from Cardiff University and the University of Venda analysed genetic samples from 232 rhinos and made a significant discovery. Dr Isa-Rita Russo from Cardiff University explained: "Despite the northern and southern populations of white rhinos splitting from each other at about one million years ago, we have been able to establish that there was contact between these populations with the occasional exchange of genes since then – possibly as recently as the last ice age, when the African savannah expanded and reconnected the two populations."

This genetic proof of contact between the populations indicates that it may be possible to successfully rescue the northern white rhino, by using southern white rhino genes to create embryos.

The team also found that population decline was very different in the north

and south, with the northern white rhinoceros declining about 1,370 years ago, coincident with the Bantu migration, and the southern white rhinoceros declining during colonialism, starting 400 years ago.



"It appears that the white rhinoceros is no stranger to low genetic diversity, as our results show that the species was subjected to several climatically and anthropogenically driven population declines, which would have reduced and compressed genetic diversity in the past. This is one of the few large animals to survive the last ice age, and it seems that the additional human pressure on an already genetically compromised species has pushed the white rhinoceros further along the road to extinction."

Professor Yoshan Moodley
University of Venda

Contact:

Dr Isa-Rita Russo
Cardiff University
w: www.cardiff.ac.uk
t: 029 2087 5073
e: russoim@cardiff.ac.uk



Cardiff

Collaboration to combat deadly diseases

Scientists involved in a cross-Wales partnership have identified new drug leads for combating life-threatening parasitic diseases.

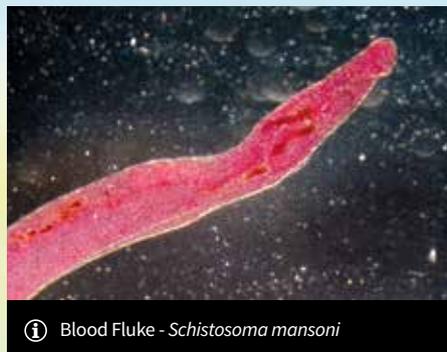
Every year, infection with parasitic worms (helminths) accounts for a significant loss of human and animal lives, as well as the destruction of important food crops.

The wide-scale deployment of anthelmintic vaccines or other preventative substances is not currently feasible, so sustainable control of these pathogens is mainly facilitated via small numbers of therapeutic drugs or pesticides. This strategy has led to the development of drug-insensitive and drug-resistant parasite populations, which means there is an urgent need for the identification and progression of new anthelmintic drug classes.

To address this challenge, Aberystwyth University has led in the creation of an

interdisciplinary research centre, the Barrett Centre for Helminth Control (BCHC). Scientists have primarily focused their efforts on the control of two related helminth species, the blood fluke 'Schistosoma mansoni' and the liver fluke 'Fasciola hepatica'.

Blood flukes are responsible for schistosomiasis, a neglected tropical disease of the developing world that kills up to 300,000 people each year. While liver flukes can also infect humans, their impact is mostly felt in the livestock industry where it is estimated that, in the



① Blood Fluke - *Schistosoma mansoni*



① Liver Fluke - *Fasciola Hepatica*



UK alone, £300 million is lost per year. Both fluke species are controlled by single drug classes (praziquantel for blood flukes and triclabendazole for liver fluke), but drug-insensitive or drug-resistant parasite populations have arisen. The search for new flukicides (substances that kill fluke worms) is therefore a priority for maintaining the control of these pathogens.

In collaboration with Cardiff University's School of Pharmacy and Pharmaceutical Sciences and Welsh company Phytoquest Ltd, the Centre has identified three new anthelmintic drug classes with promising activity against both blood and liver flukes.

In one study, derivatives of an anthelmintic natural product isolated from the goji berry plant were synthesised at Cardiff University. These derivatives were then tested for activity against blood and liver flukes at Aberystwyth University, using the Roboworm drug discovery platform. Several of the newly synthesised compounds showed greater anthelmintic potency and selectivity than the originally identified natural product.



