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Groundbreaking research to fight sepsis

Scientists at Cardiff University are working to develop a reliable way of detecting sepsis

Llywodraeth Cymru
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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
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Welcome to the Summer 2019 edition of Advances Wales.

Over the past 20 years, Wales has consistently grown the volume, quality, impact and international reach of its research base. It is now among the most efficient research performers, converting relatively small levels of funding into highly regarded research. This impressive performance stems from a long-standing collaboration between Welsh Government, universities and business, using a mix of HEFCW, Research Council and targeted EU Structural Investment Funds.

One example of this successful cooperation is the internationally recognised Sêr Cymru programme, managed by the Office of the Chief Scientific Adviser for Wales. On 19th September 2019, this programme will be celebrated at an event in Cardiff and several of the projects that will be represented at this event are included in this edition of Advances Wales: groundbreaking research to fight sepsis (page 9), new findings about the Sun's magnetic field (page 3), work beginning on a new vet research hub (page 4) and a new generation of drugs in development (page 5).

Also featured in this edition are a new test to predict how patients will respond to leukaemia treatment (page 6), smart mouthguards to tackle the concussion crisis in rugby (page 14) and research into the grass pollen that affects asthma and hay fever sufferers (page 18).

This edition, and previous editions, of Advances Wales can be viewed 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.

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New findings about the Sun's magnetic field

Scientists at Aberystwyth University have discovered that the Sun's magnetic field is ten times stronger than previously believed.

Dr David Kuridze from the Solar Physics Group at the University's Department of Physics is a leading authority on the use of ground-based telescopes to study the Sun's corona, which is the ring of bright light visible during a total eclipse. Working from the Swedish 1-m Solar Telescope at Roque de los Muchachos Observatory in the Canary Islands, he studied a particularly strong solar flare which erupted near the surface of the Sun in September 2017.

The telescope can only focus on 1 per cent of the Sun's surface at any given time, but Dr Kuridze was focused on exactly the right area at the right time when the solar flare erupted. Therefore, a combination of favourable conditions and an element of luck enabled the team to determine the strength of the flare's magnetic field with unprecedented accuracy.

www.aber.ac.uk

Dr Kuridze believes the findings have the potential to change our understanding of the processes that happen in the Sun's immediate atmosphere. "Everything that happens in the Sun's atmosphere is dominated by the magnetic field, but we have very few measurements of its strength and spatial characteristics", he explained. "These are critical parameters, the most important for the physics of the solar corona. It is a little like trying to understand the Earth's climate without being able to measure its temperature at various geographical locations. This is the first time we have been able to measure the magnetic field of the coronal loops, the building blocks of the Sun's magnetic corona, with such a level of accuracy."

Technology to increase access to space

To support the UK's national goal of capturing 10 per cent of the global space market by 2030, aerospace start-up Smallspark is developing an orbital launch vehicle, along with other smaller sub-orbital launch vehicles, powered by hybrid rocket engines.

Hybrid rocket engines are cheaper, more reliable and safer for both humans and the environment, but they have not yet been developed to deliver small payloads of up to 150kg to orbit. The Cardiff-based company's aim is to drive the price to orbit from the UK to be the lowest in the world for a dedicated small launch vehicle.

Smallspark is developing methods that will allow them to overcome issues associated with hybrid rockets, such as the fact that they can be difficult to ignite. They are also working on novel techniques and construction methods that will enable them to have greater control over the power and performance that their engines output, without increasing the cost of manufacture. They have set a goal of sending a payload to above 80km by the end of 2020. This was chosen as it is the height at which someone is awarded astronaut wings.

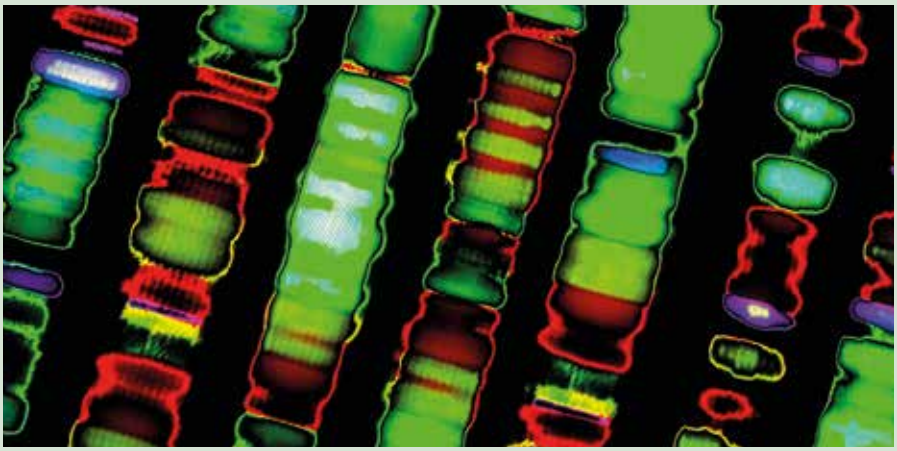
"A modernised hybrid engine could have a phenomenal impact on the UK space industry, allowing us to become true leaders in the global space market. If we take the same approach to launch as countries like China, India and the US, they will beat us on cost and development speed. The UK needs to take a smarter approach and play to our strengths, using innovative and intelligent propulsion systems that other nations cannot readily copy."

Joseph Ward
Founder of Smallspark

www.smallspark.space

Microbiology genomics revolution

Scientists in Wales are using innovative genomics technology to answer important questions about antimicrobial resistance and how different strains are related.



A collaborative approach, bringing together experts in microbiology, surveillance, bioinformatics and infection prevention & control, is already delivering services for HIV, TB and Influenza. Two further services dealing with the spread of antimicrobial resistance and Clostridioides difficile infection are to follow soon.

C.difficile infections remain a major cause of morbidity and mortality, posing a significant challenge. Although progress has been made over the last decade in terms of reducing infection numbers, there is a zero-tolerance approach to healthcare infections in Wales.

The application of genomics, in the form of whole genome sequencing, for the characterisation and typing of C. difficile is a novel service as it aims to give results in a clinically useful timeframe, rather than retrospectively. The Difficile Genomics Sequencing and Typing project (DIGEST), led by the UK Anaerobe Reference Unit in Cardiff, will offer a service linking results with epidemiological data on the antimicrobial prescribing and hospital movement history of patients.

A major impact of the project will be the ability to give greater discrimination between strains, unlinking and linking cases with more certainty, which will allow infection prevention & control and clinical teams to better focus their efforts. It will also enable scientists to look for antimicrobial resistance genes that may allow certain strains to proliferate, and improve understanding of the relationship between community and hospital acquired C.difficile infections.

www.phw.nhs.wales

IN BRIEF

Investment in fingerprint tech firm

Fingerprint technology firm Touch Biometrix has raised £2 million investment to accelerate its global expansion plans and commercialise its designs. The St Asaph-based company is currently developing a new range of fingerprint sensors for use in consumer electronics such as smartphones and laptops, and hopes to disrupt the market by boosting affordability. It secured the funding through the Deepbridge Technology Growth Enterprise Investment Scheme and comes a year after it raised £150,000. Mike Cowin, CEO of Touch Biometrix, commented: "This new and substantial investment will enable Touch Biometrix to build upon its development work, with the aim of defining its first minimum viable product ahead of scaled production in early 2020."

