MANCHESTER
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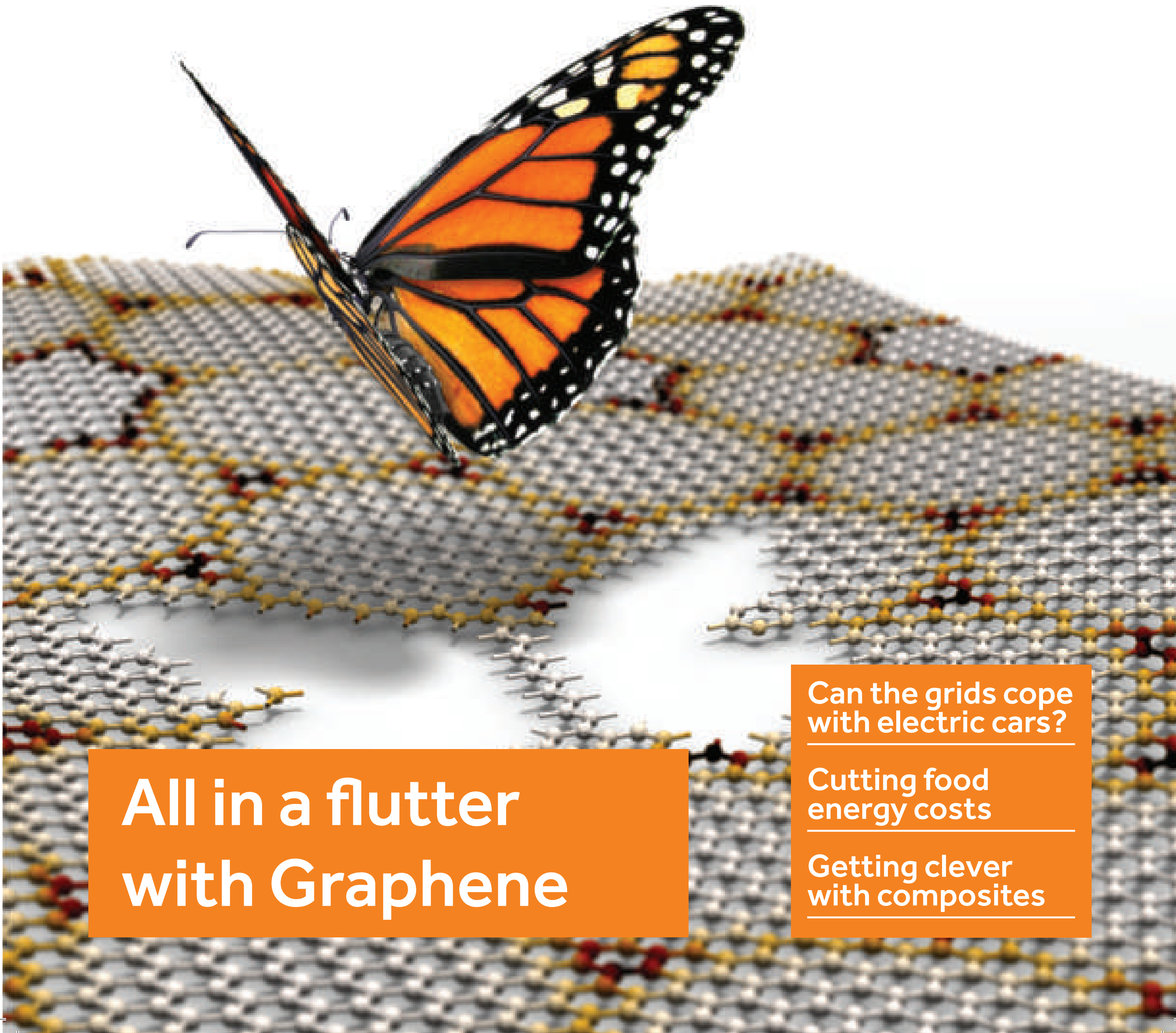
The University of Manchester

EPSNEWS

Research, Innovation and Collaboration
in the Faculty of Engineering and Physical Sciences
Summer 2013



All in a flutter with Graphene

Can the grids cope with electric cars?

Cutting food energy costs

Getting clever with composites

EPS people

The Faculty is led by **the Vice-President and Dean, Professor Colin Bailey**, and comprises **nine academic Schools** and **four Research Institutes.** The Faculty Leadership Team also includes **six Associate Deans** who support key areas of activity, including **Research, Teaching and Learning, Graduate Education, Social Responsibility, Internationalisation and Business Engagement**, the **Head of Faculty Administration**, is responsible for leading the administration across the Faculty.

School of Chemical Engineering and Analytical Science
Head of School,
Professor Mike Sutcliffe

School of Chemistry
Head of School,
Professor Christopher Whitehead

School of Computer Science
Head of School,
Professor Jim Miles

School of Earth, Atmospheric and Environmental Sciences
Head of School,
Professor Hugh Coe

School of Electrical and Electronic Engineering
Head of School,
Professor Tony Brown

School of Materials
Head of School,
Professor Paul O'Brien

School of Mathematics
Head of School,
Professor Peter Duck

School of Mechanical, Aerospace and Civil Engineering
Head of School,
Professor Andy Gibson

School of Physics and Astronomy
Head of School,
Professor Stephen Watts

Dalton Nuclear Institute
Director,
Professor Andrew Sherry

Manchester Interdisciplinary Biocentre
Director,
Professor Nigel Scrutton

Photon Science Institute
Director,
Professor Richard Winpenny

University of Manchester Aerospace Research Institute (UMARI)
Director,
Professor Costas Soutis

Acting Associate Dean (Research)
Professor Stephen Yeates

Acting Associate Dean (Teaching and Learning)
Dr Danielle George

Associate Dean (Graduate Education)
Professor Ann Webb

Associate Dean (Social Responsibility)
Dr Tim O'Brien

Acting Associate Dean (Business Engagement)
Professor Mike Sutcliffe

Acting Associate Dean (Internationalisation)
Professor Stephen Flint

Head of Faculty Administration
Rachel Brealey

Head of Faculty Finance
Pauline Morgan

Head of Faculty HR
Sue Field

Contents

Cover image courtesy of Columbia University

Welcome from the Vice-President and Dean

Welcome to the latest edition of EPS News which offers us an opportunity to share with you the latest news about the faculty. I hope you find the contents interesting and that the people and research we feature gives you an indication of the wide range of work and activities we are involved in.

This time of year provides us with an opportunity to celebrate the successes of our students with a number of end of year events such as the School of Materials Fashion Design Show and project presentations in our engineering schools. Most importantly it always gives us all so much pleasure and pride to see our graduands celebrating the successful completion of their studies with their loved ones - particularly in such fantastic Manchester weather.

You may have seen media coverage of Team Manchester - victorious in retaining its University Challenge title in April – marking the fourth win for the University in just eight years. Students included Physics with Astrophysics student Adam Barr. We've highlighted a number of student successes throughout the magazine.