① Goji berries



① Fir trees

Following on from this goji berry plant investigation, researchers sought to identify new anthelmintic natural products obtained from fir trees. Here, highly purified compounds were isolated by Phytoquest and provided to the BCHC for activity testing against liver and blood flukes. The results again identified potent compounds with selectivity towards these parasitic worm species. Together with the goji berry study, this investigation into fir trees demonstrated that plants contain anthelmintic products useful for further research.

Finally, in a study attempting to characterise inhibitors of blood fluke histone modifying enzymes, scientists identified potent anthelmintic activity for the anticancer natural product, anthracyclines. This activity has so far only been demonstrated for blood flukes. However, the research has identified a drug repurposing strategy that could dramatically increase the speed by which anthracyclines are progressed as novel anthelmintic (and potentially other anti-infective) leads.



“These examples clearly demonstrate how different disciplines can be collaboratively brought to bear on some of the most difficult-to-treat infectious diseases on our planet. With continued cross-Wales partnerships, we expect to make significant progress in the development of these and other anthelmintic leads.”

Professor Karl Hoffmann
Barrett Centre for Helminth Control

Contact:
Prof Karl Hoffmann
Barrett Centre for Helminth Control
w: www.bchc.aber.ac.uk
t: 01970 622237
e: krh@aber.ac.uk



Aberystwyth

New technology prolongs battery life

Deregallera has created technology to extend the life of lithium-ion batteries.

Lithium-ion batteries (LIBs) have the highest energy density of current battery technology. They are smaller and lighter than other systems and have therefore become ubiquitous over the past ten years – initially in portable electronics such as mobile phones, but increasingly as key technology in electric vehicles.

An issue associated with LIBs, however, is their cyclability. In electric vehicles, the short-term high power demands of rapid acceleration can cause degradation of the battery electrode materials, reducing capacity and ultimately the life of the battery.

Caerphilly-based company Deregallera has developed new technology, known as the Hybrid Energy Storage System or HESS. It combines two forms of electrical energy storage in one system – supercapacitors, which store energy electrostatically, and lithium-ion batteries, which store energy electrochemically. This combination prolongs the life of LIBs.

Batteries can generally store lots of energy (high energy density) but cannot handle it quickly (low power density). On the other hand, supercapacitors have low energy density but high power density. In the HESS, battery management algorithms balance the flow of energy between the two systems, so that the supercapacitors handle the rapid accelerations and protect the battery. They can also work in reverse, capturing the energy from rapid decelerations and reusing it for the next acceleration. This increases the range of the battery pack as it harvests energy that would otherwise be lost.

Supercapacitors typically store less energy per kilogram than standard LIB systems, so they are often bulky and heavy additions to electric vehicles. However, Deregallera's electrode material stores 50 per cent more energy per kg than leading materials, resulting in lighter and smaller devices which make HESS viable. The capacity of the supercapacitors is related to the very high surface area of carbon. The company

is continuing to work on increasing the surface area, and therefore the capacity, of its supercapacitor electrode material even further by carefully matching the pore size of the carbon to the size of the ions in the electrolyte.

The supercapacitor electrode material is derived from putting a biomass through high temperature treatments, which involve firstly reducing the biomass to a char (to remove unwanted minerals) and then chemically activating it to dramatically increase the surface area and create a hierarchical pore structure. Controlling the distribution of pore sizes is key to realising a high energy density. The company currently manufactures the material on a 1g scale, but is working with QinetiQ in order to scale up.

Another HESS innovation lies in its power electronics. There is a large disparity in the operating voltages of the batteries and the supercapacitors, which means that large currents must flow through the power electronics. Historically, this meant that



By extending the life of LIBs, the new energy storage system has the potential to reduce the running costs of electric vehicles. As a result, it could lead to wider adoption of these vehicles, which would have a positive impact on the environment. It could also reduce the CO2 emissions associated with LIB manufacture, further benefiting the environment.

prohibitively expensive components were required. However, the project makes use of recent advances in the next generation of highly efficient SiC and GaN devices, so this is not the case.



Contact:
Deregallera

w: www.deregallera.com

t: 029 2084 9009

e: enquiries@deregallera.com

Caerphilly



Innovative recycling for plastic waste

Scientists at Swansea University have developed a groundbreaking process to turn discarded plastic into hydrogen.