Speech therapy app launched

Cog-Neuro Speech Therapy Ltd has developed a new app for people who suffer from communication difficulties. The Caerphilly-based company received a £25,000 loan from the Development Bank of Wales and a £60,000 grant from Innovate UK to create the app, which helps people regain their ability to communicate, maintain relationships and re-integrate into the community. Founded by speech therapist Sheiladen Montero Aquino, it is targeted at people who are experiencing communication difficulties due to a stroke, brain injury or other progressive neurological disorders such as Parkinson's or dementia. The app uses gamification and stealth learning to help people improve their listening, speaking, reading, writing and thinking skills, as well as encouraging interactivity and concentrated attention.

Life sciences company strikes China deal

Bridgend-based company ReNeuron has struck a £80m deal for two of its innovative cell therapy programmes to be developed, manufactured and commercialised in China. Fosun Pharma, a leading healthcare group in China, will fully fund the development of ReNeuron's CTX (stroke related treatment) and hRPC (blindness) therapy programmes in China, including clinical development and subsequent commercialisation activities. Fosun Pharma has also been granted rights to manufacture the licensed products in China. Yifang Wu, President and CEO of Fosun Pharma, said: "These licensed products and unique stem cell platforms will address huge unmet needs in the Chinese market. Regenerative medicine is one of the most advanced areas with various cutting-edge technologies. The collaboration with ReNeuron will contribute to the strategic leading position of Fosun Pharma in this area in China, and also help us to enrich the pipelines for severe disease medical solutions."

Funding to develop micro and nano materials

A research team of materials engineers and performance scientists at Swansea University has been awarded £1.8 million to develop new products that make use of micro and nano materials based on specialist inks. One application already being developed is specialist clothing that will be worn by elite British athletes in training and at the 2020 Olympic and Paralympic Games. The researchers will be incorporating advanced materials such as graphene into flexible coatings, which will be printed and embedded into bespoke garments to enhance the performance of athletes. The purpose of the project is to serve as a pipeline for new ideas, testing to see which of them can work in practice and on a large scale, and then turning them into actual products. In addition to the wearable technology, two other areas will be among the first to use the pipeline: SMART packaging with Tectonic and the car industry with GTS Flexible Materials.

Work begins on vet research centre

Work is underway on a new £4.2m state-of-the-art veterinary hub to drive forward research into protecting both animal and human health. Led by Aberystwyth University, VetHub1 will provide fully-equipped, high-specification laboratories and office spaces. Researchers at the centre will work with industry to develop tests and vaccines that will help reduce losses in the livestock industry and improve animal health. They will be looking particularly at developing solutions for animal borne diseases that could pass to humans. The facility will also lead to the further development of veterinary practices and other animal health care as well as biotechnology, animal food manufacture and other allied industries. VetHub1 is expected to be fully operational by spring 2020 and aims to make a valuable contribution to the rural economy and to the livestock industry in Wales and further afield.

Trial of potential new treatment for type 1 diabetes

Researchers at Cardiff and Swansea Universities are running a new trial to investigate whether a medicine currently used for the skin condition psoriasis could also help people with type 1 diabetes.

Over 300,000 people in the UK have type 1 diabetes. Unlike the more common type 2 diabetes, which is typically related to diet and lifestyle, type 1 diabetes is an autoimmune disease caused by the immune system destroying the insulin-producing cells of the pancreas. Without insulin, the body is unable to control blood glucose, resulting in dangerously high glucose levels.

The drug being used in the trial, ustekinumab, is taken as an injection every 1-2 months and reduces the ability of the immune system to damage the insulin producing cells. It is already licensed to treat psoriasis, in which the immune system attacks skin cells, and appears to be very safe.

"In the early stages of type 1 diabetes, about 20 per cent of insulin-producing cells could still be working. We're offering newly diagnosed patients the opportunity to potentially save some of these cells, making it easier for them to control blood glucose levels. This could also reduce their risk of complications."

Professor Colin Dayan
Cardiff University School of Medicine

The trial is open to people aged 12-18 who are within 100 days of diagnosis with type 1 diabetes. Participants will be given the drug or a placebo over the course of a year. By the end of the study, the researchers will know whether the drug is well tolerated and whether it works in holding on to the insulin.

www.cardiff.ac.uk

Investment for new healthtech firm

Healthtech firm Concentric, which empowers patients to make the right decisions for themselves, has received £350,000 investment from Innovate UK. Co-founded by Carmarthen-born surgeon Dafydd Loughran, the firm has developed a platform that supports patients faced with the possibility of surgery to make shared decisions with their clinicians. It also digitises paper-based processes so that health organisations can save money and avoid unnecessary operations. The new funding will be used to scale up from a pilot at Imperial Healthcare NHS Trust across interest-ed Welsh health boards and internationally. Dafydd Loughran said: "We're hoping to drive healthcare towards data-driven, shared decision-making. We want to support decision-making around what matters to the individual, and use technology to deliver insights into what the outcomes are likely to be for that individual."

Queen's Awards for Welsh businesses

Ten businesses from Wales were named as winners of the prestigious Queen's Awards for Enterprise 2019. The annual awards are given to British companies for achievement of the "highest levels of excellence" in categories such as innovation, international trade and sustainable development. Welsh winners of the innovation award included advanced wire strippers Laser Wire Solutions and underwater yacht lighting company Lumishore, as well as Biocatalysts, Huntleigh Healthcare, Airbond and Silverlining Furniture Group. Meanwhile, international trade award winners included Concrete Canvas, Cyden and Zip-Clip. Scientific instrumentation company Markes International received awards for both innovation and international trade.