We were delighted with the triple celebration for the faculty with three of our academic colleagues – Professor Paul O'Brien, Professor Robert Young and Professor Terry Wyatt being elected as Fellows of The Royal Society. Fellows are elected through a peer review process on the basis of excellence in science, which recognises the most eminent scientists, engineers and technologists from the UK and the Commonwealth. Other well known Fellows include Tim Berners-Lee and Stephen Hawking, as well as our very own Professors Sir Andre Geim and Sir Kostya Novoselov.

Our work on the applications of graphene continue with a look at Professor Rob Dryfe's plans to explore the potential of graphene based batteries with a £2.2million project funded by the Engineering and Physical Sciences Research Council. Other significant funding announcements include £18 million funding from the UK Research Partnership Investment Fund to set up a new facility supporting research and development into advanced materials. This will be supported by an additional inward 10 year investment of more than £100 million from founding partners including BP plc, Rolls-Royce, AMEC and EDF.

We have tried to feature a variety of the work undertaken by the faculty. This issue looks at the work of Professor Adisa Azapagic who has just set up the Centre for Sustainable Energy Use in Food Chains with two other universities, and our work on Corrosion with Professor Stuart Lyon, AkzoNobel Professor of Corrosion Control in the School of Materials. Our partnership with AkzoNobel has allowed the expansion of what is already the largest academic research endeavour into corrosion control in the Western hemisphere, to expand – opening a brand new research laboratory focusing on how protective coatings work and why they fail.

We also feature some of our newest members of staff Professor Melissa Denecke, Co-Director of the Dalton Nuclear Institute and Sarah Bridle, Professor of Astrophysics. A very warm welcome to you both!

I hope you enjoy this magazine – please let us know what you think, particularly if there are any specific areas of activity that interest you and you would like to hear more about. If you have colleagues who would like to be added to our circulation list please get in touch.

Professor Colin Bailey
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Enterprise award winner set for success

Textile student Naomi Wilde (pictured right) winner of a Student Enterprise Award for her fair trade T-Shirts.

"I am so overwhelmed and grateful for the awards, and the money will definitely help Fair-T succeed!"

Below, the 2013 Fashion Design Show wowed the crowds this May.

Physics with Astrophysics student Adam Barr was part of the victorious Manchester team that retained its University Challenge title in April, beating University College, London 190 – 140 in the televised final. It is the fourth victory for The University of Manchester in just eight years. We also held the crown in 2006, 2009 and 2012.

Triple celebration for Faculty's three new Royal Society Fellows

Professor Paul O'Brien, from the Schools of Materials and Chemistry, Professor Robert Young, from the School of Materials, and Professor Terry Wyatt, from the School of Physics and Astronomy, have been elected Fellows of The Royal Society.

Professor O'Brien's (centre) research focuses on developing new chemical processes for thin films and nanoparticles; especially of chalcogenide containing materials. In 2002 he founded Nanoco, an AIM listed company that manufactures nanoparticles. He has published more than 500 scientific papers and authored with AC Jones 'The Chemistry of Compound Semiconductors' and edited many books, including a series on Nanoscience and Technology.

Professor Young is one of the world's foremost materials scientists whose innovative research has transformed our understanding of the relationships between structure and mechanical properties in polymers and composites.

Professor Wyatt is an experimental particle physicist who is distinguished for a number of original and important contributions to the experimental verification of the Standard Model, which explains how the basic building blocks of matter interact, governed by four fundamental forces.

Petroleum Geoscience students are European champions

A team of students from the University's School of Earth, Atmospheric and Earth Sciences has been named European champions in the American Association of Petroleum Geosciences (AAPG) annual Imperial Barrel Award Program (IBA).

MSc Petroleum for Geosciences Exploration students Martin Kennedy, Papi Ogban, Heather Wilson and Rhiannon Jones, aided by faculty advisor Christophe Serie, were crowned European region 1st place winners, beating competition from across the continent.

The IBA is an annual prospective basin evaluation competition for geosciences graduate students, and teams compete to win scholarship funds for their respective departments. Each team were asked to analyse a dataset before the competition, and deliver their results to a panel of industry experts. Winning teams were selected on the basis of their technical quality, clarity and originality of presentation.

Rhiannon Jones, centre, said: "Presenting to a panel of industry professionals, meeting teams from across the world and representing both the university and Europe in the global finals was an invaluable experience".

www.aapg.org/iba/

EPS SUCCESS

Angie wins Sir William Siemens Medal Award

Angie Theresia, currently a second year Mechanical Engineering student, won the award for The University of Manchester, and came second overall in the country.

The Award is given to recognise engineering excellence and achievement during a student's first year at university. The University nominated three students based on their grades and any special projects they have worked on. Angie won the award for her project on the use of engineering in the developing world, particularly around the use of mobile technology and the impact this is having.

Angie and the other hopefuls submitted a 500 word statement about why they should be chosen, and entries were judged by a panel of Siemens employees. She received her award from Juergen Maier Sector Managing Director for Industry, Siemens at an event at John Rylands Library, hosted by the President of the University, Professor Dame Nancy Rothwell.

In the future Angie is keen to follow a career in looking at sustainable engineering and support for the developing world.

Lamb curry or Christmas dinner. Who cares?

Science and environment journalist Myc Riggulsford talks to Professor Adisa Azapagic about calculating carbon and cutting the energy costs in our food chain.

A lamb curry ready-meal that you buy from a supermarket has twice the carbon emissions of a much more complicated home-cooked Christmas dinner, according to the University of Manchester's Professor of Sustainable Chemical Engineering, Adisa Azapagic.

Professor Azapagic has just embarked on a five year mission to set up the Centre for Sustainable Energy Use in Food Chains, a partnership based across three separate university campuses, looking at how we can cut the energy and carbon costs of our food on its journey from farm to plate.

Our food uses energy and generates carbon emissions at every stage of its production, from planting seeds and breeding animals, fertilising, growing and harvesting crops, to transporting the raw food materials, processing them into the brands and products we recognise and want to buy, and then distributing them to supermarkets. And finally we bring them home into our fridges and freezers. Then we cook or reheat them to feed ourselves and our families.

But if Britain is going to meet our legally agreed climate change targets by cutting our carbon emissions in the future, then we need to look at all the aspects of our lives where we could make significant energy and carbon savings, and that includes in our food.

"We need to understand first of all where the energy and carbon hot spots are", says Adisa Azapagic. "About 95% of the foods we eat in Britain, Western Europe, and the USA, are now processed in some way, and almost everyone now buys the bulk of their foods from supermarkets. So that's where we will be concentrating at first, looking for the hot spots of intensive energy use and related carbon emissions in food processing".