Plastic bottles often end up being burned or thrown into landfill, despite the fact that most are made of PET (polyethylene terephthalate) which can be recycled. However, even when bottles are sent for recycling, this does not always happen.

The bottles can only be processed for recycling if they are pure, meaning only PET with nothing else mixed in, and clean. Plastics contaminated with food or oil are almost impossible to recycle, because the impurities interfere with the recycling process. Washing can be expensive and is often not worth the effort, since the end result is rarely as good as the virgin material.

Researchers from Swansea University and Cambridge University have now jointly developed a method of recycling plastic which does not require it to be pure or clean. In the sunlight-driven process, called photoreforming, a photocatalyst (a light-absorbing material) is dropped onto the plastic which is then immersed into alkaline water. Irradiation with sunlight reduces the water to hydrogen, while the plastic is simultaneously oxidised to small organic molecules.

The team tested the system by photoreforming three common

polymers – polylactic acid, polyethylene terephthalate and polyurethane. They also demonstrated the applicability of the process to real-world waste by photoreforming a plastic bottle to hydrogen, with an efficiency comparable to pure polymers.

PET consists of terephthalic acid and ethylene glycol – two components that form a chain, making a polymer. During the new recycling process, the ethylene glycol is degraded, which produces hydrogen and CO₂, while the terephthalic acid stays intact and remains in the solution. Therefore the process produces hydrogen fuel, which could be used to power hydrogen cars, as well as a chemical that can be used to make new plastic.

It has the potential to serve as a cheaper alternative to traditional recycling methods, as any kind of plastic can be processed and there is no need to clean it first. This could enable more plastic to be recycled, which would have significant



“Our vision is that this will be an additional way of treating currently non-recyclable waste. We could scale up the process and use it for treating the leftover waste in a recycling plant. Ultimately, maybe people could treat their own plastic waste in their gardens, similarly to compost, with a solar waste-reforming device. You put your plastic waste in it and get hydrogen to heat your house or fuel your car.”

Dr Moritz Kuehnel
Swansea University

environmental benefits. The process also saves energy compared to traditional recycling, because it uses only solar energy and operates at ambient temperature and pressure. The research team predicts that rolling out the process on an industrial scale may take a few years.

Contact:
Dr Moritz Kuehnel
Swansea University
w: www.swansea.ac.uk
t: 01792 604611
e: M.F.Kuehnel@Swansea.ac.uk



Swansea

VR raises dementia awareness

Galactig has created a VR experience to improve people's understanding of dementia.

Although it affects many people as they grow older, dementia is a largely hidden condition that can be difficult to understand for people who are not directly experiencing it.

Dementia First Hand (Yn Fy Nwyllo I) was created by Caernarfon-based creative agency Galactig to educate people about, and raise awareness of, dementia. It consists of a bilingual VR experience that aims to depict how dementia patients feel on a daily basis. The project was led by Gwynedd Council, and in early stages of the project, focus group sessions were held with dementia patients and carers.

The VR experience is delivered via an Oculus Rift VR headset, allowing the user to interact with the environment with virtual hands. Meanwhile photorealistic 3D environments ensure that the experience feels immersive.

Different voiceover options are available to choose from – male or female, English or Welsh – so that the experience can be personalised. This voiceover serves as the user's internal monologue, describing their anxiety with the world around them as someone suffering from dementia. The user completes various tasks involving interaction with everyday objects, which drives the narrative forward. There are moments intended to be confusing and upsetting as the user is taken on a journey through some of the more difficult issues associated with dementia.

Project leader Meilys Heulfryn Smith explains the importance of the experience being bilingual: "When a person develops dementia, they often lose the ability to communicate in their second language. The technology paints a

poignant picture of this experience, immersing the user in a situation where they recognise the need for actions to manage the task, and the words associated with those actions, but are simply not able to retrieve them. This very real frustration is felt by thousands of people in Wales each day, and we hope that the VR experience will increase awareness and understanding of the challenges this disease brings. Dementia is a difficult and sensitive subject for many families across Wales, and this project gives family members the chance to handle this as an issue in Welsh, as being able to use your first language during a difficult time is often comforting."