Developing a new generation of drugs

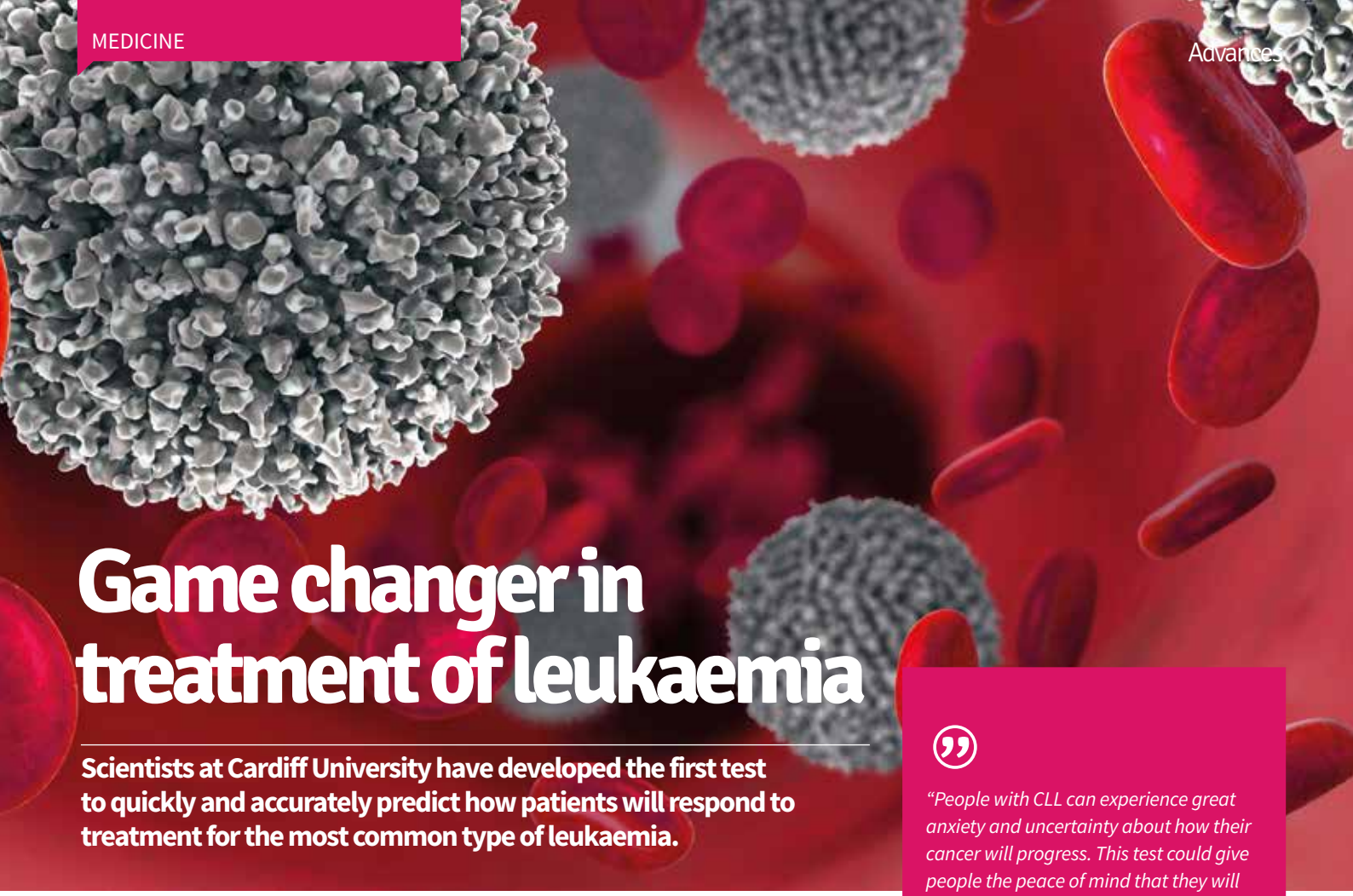
Cardiff University is stepping up the development of new drugs for mental health and central nervous system conditions, with the launch of the Medicines Discovery Institute. The new institute, located in the School of Biosciences, will develop novel medications to improve the lives of people across the world and will also provide an opportunity for training the next generation of medicines discovery scientists. One of its first big projects will focus on improving anxiety medications – an area of research in which there have been no major advances since early 1960. With the investment of £3.5 million from the Medical Research Council (MRC), the team will focus on the development of drugs that reduce side effects associated with the benzodiazepine class of anxiolytic drugs. Another grant from the MRC will allow the team to develop improved medication options for people with fragile X syndrome, which is the most common inherited cause of learning disabilities.

Electron microscopy to boost Welsh industry

An £8.6m Electron Microscopy Facility (EMF) to help Welsh industry develop new products is to be built at Cardiff University. A suite of next-generation, ultra-sensitive microscopes at the facility will give researchers the opportunity to study materials and processes on an atomic scale, which will in turn aid collaborating industries to make cleaner, greener and cheaper products. The EMF will be at the heart of Cardiff Catalysis Institute (CCI)'s future home – the Translational Research Facility on Cardiff Innovation Campus. Professor Duncan Wass, Director of the CCI, says that the EMF will allow the Institute to build on its work promoting catalysis as a sustainable 21st-century technology. He explained: "The facility's nanoscale capabilities will help us break new ground across established and future areas of CCI expertise including selective oxidation, gold catalysis, bio-renewables, photocatalysis and catalytic routes for sustainable processes."

Next steps for tidal energy scheme

Marine energy developer Minesto has been awarded €14.9 million of EU funding for the next phase of its tidal energy scheme in Wales. The investment will enable continued site development and operations at Minesto's Holyhead Deep site 6km off the coast of Anglesey, strengthened manufacturing and assembling capability, and enhancement of the company's utility-scale product range. It will also facilitate installation and operation of an additional, uprated unit at the Holyhead site (at least 50 per cent higher than current 0.5MW system) as well as design of subsea infrastructure for the 80MW site development. Minesto, with its subsea kite technology known as Deep Green, is now the EU's largest investment in marine energy to date.



Game changer in treatment of leukaemia

Scientists at Cardiff University have developed the first test to quickly and accurately predict how patients will respond to treatment for the most common type of leukaemia.

Chronic lymphocytic leukaemia (CLL) is a slowly developing blood cancer in which patients produce mutated versions of white blood cells that build up in the blood, bone marrow and lymph nodes and crowd out healthy blood cells. It progresses at different rates in different people, and in a third of patients it never progresses at all. Until now, there has been no accurate test that can be used to indicate whether and how fast the cancer will develop for individual patients.

The new test, developed by researchers at Cardiff University, measures the length of sections of DNA in cancer cells called telomeres, which are found at the end of chromosomes. They act in the same way as protective plastic tips on the end of shoelaces, preventing chromosome ends from 'fraying'.

Telomeres shorten every time a cell divides to create a new cell and eventually the chromosome ends are left exposed, leading to extensive DNA damage that speeds up cancer progression. The researchers have found that people who have CLL cells with very short telomeres when diagnosed are much more likely to have a fast-progressing cancer.

Samples from 260 patients were analysed with the new test to see if it could predict how they would respond to intensive chemotherapy combined with immunotherapy. It showed that people with short telomeres relapsed sooner after treatment than patients with long telomeres – on average 3.7 years after treatment compared to 5.5 years.

Patients with cancer cells containing mutations to the IGHV gene are known to have a better outcome than patients without this genetic mutation. The new test was found to be a more accurate predictor of relapse than testing for the IGHV mutation, or any other current prognostic or predictive test.

It is thought that the test could be a game changer and could guide decisions on which drugs to give to patients. It also has the potential to change how other cancers, including myeloma and breast cancer, are treated. While previous versions of the test had taken a week to process, results can now be ready in a day.

> *"People with CLL can experience great anxiety and uncertainty about how their cancer will progress. This test could give people the peace of mind that they will receive the most effective treatment possible if it does. It may even allow some people to be told that their cancer is unlikely to progress."*
>
> **Dr Alasdair Rankin**
> Director of Research
> Bloodwise

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Cardiff

Sweet discovery from honey molecule

Sugars for Health Ltd has discovered a potential new medicine from an extremely rare honey molecule.

As animals age, they typically have weaker immune responses and this provides more opportunities for cancerous cells to take hold. Tumour cells become established and are able to spread by evading the immune system, or if the immune system response is defective in some way. Once established, they can release factors that inhibit effective immune responses to the tumour cells.

Sugars for Health Ltd, a company based at Aberystwyth University, has discovered a small group of sugar-like molecules (iminosugars), a specific type of which appears to selectively reactivate the immune system via a new mechanism. The natural form is present in a certain type of honey, which means that useful information can be obtained from ageing dogs and cats whose owners have volunteered them. However, the main goal that scientists are working towards is a pure chemical which can be used as a regulated medicine.