The new Centre for Sustainable Energy Use in Food Chains, led by Prof Azapagic at Manchester, Prof Savvas Tassou at Brunel, and Prof Peter Fryer at Birmingham, will be working closely with over 30 industrial partners including household names such as Heineken, Heinz, Kellogg's, Kraft Foods now Mondelez, Premier Foods, Tesco and Waitrose, all of whom want to increase energy efficiency and cut their greenhouse gas emissions.

"Next comes the distribution chain, with both raw ingredients and finished products either chilled or frozen at several stages in their journeys from farms to storage and processing, and then their eventual

"Both raw ingredients and finished products are either chilled or frozen at several stages in their journeys from farms to storage and processing, and then their eventual appearance on the supermarket shelves... And when we get them home we typically put them straight into the fridge or freezer."

appearance on the supermarket shelves", says Adisa Azapagic. "And when we get them home we typically put them straight into the fridge or freezer".

Which is a chilling thought. As an environment journalist, I had believed that most of a crop's energy use and carbon emissions were in the energy-expensive production of modern fertilisers, either to encourage grass pasture or to grow grains and vegetables. And then there would be the further environmental and energy costs of cleaning up the polluted rivers and streams when excess fertilisers run off into watercourses, which is one reason why I favour organic farming. Apparently, I was wrong.

"Yes, ammonium sulphate and ammonium nitrate are energy intensive to produce in the first place, and then to transport and turn the raw materials into fertilisers for farmers to use", says Adisa. "But the greatest greenhouse gas emissions in agriculture come from the application of the fertilisers, not their original production. Nitrogen in the fertiliser and oxygen from the atmosphere react to form nitrous oxide, a greenhouse gas three hundred times more potent than carbon dioxide".

In meat production the major impact of farming comes from the fermentation of grass and all the other food in the sheep and cattle's guts, leading to serious quantities of methane emissions from both the front and back ends of the animals. Industrially preparing animal feed from corn and other grain, and making it into sheep and cattle nuts, also increases this environmental impact.

"We haven't looked at the environmental and energy impact of keeping horses, but given the proportion of horse meat that seems to be turning up in the cheaper end of the processed food chain at the moment, perhaps we should," says Adisa.

On the positive side, a not necessarily statistically reliable piece of research from May this year, to promote Fresh Week, showed that 24% of Britons surveyed claimed to have cut down on the amount of processed food they were eating following the horse meat scandal. Apparently British fruit and vegetables have made a comeback, according to Cold Feet actress Fay Ripley, who has the unlikely accolade of being branded a Tefal ambassador for the non-stick frying pan makers who commissioned the research.

"If the produce is grown in greenhouses which are in the UK, and are typically heated using electricity, we may still be better off importing vegetables and fruit from abroad. If they have been grown in the sun the energy consumption and carbon emissions may be lower", says Adisa Azapagic.

The five year project will be looking across different food types trying to identify different product hot spots, where interventions in processing, at the consumer end, and in policy requirements could cut energy use and carbon emissions. The final recommendations will suggest ways that government could help industry and consumers to make the changes needed.

Adisa Azapagic's background is in chemical engineering not agriculture, but as she explains, that makes her better placed to understand the processing side of our food.

"We need to work on understanding the whole life cycle and environmental impacts of food production", says Adisa. "The carbon footprint is one impact. But there is also an economic impact along the supply chain, providing jobs and re-investment for industry and cutting costs for consumers. Can we drive these parameters apart, adding more value, such as by processing foods, but reducing the environmental impact at the same time?"

By developing the Centre across three universities, with different experiences and approaches, the researchers hope to bring together a range of interdisciplinary skills.

"We also need to assess the social impacts of food production in developed countries", says Adisa Azapagic. "For example, these days many people don't care to cook from scratch, or they may even not know how to. This has led to an increasing reliance on ready-made, convenience food".

Slightly fed up with strident criticisms from some vegetarian activists, I have always found the widespread but poorly referenced claims about the enormous quantities of water needed to produce steaks instead of corn difficult to believe. As a small farmer who keeps a traditional breed of sheep, Exmoor Horns, on very rain soaked pastures myself, I know that it simply wouldn't be possible to grow crops in places that my ewes can survive happily.

"About 95% of the foods we eat in Britain, Western Europe, and the USA, are now processed in some way."

So what about the claimed water impacts?

"There has been very little reliable work on water use so far", says Adisa Azapagic. "Water footprints are only just starting to be calculated, we simply don't have enough reliable data or even the methodologies to calculate them yet".

For the first six months the Centre expects to be fact finding, then once the team know where the hot spots are, they will start trying to find ways of reducing the energy used in our food chain.

"What we look at in the later years of our research will depend upon our findings. We may look at alternative supply chains, for example, suggesting how supermarkets source our food in future. For instance, do we still import vegetables and meat or do we produce them locally?" says Adisa.

The Centre for Sustainable Energy Use is being established using a £7 million grant funded by the Engineering and Physical Sciences Research Council, of which £1.9 million has been awarded to The University of Manchester.

Thanks to Adisa's previous work, The University of Manchester's School of Chemical Engineering and Analytical Sciences provides free tools for carbon calculations over the life cycle of industrial activities, which have won awards from GlaxoSmithKline, the Institution of Chemical Engineering, and the Chemical Industry Association, and can be downloaded free at www.ccalc.org.uk.

"The CCaLC tool we have developed is now used by thousands of users across the globe, including industry, government bodies and NGOs to calculate their carbon footprint", says Adisa Azapagic.

So should we worry as individuals? Well, according to our Professor of Sustainable Chemical Engineering, the carbon footprint of each lamb curry which we eat as a ready-meal emits around 6 kg of carbon dioxide equivalent. That means that the lamb curries alone, not including the other ready-made meals, which roughly 30% of British adults all eat once a week, is equivalent to 140 million car miles, or 5500 car trips right around the world. There must be room for some movement there.

The Centre for Sustainable Energy Use in Food Chains is a partnership between the universities of Brunel, Manchester and Birmingham.

The CCaLC carbon footprinting tool available at www.ccalc.org.uk was developed by Professor Adisa Azapagic with funding from the Carbon Trust, the Engineering and Physical Sciences Research Council, and the Natural Environment Research Council.

> FIND OUT MORE
about carbon calculations and the Centre for Sustainable Energy Use in Food Chains
adisa.azapagic@manchester.ac.uk

X-rays reveal new picture of 'dinobird' plumage patterns

The first complete chemical analysis of feathers from Archaeopteryx, a famous fossil linking dinosaurs and birds, reveals that the feathers of this early bird were patterned – light in colour, with a dark edge and tip to the feather – rather than all black, as previously thought.

The findings came from X-ray experiments by a team including Dr Phil Manning and Professor Roy Wogelius from the School of Earth, Atmospheric and Environmental Sciences, working with colleagues at the US Department of Energy's (DOE) SLAC National Accelerator Laboratory. The scientists were able to find chemical traces of the original 'dinobird' and dilute traces of plumage pigments in the 150 million-year-old fossil.