Arloesi Gwynedd Wledig, a programme that develops and implements pilot projects in Gwynedd in collaboration with the community, has been using the VR experience at dementia workshops. It is already having a positive impact on the local community, with users reportedly having emotional responses to the content.



**Contact:
Galactig**

w: www.galactig.com

t: 01286 675722

e: derick@galactig.com

Caernarfon



Digital lie detector for police reports

Computer scientists from Cardiff University have developed a digital tool to detect false police statements.

In many parts of the world, the filing of false police statements is a crime that carries serious consequences, such as jail terms and heavy fines. False statements not only contaminate police databases and damage the outcomes of criminal investigations, but also waste significant amounts of public resources that could be dedicated to pursuing other crimes. Nevertheless false reports are very common, especially in the reporting of low-level crimes such as robbery.

A team of researchers, including computer science experts from Cardiff University and Charles III University of Madrid, have developed a digital tool that can spot if somebody has filed a fake police statement based purely on the text included in the document. Known as VeriPol, the tool is specific to reports of robbery and can recognise patterns that are more common with false claims, such as the types of items reported stolen, finer details of incidents and descriptions of the perpetrator. Using a combination of automatic text analysis and advanced machine learning techniques, it

is able to successfully identify false robbery reports with a high level of accuracy.



VeriPol is partly based on a process known as natural language processing – a branch of artificial intelligence that helps computers to understand, interpret and manipulate human language. For example, the tool uses algorithms to identify and quantify various features in text, such as adjectives, acronyms, verbs, nouns, punctuation marks, numbers and figures. Historical police reports known to be false were fed through the system, enabling it to code each one and learn specific patterns.

The tool is expected to save the police both time and effort by complementing traditional investigative techniques, while also deterring people from filing fake statements in the first place. It has now been rolled out across Spain to support police officers and indicate where further investigations are necessary.

In an initial study of more than 1,000 police reports from the Spanish National Police, the

tool had a success rate of more than 80 per cent in discriminating between true and false reports. It identified a number of themes that were common amongst false robbery reports, including shorter statements that were more focused on the stolen property than the incident itself, a lack of precise detail about the attacker, limited details of the attacker, and a lack of witnesses or other hard evidence.

VeriPol was also put to task on a real-life pilot study in the urban areas of Murcia and Malaga in Spain. In one week in June, 25 cases of false robbery reports were detected in Murcia, resulting in the cases being closed, and a further 39 were detected and closed in Malaga. In comparison, over the course of eight years between 2008 and 2016, the average number of false reports detected and cases closed by police officers in the month of June was around 3 for Murcia and 12 for Malaga.

Contact:
Cardiff University
w: www.cardiff.ac.uk
t: 029 2087 4812
e: comsc-office@cardiff.ac.uk



Cardiff

Exploring the human dimension of driverless cars

Researchers in Wales and France are collaborating to investigate the human dimension of driverless vehicles.

Driverless vehicles have the potential to revolutionise society. They are expected to significantly improve road safety, because in a driverless world, unsafe driving behaviours would be eradicated by smart technologies. They would also allow people to spend less time driving and more time doing other tasks. However, there are significant challenges to address before driverless vehicles can become commonplace.

Researchers at Swansea University's CHERISH Digital Economy Research Centre, in collaboration with the French Institute for Research in Computer Science and Automation in Grenoble, are investigating one of the most complex obstacles to mainstream adoption and societal acceptance of driverless vehicles – the human dimension.

People may think nothing of boarding an 'autonomous' vehicle when flying, but the models of auto-pilot systems in civil aviation rely on the fact that there is always a human pilot engaged at all times, who can intervene in case of a system failure. For example, when US Airways flight 1549 crash-landed into the Hudson River in 2009, there was no loss of life at all among the 155 people on-board, and this was achieved thanks to human factors – attitude, skills, experience, knowledge and mental preparation for the unexpected, which all helped the pilot to perform under extreme conditions.

One of the main barriers to adoption of driverless vehicles is a lack of public trust, and this is a multifaceted challenge. Tech companies and car manufacturers are investing billions in self-driving cars, but research indicates that people do not regard them as safe. According to an MIT White Paper published in 2017, nearly half of 3,000 people surveyed said they would never purchase a car



that completely drives itself, citing concerns over loss of control and lack of trust in the technologies.