The molecules are small, can be taken orally, have no apparent toxic effects and interact with certain receptors on specific immune cells. No other drugs are targeting these receptors, so the newly discovered molecules offer a new approach to treating disease, especially many types of cancer. The molecules are natural, but very rare and have been historically overlooked by other laboratories.

The initial discovery was made when Dr Robert Nash, an Aberystwyth-based scientist, was contacted by a woman who had been prescribed a herbal preparation in Western Samoa following a diagnosis of breast cancer. The preparation yielded a new natural iminosugar, PDC001, which was found to boost the immune response in cell cultures, animals and humans. It is extremely rare, but coincidentally, it was found to occur in a Mediterranean plant growing in Aberystwyth.

Scientists were able to find a specific type of honey rich in iminosugar PDC001 and started offering it in single portion sachets for quality of life in elderly dogs and cats, many of which develop cancers due to their old age. An amount of 5ml can be added to the pet's food once every three days, and information gained from these animals is providing invaluable insights on future potential applications for the pure chemical human medicine.

There are other new drug immunotherapies for cancer treatment which also result in increased Natural Killer cell and T lymphocyte activity against tumour cells. However, an advantage of the new molecules is that they seem to have no side effects. It is probable they can be used with some more conventional chemotherapies to improve their effectiveness by helping the immune system to kill remaining cancer cells.

The Aberystwyth team has worked with leading oncology teams at Cardiff University, chemists from Oxford University and immunologists from University of Strathclyde in order to better understand how the molecule works. The mechanism is new and still requires further work, but the rewards could be significant, so more detailed investigations into the mode of action and underlying mechanisms are underway.

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Aberystwyth

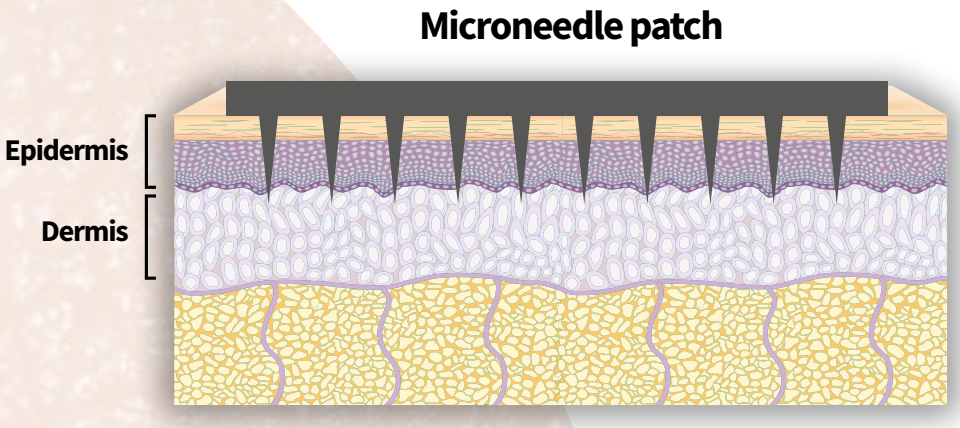
Manufacturing microneedles for future medicine

Picofluidics have developed technology that offers a novel low-cost method of fabricating microneedles.

Thinner than human hair and piercing the skin a fraction of a millimetre, microneedles have the potential to deliver medicines more effectively than traditional hypodermic needles, often in the form of a patch applied to skin.

Largely due to their very shallow penetration depth into the patient's skin, they provide virtually pain-free injection of medication, such as vaccines or insulin. They can also deliver treatments to localised skin problems, such as certain forms of skin cancer. Additionally, hollow microneedles can be used to remove intradermal fluid for diagnostic purposes, in order to facilitate the early detection of disease.

Research and development into microneedles has been taking place for over 20 years. In principle, the simplicity of use and reduction in pain for the patient, combined in many cases with improved efficacy of drug delivery, provide compelling reasons for adopting the technology. However, limited progress has been made in its commercial exploitation. This is due to a number of factors such as technical limitations of the current microneedle formats, regulatory approval and cost.



Picofluidics, in partnership with Coventry University, have recently completed a project which has demonstrated a low cost fabrication method to make microneedle arrays. A key benefit of microneedles is that patients are able to self-administer patches, so the research has focused on arrays that can be made in large panels which are subsequently cut to size.

Hollow and solid microneedles over a variety of lengths (0.3-1.5mm) with arrays of over 1000 have been fabricated at Picofluidics. The company is based at Cardiff Medicentre, which is jointly run by Cardiff University and Cardiff and Vale University Health Board. Solid microneedles can be coated with a medication, for example a vaccine, while hollow ones can operate like small hypodermic needles and are capable of administering a drug in small volumes.

Many of the process steps in making the microneedles have more in common with the fabrication of printed circuit boards or microchips than with conventional hypodermic needle manufacture. By employing established techniques, as well as new developments specific to microneedle fabrication, the cost of manufacturing these devices in volume is projected to be a small fraction of the cost of current approaches.

Although many standard injections could potentially be replaced by a microneedle patch, the company believes that adoption will begin with 'niche' applications, such as pain relief where patients can self-administer a patch instead of applying a cream or gel. They then expect it will start replacing standard syringes in the delivery of some medicines.

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Cardiff

Groundbreaking research to fight sepsis

Researchers at Cardiff University are working to develop a reliable way of detecting sepsis.

Sepsis kills five million people per year. Although it has many symptoms, they can be difficult to detect, so identifying it is very challenging. Cases can go undetected until more extreme symptoms are noticeable, by which time it is often too late to save the patient's life.

Professor Peter Ghazal, Sêr Cymru Chair in Systems Medicine at Cardiff University, is leading research into both the diagnosis and treatment of sepsis. Project Sepsis, a study involving academics, clinicians and patients, aims to improve neo-natal sepsis care and also further understanding of the condition in children and adults. The study integrates three different disciplines – Mathematics, Medicine and Biology.

Using pre-term babies to study how the immune system reacts to sepsis, researchers have found a signature set of biomarkers with three biological pathways comprising different arms of the immune system and metabolism. When these biomarkers are combined, they are able to predict with extremely high accuracy the presence of a bacterial infection underlying the illness.

Pilot studies have led to the discovery that these same markers and biological pathways can also be used to predict sepsis in children and adults. The project aims to clinically validate this new method of detection across all ages and to uncover mechanisms, especially those linking immunity with metabolism, which drive sepsis and could be used to devise new treatments.

The work has involved developing methods that allow researchers to use very small quantities of blood in order to decode the messages from immune cells that provide information about the response to infection. This provides very high sensitivity and specificity, as the bacteria that trigger sepsis do not have to be present in the sample. The current 'gold standard' sensitivity of capturing the bacteria in a blood culture test is around 15-20 per cent of cases.