"This is a big leap forward in our understanding of the evolution of plumage and also the preservation of feathers," said palaeontologist Dr Manning, lead author of the report in the June 13 issue of the *Journal of Analytical Atomic Spectrometry* (Royal Society of Chemistry).

Two recently developed methods have turned up more information about the dinobird and its plumage. The first is the discovery of melanosomes microscopic 'biological paint pot' structures in which pigment was once made, but are still visible in some rare fossil feathers.

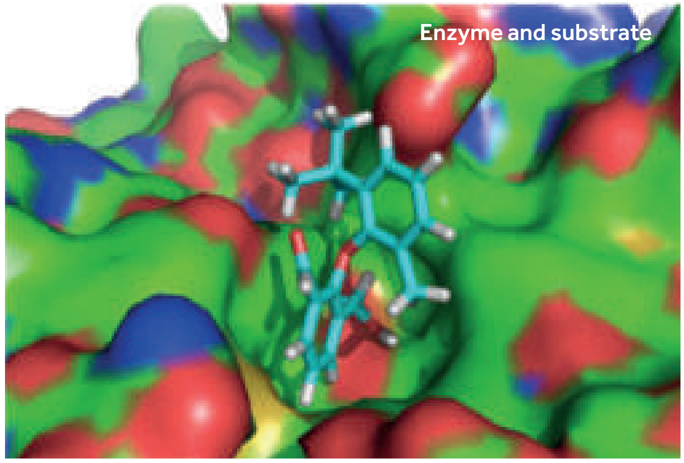
The second is a method for rapidly scanning entire fossils and analysing their chemistry with an X-ray beam at SLAC's Stanford Synchrotron Radiation Lightsource (SSRL) in the USA.

Over the past three years, the team used this method to discover chemical traces locked in the dinobird's bones, feathers and in the surrounding rock, as well as pigments from the fossilised feathers of two specimens of another species of early bird. This allowed them to recreate the plumage pattern of an extinct bird for the very first time.

The plumage patterns can begin to help scientists review their possible role in the courtship, reproduction and evolution of birds and possibly shed new light on their health, eating habits and environment.

Dr Manning added: "It is remarkable that x-rays brighter than a million suns can shed new light on our understanding of the processes that have locked elements in place for such vast periods of time."

http://dinosaursabbatical.blogspot.co.uk/



From fossil fuels to fatty acids

Professor Nick Turner from the School of Chemistry has led a team of researchers from Manchester and the University of Turku in Finland to identify a biocatalyst which could lead to the replacement of chemicals derived from fossil fuels. The biocatalyst could produce chemicals which are found in ice cream, soap and shampoo.

In a paper published in *Proceedings of the National Academy of Sciences,* the team has shown that the emerging field of synthetic biology can be used to manipulate hydrocarbon chemicals in cells. This development could lead to car fuel or household power supplies being created from naturally occurring fatty acids. Synthetic biology is an area of biological research and technology that combines science and engineering for the benefit of society. Significant advances have been made in this field in recent years.

Hydrocarbon chemicals are ubiquitous; as fragrance in soap, thickener in shampoo and fuel in the car. Their number of carbons and whether they are acid, aldehyde, alcohol or alkane are important parameters that influence how toxic they are to biological organisms, the potential for fuel, and their olfactory perception as aroma compounds.

The researchers used synthetic biology to hijack the naturally-existing fatty acids and direct those fatty molecules towards the production of ready-to-use fuel and household chemicals.

The breakthrough allows researchers to further explore how to create renewable energy from sustainable sources, and the advance could lead to more innovative ways of sourcing fuel from natural resources.

Professor Turner said: "We currently work with many different biocatalysts that catalyse a range of chemical reactions – the key is to match up the correct biocatalyst with the specific product you are trying to make.

"Biocatalysts recognise molecules in the way that a lock recognises a key – they have to fit perfectly together to work. Sometimes we redesign the lock so that it can accept a slightly different key allowing us to make even more interesting products. In this example we need to make sure that the fatty acid starting materials would be a perfect match for the biocatalysts that we discovered and developed in our laboratories.

"As with many leading areas of science today, in order to make major breakthroughs it is necessary for two or more laboratories around the world to come together to solve challenging problems."

Extinct giant camel found far from the desert in Arctic discovery

A Canadian research team, helped by scientists at The University of Manchester, has discovered the first evidence of an extinct giant camel in the High Arctic. The three-and-a-half million year old fossil was identified using collagen fingerprinting from bone fragments unearthed on Ellesmere Island; the furthest North a camel has ever been found.

An illustration of the High Arctic camel in its forest environment.

Researchers were unsure of which species the bone came from, so enlisted the help of Dr Mike Buckley from the Manchester Institute of Biotechnology. He used the pioneering new technique - collagen fingerprinting - to identify the animal from the bone fragments.

The technique allowed Dr Buckley to extract minute amounts of collagen, the dominant protein found in bone, from the fossils. Using chemical markers for the peptides that make up the collagen, a collagen profile for the fossil bones was developed which was then compared the profile of 37 modern mammal species, as well as that of a fossil camel found in the Yukon.

He found that the collagen profile for the High Arctic camel was almost an identical match to the modern day Dromedary as well as the Ice-Age Yukon giant camel. The collagen information, combined with the anatomical data, demonstrated that the bone fragments belonged to a giant camel as the bone is roughly 30% larger than the same bone in a living camel species.

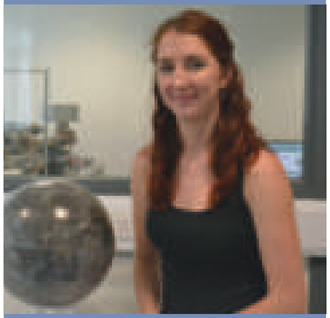
Dr Buckley remarked: "This is the first time that collagen has been extracted and used to identify a species from such ancient bone fragments. The fact the protein was able to survive for three and a half million years is due to the frozen nature of the Arctic. This has been an exciting project to work on and unlocks the huge potential collagen fingerprinting has to better identify extinct species from our preciously finite supply of fossil material."

Dr Natalia Rybczynski from the Dalhousie University, Halifax, Nova Scotia, said: "These bones represent the first evidence of camels living in the High Arctic region. It extends the previous range of camels in North America northward by about 1,200 km, and suggests that the lineage that gave rise to modern camels may have been originally adapted to living in an Arctic forest environment."

Professor Roy Wogelius from The University of Manchester's School of Earth, Atmospheric & Environmental Sciences analysed the mineral content of the bones. His findings suggest that mineralisation worked along with cold temperatures to help preserve the proteins in the bones: "This specimen is spectacular, and provides important clues about how such exceptional preservation may occur".