The research project between Swansea and Grenoble is rising to this challenge, bringing together a range of research fields including Human-Centred Design, Artificial Intelligence and Multi-Robot Systems in order to design algorithms and develop models that would allow vehicles to navigate and operate in dynamic, human-populated environments. The researchers are also exploring the use of sound and the impact of sonic attributes in safety-critical systems, addressing complex questions around how manufacturers design for driverless scenarios and calibrate trust between humans and machines. Human-robot interaction plays a critical role in increasing trust between passenger and the vehicle.

People are generally willing to trust automation in routine tasks where the consequences of error are minor, but in the high-stakes realm of driverless vehicles they are more reluctant. The research team is hoping that their work will help to change this perception.



“Driverless does not mean humanless. We want to ensure that our work speaks to the complexities of the human experience of driverless cars. By working closely with our international research partners, the automotive industry and, most crucially, the people who will actually use these future vehicles, we hope to help shape the next generation of autonomous vehicles that places humans at the heart of technology design.”

Jay Doyle

Research and Business Engagement
Officer
Swansea University

Contact:
Jay Doyle
Swansea University

w: www.swansea.ac.uk
t: 07970 577879
e: j.c.doyle@swansea.ac.uk



Swansea

Software to speed up property development

Urban Intel has developed a digital tool to make land appraisal quicker and easier for property developers.

When appraising land, property developers typically have to enlist help from a variety of professionals including planning consultants, environmental consultants and surveyors. As a result, the process can become time-consuming and complex.

Cardiff-based Urban Intel was founded by a planning consultant frustrated with this complexity and with the need to extract information from so many different sources in order to appraise sites. The company has created a software tool, known as SiteScore, which analyses the development potential of any parcel of land in Wales and England. A report can be produced in a matter of seconds, allowing property developers to make immediate and well-informed decisions.

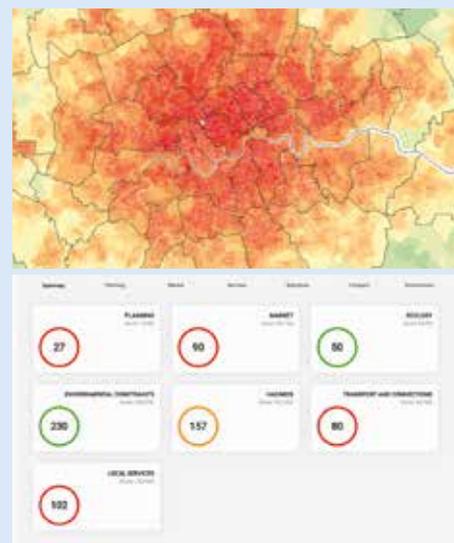
The algorithm takes into consideration a wide range of data and information related to development, including local market forces, access to transport, planning attitudes and likely site development viability. It ingests terabytes of data on property markets from HM Land Registry, flood risk data from the Environment Agency, road layouts and topography from Ordnance Survey to enable the automation of many tasks that previously had to be done by professionals working on a project-by-project basis.

In addition to saving time, having this data all in one place for the first time allows industry and government to more easily undertake huge appraisals of the UK's land. This could lead to improved planning coordination and the identification of land for new housing. The tool not only identifies where sites are strong for development, but also highlights where they are particularly weak. This enables better targeting for infrastructure improvements and policy interventions to support changing communities.

The software is expected to have a big impact on the way that property developers and their professional agents identify land development potential. Instead of waiting weeks for a report, they will be able to analyse in seconds, and even tailor the algorithm to identify land that fits their requirements. Aside from applications in the private sector, planners and policy makers in government will have the ability to allocate the most appropriate development sites in local plans in real-time, and more effectively hold developers to account in when receiving their viability claims.

SiteScore will initially be able to produce a report, summarising the positive and negative factors that relate to a site, indicating its development potential. Some of the factors include whether there are environmental

constraints on the site, whether there is a direct access point to a highway, or whether there is growing demand for new development in that location.



Examples of the software interface

Contact:
Urban Intel
w: www.urbanintel.io
t: 029 2010 4956
e: dan@urbanintel.io



Cardiff