> *"The immune system evolves as you go forward in life, with a history of events in terms of infection and vaccination. By studying and understanding the newborn baby, which hasn't had that history, the immune system is relatively clean, almost like a blank slate. So we're able to pick up very strong signals that happen early in life, which can then translate for us in children and adults."*
>
> **Professor Peter Ghazal**
> Chair
> Systems Medicine
> Ser Cymru
> Cardiff University

By enabling earlier, more reliable diagnosis of sepsis and finding new medical interventions, Project Sepsis has the potential to meet a currently unmet clinical need and save a significant number of lives.

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Cardiff

Exploring the health benefits of camel milk

Scientists at Cardiff Metropolitan University have found that camel milk has the potential to reduce cell inflammation associated with type 2 diabetes.

Over the years, there has been some evidence to suggest that consumption of camel milk can have benefits for people with type 2 diabetes. However, few studies have thoroughly investigated this to determine what component or components present in camel milk are actually responsible for any of its supposed anti-diabetic benefits.

Studies that increase our understanding of dietary components can be challenging, and particularly for a food as complex as milk. Milk is made up of lipids and proteins, including immunoglobulins (antibodies produced by plasma cells) and vesicles (liquid produced by cells which is enclosed in a lipid membrane), as well as vitamins and minerals. Given this complexity, the team chose to investigate only the lipids (fats) in camel milk and their effect on an aspect of diabetes known as inflammation.

Inflammation in abdominal fat around the waist is known to be a dangerous feature of type 2 diabetes. Normally inflammation is a way of dealing with infections such as viruses. However, obese and type 2 diabetic individuals have continuous chronic inflammation that does not involve any infections. This inflammation can lead to many complications including heart disease and strokes.

A cell called the macrophage, present in abdominal fat, is a major player in the development of this inflammation. Therefore scientists at Cardiff Metropolitan University, led by Professor Keith Morris, decided to study whether camel milk lipids could prevent macrophages, similar to those found in fat, from becoming inflamed when in the presence of the proteins found in diabetics.

Camel milk, butter and yoghurt are nutritious foods with a high content of vitamin C, iron, calcium, insulin and protein. The presence of fat in any milk is often the basis for avoiding dairy products, but milk fat is an important component given its high nutritional value. However, camel milk has a lower fat content compared to cow milk and its fatty acids are mostly polyunsaturated fatty acids. These are generally regarded as healthy fatty acids, but the saturated fat or lipid content of camel milk can be as high as 65 per cent.

"A particularly interesting finding was that a complex of proteins known as the inflammasome (a central driver of inflammation) was reduced by these lipids. If these effects could be repeated in studies with humans, this would show that the milk may prevent the inflammation associated with diabetes. These results may also explain some of the benefits reported for camel milk consumption in preventing type 2 diabetes."

Professor Keith Morris
Cardiff Metropolitan University

The team incubated macrophages with saturated and unsaturated lipids taken from camel milk, both individually and in a mixture of the two, because this is how we would consume them and how they are generally stored in the body. The experiments showed that the fatty acids from camel milk reduce inflammation, but the effect was more pronounced in the mixture of the lipids than when the camel milk was with only unsaturated fatty acids.

To take this experimental data to the next stage, and establish whether camel milk or other milk such as that from cows would successfully reduce inflammation if a person with type 2 diabetes consumed it regularly, further research and human trials are required.

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Cardiff

Innovative platform for health monitoring at home

Forth has created a biometrics tracking platform that allows people to monitor their own health through finger-prick blood testing at home.

The healthcare landscape is changing as people become more interested in keeping track of their own health via new digital technologies such as apps and wearables. Currently, blood testing only tends to be done by GPs when someone is ill or suspected to be ill, and it is not typically used by the public as a method for monitoring their general health.

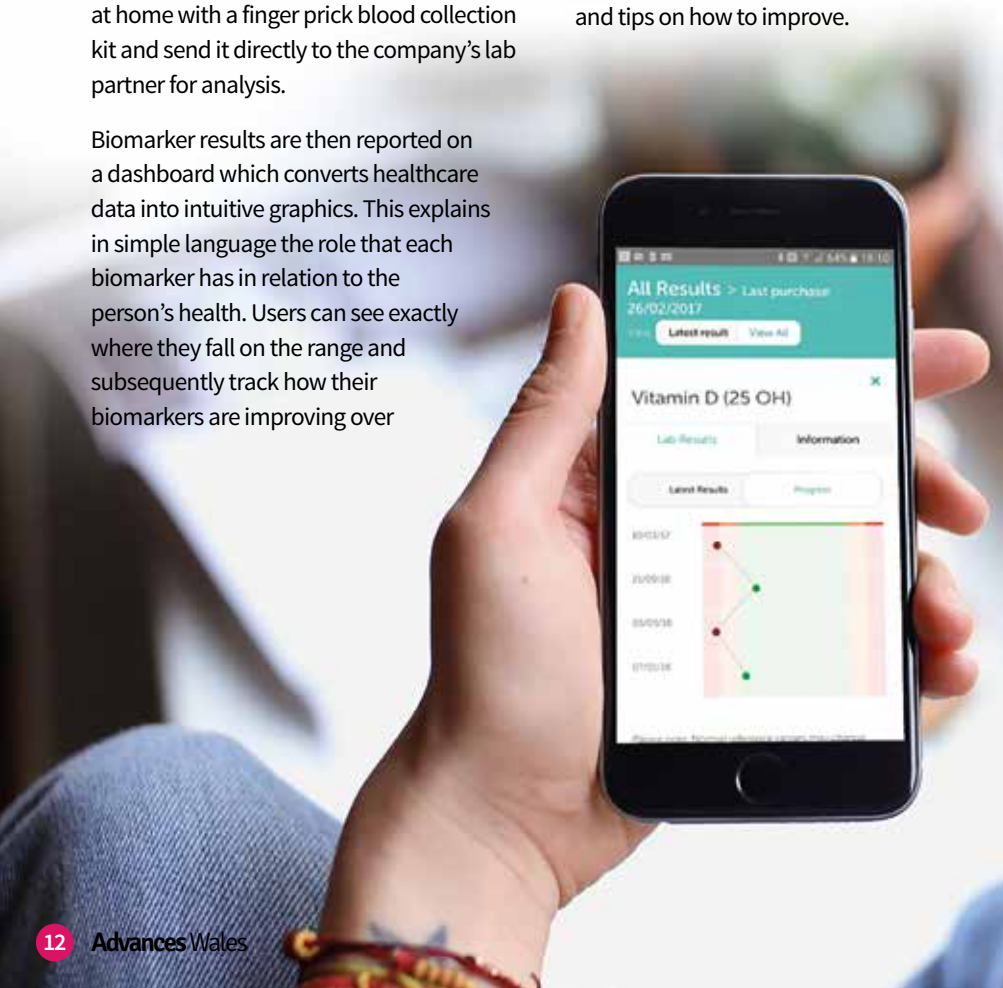
Chepstow-based company Forth has developed a platform that measures and tracks over 50 key internal biomarkers in the blood which are integral to good health. Users collect a small sample of their blood at home with a finger prick blood collection kit and send it directly to the company's lab partner for analysis.

Biomarker results are then reported on a dashboard which converts healthcare data into intuitive graphics. This explains in simple language the role that each biomarker has in relation to the person's health. Users can see exactly where they fall on the range and subsequently track how their biomarkers are improving over time if they choose to make changes to their lifestyle. All results are reviewed by a healthcare professional, who can offer advice and tips on how to improve.