EPS SUCCESS

Royal Astronomical Society award



Dr Katherine Joy from the School of Earth, Atmospheric and Environmental Sciences has been awarded a Royal Astronomical Society prize for her research unravelling the impact history of the inner Solar System through studies of lunar samples.

The Royal Astronomical Society awards honour individuals who have made an outstanding contribution to astronomy or geophysics. The 2013 Winton Capital Award is in recognition of her pioneering work on lunar meteorites and rocks brought back by the Apollo astronauts.

Dr Joy's work combines laboratory chemical analysis of Moon samples with the analysis of spacecraft data, most notably from the ESA Smart-1 mission. Her research has enabled Dr Joy and colleagues to identify probable fragments of the lunar basin-forming 'impactors'. This now allows the source population of asteroidal impactors in the early Solar System to be better constrained and has led to a number of high-profile publications including a recent paper in the prestigious journal Science.

As well as undertaking ground-breaking research, Dr Joy is highly committed to teaching and public outreach. She now holds a Leverhulme Early Career Fellowship at Manchester.

Protective measures

You have decided to splash out; it is time for a new car. You make the trip to the dealer and proudly return home with a gleaming new vehicle. But the shine soon fades when you discover that your neighbour has done exactly the same.

Edwin Colyer talks corrosion with the School of Materials' new AkzoNobel Professor of Corrosion Control, Stuart Lyon, pictured below.

In unspoken rivalry you both try to keep your identical cars in pristine condition, but as the years pass rust blemishes begin to creep across your paintwork. Your neighbour's car, however, still sparkles like new.

It may be of little consolation, but your mini battle for car supremacy reveals some of the mystery that still exists in the area of corrosion control. Despite the latest and most advanced anti-corrosion formulas, special protective coatings still fail; moreover, their failure may not be uniform or predictable. What caused rust to ravage your car's bodywork yet leave your neighbour's vehicle untouched?

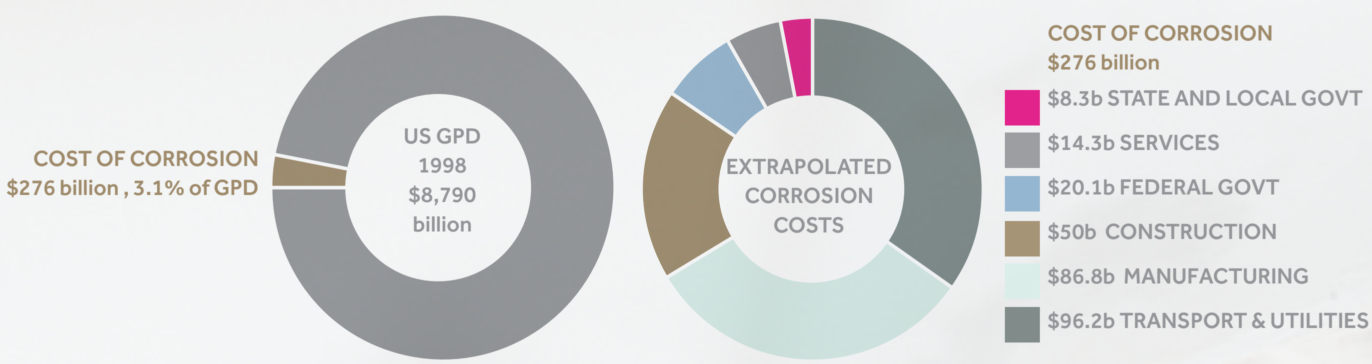
Someone should invent a paint that lasts for ever – it would save a lot of time and money …

The cost of corrosion

Rusty cars may be a classic picture of corrosion, but the scale of corrosion damage – and hence the importance of corrosion control – should not be underestimated. A massive global burden, corrosion costs 2-3% of global GDP, a staggering $3 trillion annually world-wide! If left unchecked, within 35 years depreciation from corrosion would wipe out the entire value of all our built and manufactured assets. It's easy then to see that the demand for effective, long-lasting, high performance protective coatings is intense.

AkzoNobel, the world's largest manufacturer of paints and protective coatings (eg Dulux, Hammerite, International, etc), understands that novel corrosion protection systems need support from fundamental science. The company's paints and coatings are used the world over to protect industry assets and

The cost of corrosion in the US



everyday objects – from oil rigs and aircraft to car alloys – from corrosive damage and destruction.

The company has therefore established a five year partnership with the School of Materials at The University of Manchester to further expand what is already the largest academic research endeavour into corrosion control in the Western hemisphere.

The partnership has opened a brand new research laboratory and has appointed Stuart Lyon as the AkzoNobel Professor of Corrosion Control. Professor Lyon oversees the research programme which will involve post-doctoral researchers and PhD students working on projects with active AkzoNobel technical involvement.

"We still don't really understand exactly how protective coatings work, and – even more importantly – why they fail to protect against corrosion damage. This will be the focus of our studies and our discoveries should reveal how the performance of coatings could be made more consistent and predictable," remarks Professor Lyon.

AkzoNobel partnership

The new AkzoNobel laboratory is developing methods for material characterisation to look at protective coatings and their substrate surfaces from the macro to the micro, nano and atomic scales. The multidisciplinary research focuses on the molecular and atomic microstructure of materials, using the very latest analytical tools (e.g. electron microscopy and atomic force microscopy).

Recent findings have already shown that often it is not the coating which is to blame when corrosion protection fails.

Applying an AkzoNobel protective coating

"Recent high resolution imaging has shown that heterogeneity in the substrate material leads to corrosion sensitive spots," explains Professor Lyon. "For example, we analysed the alloy of a car wheel where the clear lacquer was all peeling away and corrosion had set in. We found clusters of copper atoms in the alloy that acted as the nuclei for corrosion. We've also looked at the microstructure of paints and discovered tiny holes and cracks which could act as pores for water to penetrate through to the metal surface.

"It is only when you can look at coatings at this microscopic scale that you can begin to work out ways to improve performance."

Building upon this thorough material characterisation, the AkzoNobel laboratory will also draw on expertise from across the School of Materials in the Faculty of Engineering and Physical Sciences to help it develop advanced materials for corrosion inhibition and new corrosion control technologies. Focused research also seeks to develop alternative additives to strontium chromate, an anti-corrosion compound widely used in protective paints, but banned by EU legislation from 2017. Although alternatives already exist, no-one really understands why they work and what microstructural features lead to their eventual failure.

Probing the mechanisms of corrosion at the atomic scale, the AkzoNobel partnership is discovering just what it takes to keep rust and corrosion at bay. Corrosion will always win in the end, but protective paints based on this research could help to put off the inevitable for many more years – and perhaps keep your next car in better shape too.

> FIND OUT MORE

manchester.ac.uk/materials

akzonobel.com/international/our_markets/protective_coatings/

Chocolate power challenge for chemists

Science and environment journalist Myc Riggulsford talks to The University of Manchester's Professor Rob Dryfe, pictured right, about his plans to create a graphene -based battery.