> *"I've worked in healthcare for the last ten years as a strategy planner for healthcare companies. Through that work, I could see that things were changing and that people were starting to become much more engaged in their health, aided by the massive explosion of health apps and wearables. However, although I was able to gain insight into heart rate, how many steps I had walked and how many calories I'd burned, I was lacking the vital metrics concerning what was happening inside my body."*
>
> **Sarah Bolt**
> CEO and Co-founder
> Forth

By providing people with fast and convenient access to biomarker testing, with a simple results dashboard, the company aims to help people better manage their own health. Many illnesses are preventable, so they hope that giving people more insights into their health could encourage them to adopt healthier behaviours, which ultimately could extend their life expectancy.

The platform also has the potential to alleviate some of the pressures on GP surgeries. For example, among current users, many are using it to monitor an existing medical condition. Valuable appointment times in GP surgeries could be freed up, with some patients choosing to do their own testing at home using a Forth finger-prick test kit.



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Chepstow

Speeding up enzyme discovery and development

Biocatalysts has created a platform that speeds up the process of discovering, developing and manufacturing novel enzymes.

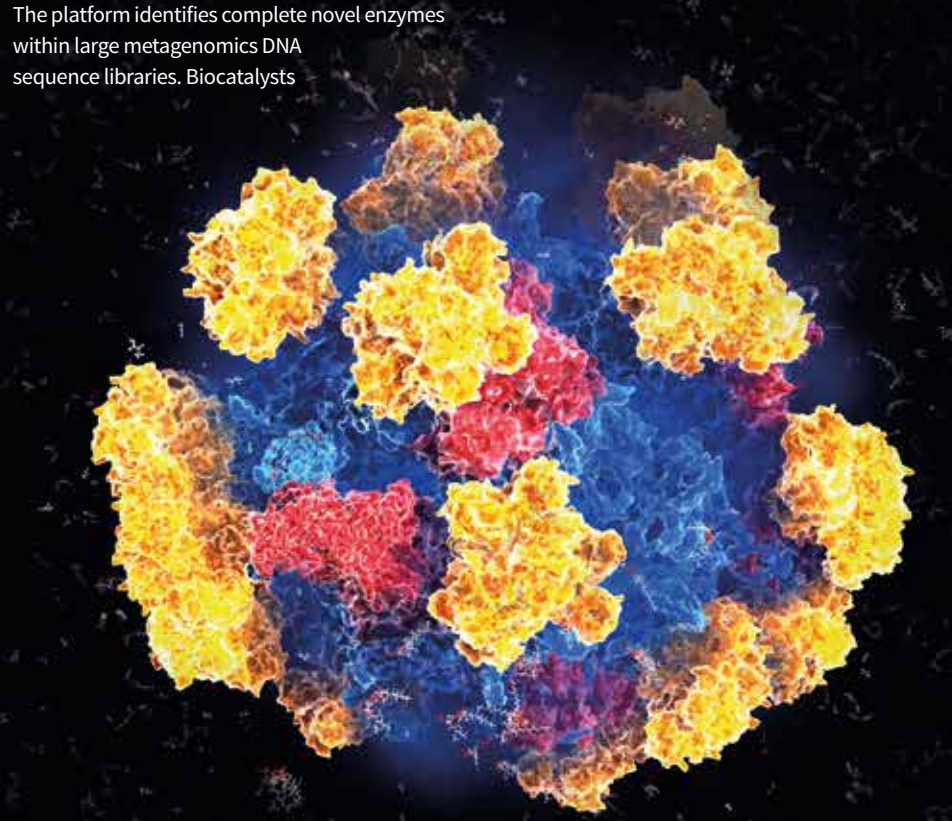
Identifying and commercialising a novel enzyme has historically been a long and costly process. With recent advances in manipulation of mega data and new tools available to identify genes and manipulate them into expression systems, Biocatalysts Ltd sought to reduce the time and cost of novel enzyme discovery, development and manufacture.

The Cardiff-based company developed a unique bioinformatics platform, in collaboration with the European Bioinformatics Institute (EMBL-EBI) at the Wellcome Genome Campus in Cambridgeshire. It was recently awarded a Queen's Award for Enterprise in Innovation.

It is able to screen millions of sequences in a few hours, in order to identify new enzymes based on either user-derived target sequences or on functionality, for example and enzyme that is active at high or low temperature or pH. This means that the early stages of enzyme discovery can be reduced from years to a few weeks. These enzymes can then be developed and scaled up in a few months, so that companies can access enzymes in realistic time frames, giving them the opportunity to promptly produce new products in response to market trends.

The platform identifies complete novel enzymes within large metagenomics DNA sequence libraries. Biocatalysts has combined its own metagenomics libraries with open source databases, giving it access to over 350 million enzyme gene sequences. As DNA sequencing is no longer necessary, screening can be completed in minutes rather than days. Even wild-type enzymes, which have been excluded from industrial use due to impracticability, can now be exploited.

More than 20 biochemical and biophysical algorithms are applied in order to filter candidate enzyme sets. These algorithms are designed to maximise the success of commercial production of enzymes at large scale, not just in the laboratory, and reduce commercial risk. The selected enzyme sequences are synthesised into genes, and from these a panel of 1g lyophilised samples are produced for evaluation.



It is believed that more than 99 per cent of microbes in nature cannot yet be cultivated in the laboratory. Consequently, using traditional techniques means that it is not possible to access over 99 per cent of this valuable genetic heritage. However, new metagenomic techniques make it possible to DNA sequence directly from environmental samples, avoiding the need to culture the organisms in a laboratory.

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Cardiff

Smart mouthguards tackle the concussion crisis

Sports and Wellbeing Analytics (SWA) have created a system that monitors and reports head impact data in contact sports.

Concussion has long been an issue in the world of rugby, with evidence showing that 85 per cent of players suffer with concussion at some point in their career. Swansea-based company SWA aims to support the future of the game by helping to provide a greater level of information around head health.

Until now, there has been no objective way to monitor head impacts and measure the force of impact, as well as the resultant rotation of the head. Professionals responsible for monitoring player wellbeing can only base their judgement on what they can see. This means that currently 50 per cent of concussion cases can go undiagnosed, as only 5 per cent of players will actually lose consciousness.

The company's PROTECHT chips are incorporated into intelligent mouthguards, which transmit the head impact data of each player immediately to a laptop on the sidelines to be viewed by staff. The system provides an additional indicator on head impacts and could serve as a tool for rugby management in the future by providing objective surveillance and data.

Through monitoring of training and match data over time, the system will allow rugby

management to understand the size, frequency and types of impact. The data collected will help improve player welfare and enable informed training choices. Another benefit of the system will be how it supports the performance objectives of a team and has the potential to provide marginal gains which could be the difference between winning and losing.

The system has also been supported by a research project at Swansea University's Sport and Exercise Science Department. This project aims to translate the data collected by the intelligent mouth guards into information that is valuable and beneficial for staff and coaches.
The electronics are produced by Hirwaun-based company Philtronics and the user interface for the system was developed by Keytree, which has now established an office in Port Talbot.

Welsh rugby team the Ospreys have been involved in testing and improving the system by wearing the mouthguards for the last two seasons. More recently another team, the Cardiff Blues, have been trialling the technology with their professional side.