How do you design a better battery that can deliver the same energy as a Mars bar? And then do it again, and again, and again? That's the challenge that Professor Rob Dryfe of the University of Manchester's Department of Chemistry, has taken on this year in a £2.2 million project funded by the Engineering and Physical Sciences Research Council.

To make the test even trickier, Rob and his colleagues are also trying to design a supercapacitor that can deliver roughly the same amount of electricity, but as an instant burst of energy.

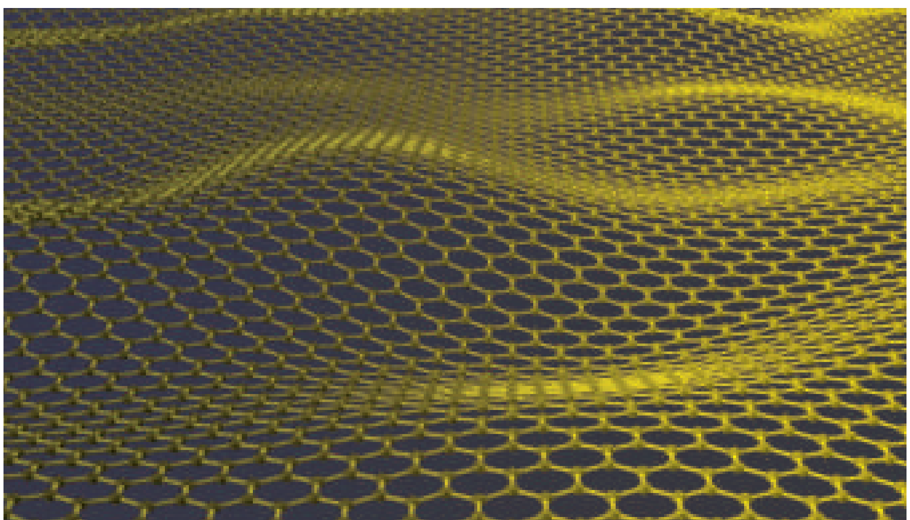
So you can imagine them with one Mars bar stuck full of electrodes trying to slowly extract the energy trapped inside, and another being blown to bits to instantly release it. Or they may even try to combine the two applications in a single machine. Either way, their goal is to produce working prototypes within five years.

"Batteries cannot deliver a lot of energy at once, but they can do it for a long time, and do it over and over again", says Rob Dryfe. "Once you've eaten your Mars bar, that's it. It's not reversible. You can't take the water and carbon dioxide and energy and turn them back into a bar of chocolate. Well, not unless you're a plant".

Our society has moved from heavy and cumbersome lead acid batteries to lighter and longer lasting lithium-ion batteries, giving us mobile phones, laptops and even aircraft that have reliable electrical power.

"Lithium-ion batteries can store and deliver so much power that we've even seen some problems with them", says Rob Dryfe.

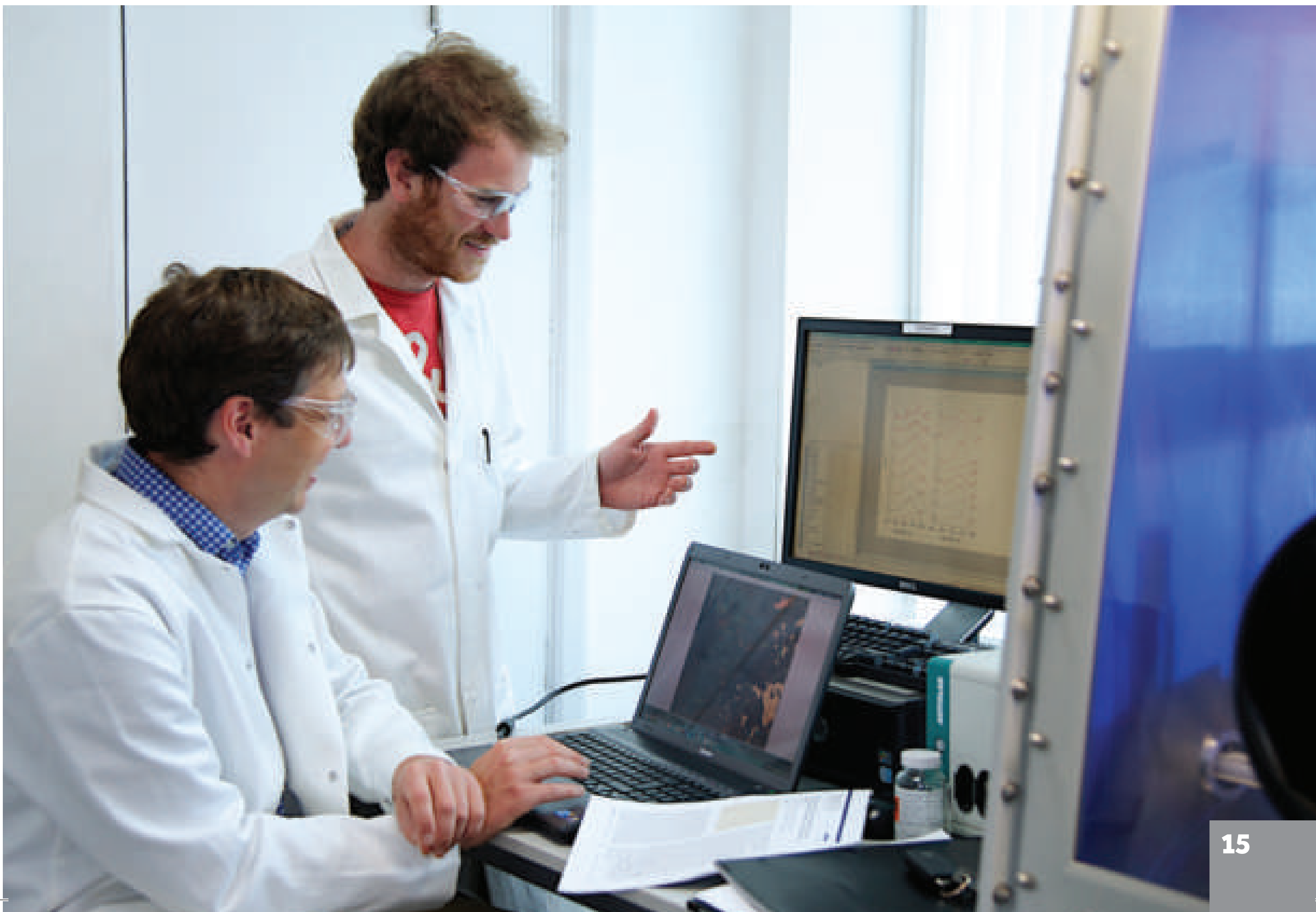
There were two incidents with lithium-ion batteries overheating on Boeing 787 Dreamliner aircraft, one of which caught fire in Boston in January this year, grounding the planes until May when new stainless steel casings, cooling and ventilation systems were introduced. This follows a hotel fire and other incidents



Artistic impression of a corrugated graphene sheet. Credit to Jannik Meyer.