"The development of the new system has ultimately been focused on one key priority; making the game safer for the players. The system allows objective surveillance so that unseen head impacts are recognised and understood, and this data provides a new layer of information on which rugby management can base their judgements. We are already seeing that this data can support and add real value to the performance environment of a rugby club, as adaptations can be made to training loads, drills and even moves as the system provides a far greater understanding on impacts."

Chris Turner
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Swansea

Technology for better traffic management

Route Konnect is developing technology to detect traffic movements in real time and enable smarter traffic management.

Cardiff-based company Route Konnect is developing a network of Internet of Things (IoT) sensors to detect traffic movements from above the road in real time. It involves utilising LIDAR sensors and placing them on infrastructure, rather than on the vehicles themselves.

The innovative technology can paint a picture of how traffic behaves across a junction. This real-time data can then be used to provide smarter traffic management and to judge the effectiveness of new developments and schemes. It could also be analysed alongside air quality data in order to identify the root cause of air pollution and determine how to mitigate it. LIDAR sensors are inexpensive and the company is aiming to provide a way of monitoring traffic at a lower cost than existing methods available.

As the system is installed overhead and only detects vehicles from above, it does not interfere with the road, which makes it simpler to introduce in existing roads. Furthermore, the system will be able to classify vehicles passing below by type (car, bus, van, etc) based on the silhouettes of the vehicles. It may even be possible to detect bikes, motorbikes and pedestrians as the technology improves. This classification system will be achieved through development of machine learning software.

The technology has potential uses across multiple sectors, such as cities seeking smart solutions to digitise their roads, air quality consultants looking to link pollution data to traffic that causes it, and traffic management systems wanting to improve efficiencies and waste less fuel. It could also improve navigation priority flow for public transport, emergency services and refrigerated trucks, in addition to connecting autonomous vehicles of the future through infrastructure in the long term.

In the area of emergency services, Route Konnect was recently selected by the Dubai Government to collaborate with Dubai Police, and the concept has also been presented to the Vice President of China.

> *"I'm eager to see this technology make an impact when we can worry less about getting the hardware out there, and focus more on developing the software for all the cities that could benefit."*
>
> **Mohamed Binesmael**
> Founder
> Route Konnect

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Cardiff

New way of measuring ocean turbulence

Researchers at Bangor University have developed a new method for measuring turbulence in the ocean.

Turbulence is a key parameter in the marine environment as it mixes heat, freshwater, nutrients and carbon across critical interfaces in the ocean. So that computer models (such as global climate models, estuary models or ocean models) can be trusted to make accurate predictions, they must be able to correctly predict the mixing due to turbulence. An understanding of ocean turbulence is vital in a range of areas, including oceanography and climate sciences.

Measurements of turbulence were traditionally made using hand-built profilers lowered from the back of ships. Due to the high level of expertise required, in addition to the high cost of ship time, this activity was restricted to only a small number of institutions globally, including the Physical Oceanography group at Bangor University, and the high cost of measurements meant they were limited to only one or two days.

However, a new generation of off-the-shelf acoustic Doppler current profilers (ADCPs) facilitated the development of a technique for measuring turbulence using these instruments, which enabled measurements over much longer time periods. Bangor University researchers were among the first to demonstrate the validity of this new technique from measurements made in the Menai Strait, but they also discovered that turbulence measurements were easily corrupted by the impact of instrument movement and the presence of surface waves. This essentially meant that this method was useless in wavy conditions and that the instrument had to be fixed to the seabed, significantly restricting the depth range of the measurements.

For this reason, the researchers developed a new method, which has recently been awarded The Royal Meteorological Society's Vaisala Award for Weather Observing and Instrumentation. The groundbreaking method is based on a technique used by meteorologists to measure turbulence in the atmosphere with ground-based radar. It can be used to measure turbulence over significantly longer periods of time and is insensitive to instrument movement. The team has also developed algorithms to account for the impact of surface waves.

Initial measurements were made in the Menai Strait and Anglesey's Red Wharf Bay in order to validate the method, and it has now also been applied worldwide. Applications have included a 12-month unbroken series of measurements in the middle of the Atlantic Ocean to help understand the role of storms in stirring up the ocean. The Bangor team currently have several instruments deployed under sea ice in the Arctic Ocean to monitor the stirring up of heat towards the sea ice.

Understanding and predicting turbulence is also important in engineering applications, because it is essential to factor in turbulence stresses in engineering design of any infrastructure to be deployed in the ocean. Consequently the new method is now being widely used by the marine renewable energy industry in site assessments.

> *"This new approach can be used wherever a vehicle can deploy and recover a mooring, and that includes most of the polar regions. As a result these measurements will help revolutionise understanding of marine turbulence and its impact on global climate."*
>
> **Professor Tom Rippeth**
> Bangor University

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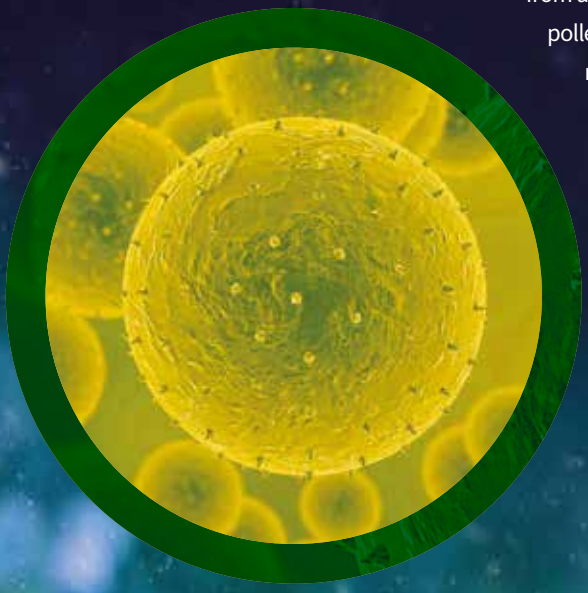
Bangor

Identifying the grass pollen that triggers allergies

Research led by Bangor University has brought us a step closer to more precise pollen forecasts for people who suffer from asthma or hay fever.

A major three-year project known as PollerGEN, involving several partners, is working to analyse airborne grass pollen and its effects on human health. The first year's findings have shown that it could not just be the overall amount of grass pollen in the air that causes particularly bad days for asthma and hay fever sufferers, but the release of pollen from certain grass species.

To date, pollen forecasts provided by the UK Met Office have been based on counting the total number of grains of pollen in the air from trees, weeds and grass. The pollen is collected using air sampling machines that capture the particles on a slowly rotating sticky drum.



However, while these forecasts focus on the level of all pollens in the air, people suffer from allergic reactions to different types of pollen. For example, grass pollen is the most harmful aeroallergen and more people are allergic to it than any other airborne allergen. Health data also suggests that allergies to this pollen vary across the grass flowering season. Although scientists can use microscopes to distinguish between the pollen created by individual tree and weed species, it has been virtually impossible to visually identify different grass pollens because they look so similar.

> *"I'm a hay fever sufferer myself, and I know that on some days, despite a high pollen forecast, I can be less affected than on other days when the forecast appears to be lower. This led me and others to wonder whether it's the high load of pollen alone that causes the problem, or whether the different grass pollens cause different levels of reaction."*
>
> **Professor Simon Creer**
> Bangor University

Metabarcoding is a technique that enables scientists to automatically identify any fragments of material caught in a sample of air, water or soil, by matching its unique DNA 'barcode'. For the first time, grass

pollens collected over the course of one allergy season have now been analysed using this high-tech method. This has enabled the team to start investigating links between certain pollen types and the days on which people with asthma or hay fever are most affected. The research was led by Professor Simon Creer from Bangor University, while the aerial pollen 'environmental DNA' was analysed in collaboration with Aberystwyth University and the National Botanic Garden Wales. They are joined by additional team members from other Welsh universities and investigators from Worcester, Exeter, the UK Met Office and the University of Queensland.

The team's next task is to develop a clearer picture of where the pollen comes from, how it moves through the air and how different types of pollen can be linked to allergies. Researchers are also investigating datasets on hospital admissions and GP prescriptions for certain pharmaceutical products, in order to identify correlations between healthcare data and increases in particular grass pollens. With these new insights into pollen characterisation, there can be a focus on future implications for pollen warnings and self-care strategies.

Leading on from this new environment DNA research, the UK Met Office is currently developing maps of where these species of allergenic grasses are located in the UK.

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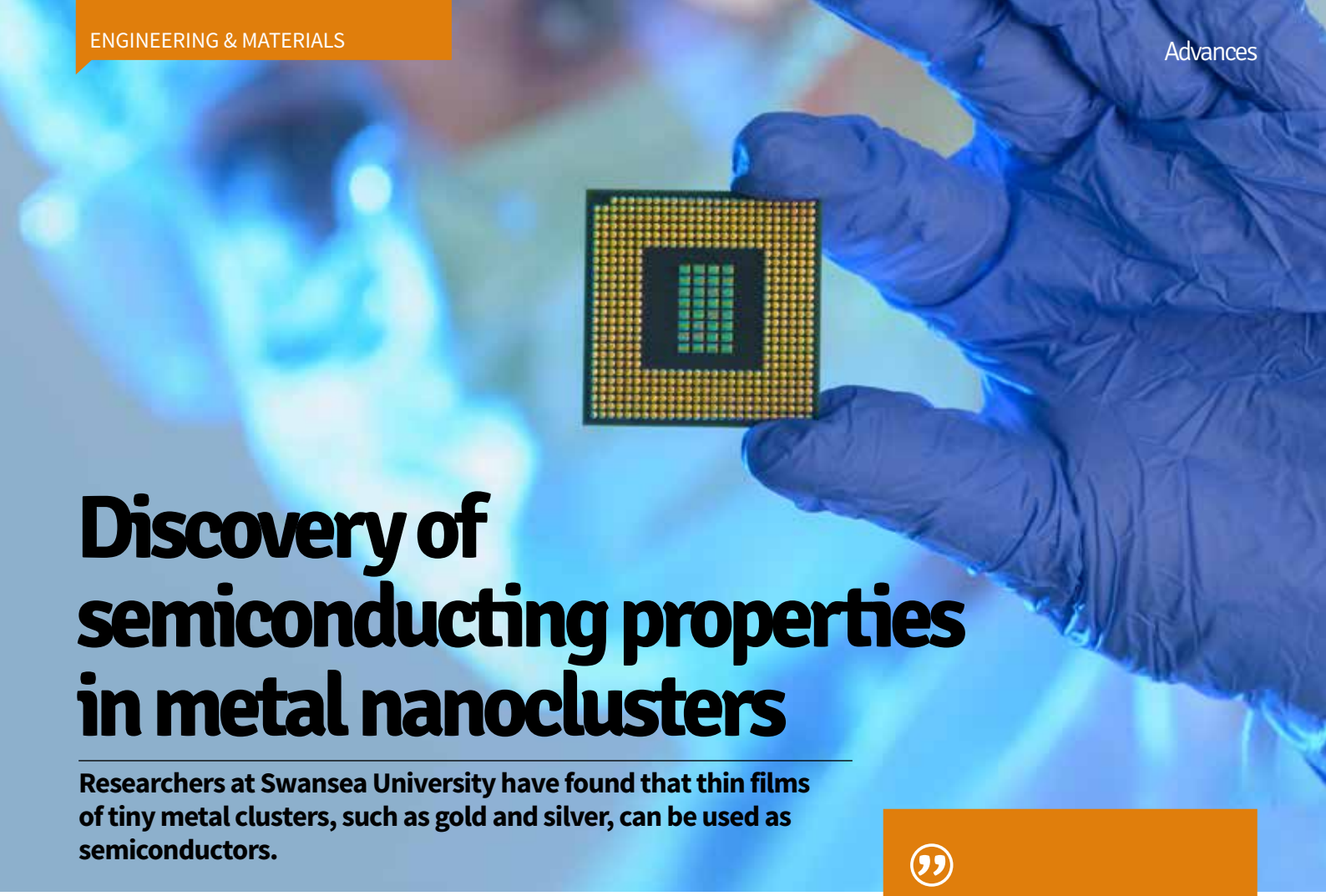

Discovery of semiconducting properties in metal nanoclusters

Researchers at Swansea University have found that thin films of tiny metal clusters, such as gold and silver, can be used as semiconductors.

Semiconductors are at the heart of modern electronics, being used in display devices for mobile phones and televisions, light detectors and solar cells for providing energy.

The two main types of particle-based semiconductors already in use are colloidal quantum dots and organic semiconductors. These materials are at the nanoscale. Due to their tiny size, they are subject to a phenomenon known as quantum confinement, which causes changes to their optical and electronic properties, and these changes make them suitable for their intended applications.

Metal nanoclusters combine aspects of both of these materials. Like colloidal quantum dots, they are very stable. Like organic semiconductors, they are atomically precise, or molecular, containing a specific number of atoms in their metallic core. However, despite containing all of the right ingredients, they have never before been shown to display semiconducting properties.

A team of researchers from Swansea University's chemistry department and Hamburg University devised a way of making films of nanoclusters consisting of 25 gold atoms (Au25). They then observed that they displayed semiconducting properties. Specifically, they observed field effect and photoconductivity in transistors made of these films. These unique properties are hallmarks of all semiconducting materials.

The discovery of these semiconducting properties could pave the way for a variety of new applications, from field effect transistors and photodetectors, to light emitting diodes and solar cells. These devices could be manufactured on flexible substrates, like plastic foils. Many metal nanoclusters, including the ones investigated in this study, have almost infinite stability, which could make them suitable for ink-jet printing applications. The affinity of the metal core to different molecular functionalities could also make them highly sensitive gas sensors.

The research has shown that metal nanoclusters can be used to produce high quality semiconducting films that are easy to assemble. Next steps will now involve building on these findings and refining the technique further.

> *"Semiconductors are a big focus for our work at Swansea, both in the chemistry department and the Centre for NanoHealth. This work led by Professor Christian Klinke is very exciting for next generation semiconductor materials – an area in which Swansea University is leading activity, with our industry partners. These findings, made possible by our close links with Hamburg, are a significant step forward in the field."*
>
> **Professor Owen Guy**
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