"It's about the same as the energy stored in a Mars bar."


PURE
LAB



in 2006 when Dell computers containing Sony laptop computer batteries were also overheating and burning up, leading to the recall of 4 million computers.

But increasingly we need even bigger, better, more reliable batteries for larger equipment, such as electric cars and trucks. And for aeroplanes like Dreamliners to provide back-up power in case of failure or just to run the wing systems more cheaply and cleanly, since electrochemical power conversion is much more efficient than burning fossil fuels.

It all comes down to questions of energy and power density. How much is stored in a given weight or mass of material, and how quickly can you extract that energy? We could technically build massive batteries now which could deliver enough power to drive an electric truck all the way across Britain. But the batteries would have to be the size of an office block, so totally impractical.

"For an electric car you need a battery for long range energy, and a capacitor for short bursts of power to accelerate", says Rob Dryfe. "It's an energy trade-off. The more power needed instantly, the shorter the time you can have it for".

The weight-to-power ratio is also critical. That's why lithium-ion batteries have taken over from lead-acid ones. Lead is very heavy. Lithium is the third lightest element, and of the two lighter elements, hydrogen is a gas at normal temperatures and pressures, and helium is inert and won't react with anything, so it's useless

"Graphene-based batteries and supercapacitors could deliver what we are looking for."

for generating electricity. But lithium is very reactive and wants to turn to lithium ions in a solution if it has been transformed into lithium metal.

"We can all remember chemistry lessons at school where someone chucked a small lump of sodium into a sink full of water and it fizzed or caught fire", says Rob Dryfe. "You can't do that demonstration with lithium because it would just explode".

Whilst we cannot improve on the chemistry of lithium-ion batteries, we can improve on the performance of electrochemical energy storage, whether it is in batteries or supercapacitors.

"Lithium is probably the most efficient element for reversible energy storage, but that doesn't mean that we're using it in the most efficient way", says Rob Dryfe.

Lithium is expensive as an element. It's light and quite widely available on Earth, but it's also quite difficult to get at and refine from rock, because it's so reactive. It's this unstable quality which makes it useful for batteries, converting backwards and forwards from one state to the other.

Batteries work at the electrodes. For a good battery you need a light, cheap and fairly inert substance like graphite - familiar to most people as pencil lead - otherwise it could overheat as the reaction gets out of control. The chemical reaction all happens on the surface of the electrode, so you also want as big a surface area as possible for the smallest bulk or weight.

"Graphene, the new carbon material discovered in Manchester as a single layer of carbon atoms, which is a light element, is excellent because it's a good electrical conductor, practically inert, and it's all surface, so it has no bulk", says Rob Dryfe. "Theoretically at least, graphene based batteries and supercapacitors could deliver both the needs we are looking for. A big kick to get a car accelerating, and continuous energy delivered for long trips".

So instead of looking at the chemical solutions used to deliver power, such as lead-acid or lithium-ion, which is how earlier batteries were improved, Rob Dryfe and his colleagues Prof Ian Kinloch and Prof Andrew Forsyth in Manchester, and Dr Ian Hardwick, the fourth member of the consortium based at the University of Liverpool, are planning to re-engineer the electrodes.

The weak link with our present supercapacitors is the amount of energy that can be released in one jolt. The researchers think that graphene-based electrodes should have a better power output.

There are two key problems to overcome before the group can deliver their

PROJECT PROFILE

1 February 2013 project started

2 universities – The University of Manchester and The University of Liverpool

5 year project

7 postdoctoral assistants

2 postgraduate students

4 project leaders

promised Mars bar's worth of power in a battery within five years. The first is finding ways to improve the performance of the graphene itself.

"If your laptop battery only held a charge for a few weeks, and then stopped recharging, you'd quickly get fed up with it", says Rob Dryfe. "You would probably be happy to sacrifice some power or performance to have a longer overall battery life. A car battery might need to be recharged 100,000 times. A supercapacitor might click on and off 100,000 times during a few trips to deliver your acceleration. We don't yet know how long graphene electrodes will hold their life".

The problem with graphene is that as a single layer of carbon atoms it wants to stick back together with other layers to form a more stable lump of graphite, like in pencil lead. The layers want to stack up and stick together, which would stop a battery working so well.

"It naturally binds together over time, and especially through the constant cycling of electrical charges passing through it and stressing it", says Rob Dryfe. "We need to find a way of keeping the sheets apart, but close together so that the battery stays small and light for its power".

One promising idea is to use carbon nanotubes to hold the graphene stacks apart. Single walled carbon nanotubes are strong, but close to only one thousandth of the thickness of a human hair, and also being made of pure carbon, they are relatively light.

The second big problem is making enough high quality graphene in the first place. At the moment the original method, which led to its discovery, of sticking Sellotape to a graphite block and peeling off a single sheet of atoms just one layer thick is still the most reliable way to make high quality material. What we might call the Blue Peter approach.

"It's still the best and quickest way to get high quality samples for us to experiment with", says Rob Dryfe. "But it's no use for industrial processes".

Their research group is thinking about some of the other methods of producing graphene such as by using ultrasound to shake blocks of graphite apart, which isn't yet very efficient, only yielding less than 1% of single layers of graphene.

Or they could use chemical deposition, using methane vapour over a catalytic surface to deposit the graphene as a thin film of coke, a bit like dusting it evenly with minute particles of photocopier toner. Some industry groups claim to have produced one metre square sheets of graphene this way, but it's energy intensive, needs a large furnace, and you have to keep the air out or it all explodes.

How do you design a better battery that can deliver the same energy as a Mars bar? And then do it again, and again, and again?

The group's most promising idea so far for this part of the problem is to make the graphene electrochemically by converting graphite electrodes into graphene.

"That way we could put the bits in to stop it forming clumps, such as the carbon nanotubes, into the graphite electrode at the beginning", says Rob Dryfe. "Then we'd have the perfect structure from the start".

The group wants to pursue the two parallel strands of their research - to make a battery and a supercapacitor, which need different electrode arrangements - simultaneously. Although it's always possible that they will be so successful that they will solve both problems at the same time.

Prof Andrew Forsyth has a one megajoule supercapacitor test rig in his Manchester laboratory.

"That's about enough power to light up five old-fashioned 60 watt lightbulbs for an hour, but delivered as one burst", says Rob Dryfe. "So that's our goal".

It would be enough power for a laptop computer, but not enough for an electric car.

"It's about the same as the energy stored in a Mars bar", says Rob Dryfe. "But we need it to be reversible".

> FIND OUT MORE
about graphene batteries and supercapacitors
contact Professor Rob Dryfe, School of Chemistry, University of Manchester
robert.dryfe@manchester.ac.uk

EPS SUCCESS

Computer Pioneer Award

Professor Steve Furber, ICL Professor of Computer Engineering in the School of Computer Science, has been honoured with the 2013 IEEE Computer Society's Computer Pioneer Award.

The Computer Pioneer Award was established to recognise and honour the vision of those people whose efforts resulted in the creation and continued vitality of the computer industry. The award is presented to outstanding individuals whose main contribution to the concepts and development of the computer field was made at least 15 years earlier.

Professor Furber worked for Acorn Computers during the 1980s and was a principal designer of the BBC Microcomputer, which introduced computers into most UK schools. He was a principal designer of the first ARM 32-bit microprocessor. Its descendants power most of the world's consumer electronics, and more than 44 billion ARM processors have been shipped to date by ARM's semiconductor partners.

He is currently ICL Chair at Manchester and serves as head of the Advanced Processor Technologies research group. His research interests include asynchronous digital design, multicore computer architecture and neural systems engineering.

UK collaboration to track greenhouse gases

Scientists from Manchester are about to embark on a UK-wide study to help gauge and track progress on Government targets to cut greenhouse gas emissions by 80% by 2050.

The study, funded by the Natural Environment Research Council, will be carried out by the Universities of Manchester, Edinburgh, Bristol, Cambridge, Leeds and Leicester, the NERC Centre for Ecology and Hydrology, the Met Office and the STFC Rutherford Appleton Laboratory.

greenhouse gases

80%

2050

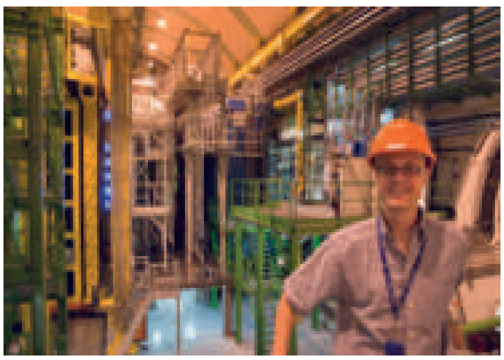
Using measurements taken from satellites, aircraft and ships they will help to create a detailed picture of UK emissions of harmful greenhouse gases from various sources, including industry, landfill and agriculture. The study will also allow researchers to improve their understanding of how the gases affect climate change.

A team of British researchers will fly across the UK in an aircraft equipped with sensors to measure carbon dioxide, methane and nitrous oxide in the air. The team will also take samples from sensors on a North Sea ferry, and from a series of towers situated across the UK.

Results from the four-year survey will be coupled with observations from European, US and Japanese satellites of greenhouse gas movements. Together this will give details of UK emissions to the atmosphere in a global context, taking account of seasonal changes, such as emissions linked to agriculture.

Dr Grant Allen, from The University of Manchester's School of Earth, Atmospheric and Environmental Sciences and leader of the airborne survey component of the project, said: "This exciting project will see the first ever comprehensive measurements of emissions of greenhouse gases from the UK as a whole, leading us away from potentially inaccurate industry-reported estimates and towards measured and real emissions data as required under our treaty obligations".

Professor Paul Palmer, of the University of Edinburgh's School of GeoSciences, who is leading the project, said: "This will deliver robust greenhouse gas emissions estimates from the UK and the world, by bringing together comprehensive data and talented scientists who can make sense of it – this should help track progress towards tackling climate change".



CERN scientists discover new matter-antimatter difference

A subtle difference between matter and antimatter has been observed for the first time by the Large Hadron Collider beauty (LHCb) experiment at the European Organisation for Nuclear Research (CERN).

The work forms part of the studies to understand why the Universe only contains matter when it is believed that matter and antimatter were created in equal amounts at the time of the Big Bang.

LHCb was specifically designed to look for small differences between matter and antimatter – called CP violation – in particles produced by the Large Hadron Collider (LHC). The first observation of CP violation was made in 1964 leading to the 1980 Nobel prize; a later discovery confirmed the theoretical description of the phenomenon and led to the 2008 Nobel prize. LHCb has now observed CP violation in Bs mesons, combined states made from beauty and strange quarks, and antiquarks.

Members of the LHCb collaboration analysed 70 trillion proton-proton collisions that took place in the heart of the detector. They looked at two variants of a decay of the Bs meson and its 'mirror image' where all particles are replaced by their antiparticles. A small difference in the rates at which these two decay modes happen demonstrated a difference of behaviour between matter and antimatter.

Professor Chris Parkes, from the University of Manchester's School of Physics and Astronomy and spokesperson for the UK university groups involved in the LHCb collaboration, said: "This is an excellent result, consistent with the Standard Model [of particle physics], so it isn't unexpected – we thought we should be able to make this observation with LHCb based on previous results. We've been able to confirm the discovery so soon due to the sensitivity of our detectors, the quality and quantity of data, and the precision of our analysis".

Mysterious matters on red supergiant star

A new image of the outer atmosphere of Betelgeuse – one of the nearest red supergiants to Earth – has revealed the detailed structure of matter being thrown off the star.

Betelgeuse is easily visible to the unaided eye as the bright, red star on the shoulder of Orion the Hunter. The star itself is huge – 1,000 times larger than our Sun – but at a distance of about 650 light years it still appears as a tiny dot in the sky, so special techniques combining telescopes in arrays are required to see details of the star and the region around it.

Taken by the e-MERLIN radio telescope array operated from The University of Manchester's Jodrell Bank Observatory in Cheshire, the image also shows regions of surprisingly hot gas in the star's outer atmosphere and a cooler arc of gas weighing almost as much as the Earth.

The new image has been published in the journal *Monthly Notices* of the Royal Astronomical Society, and shows its atmosphere extends out to five times the size of the visual surface of the star. It reveals two hot spots within the outer atmosphere and a faint arc of cool gas even farther out beyond the radio surface of the star.

Lead author Dr Anita Richards, from The University of Manchester, said: "One possibility why the hot spots are so hot is that shock waves, caused either by the star pulsating or by convection in its outer layers, are compressing and heating the gas. Another is that the outer atmosphere is patchy and we are seeing through to hotter regions within. The arc of cool gas is thought to be the result of a period of increased mass loss from the star at some point in the last century but its relationship to structures like the hot spots, which lie much closer, within the star's outer atmosphere, is unknown".

Dr Richards, who is based in Manchester's School of Physics and Astronomy, added: "This is the first direct image showing hot spots so far from the centre of the star. We are continuing radio and microwave observations to help decide which mechanisms are most important in driving the stellar wind and producing these hot spots. This won't just tell us how the elements that form the building blocks of life are being returned to space, it will also help determine how long it is before Betelgeuse explodes as a supernova."

Future observations planned with e-MERLIN and other arrays, including ALMA and VLA, will test whether the hotspots vary in concert due to pulsation, or show more complex variability due to convection. If it is possible to measure a rotation speed this will identify in which layer of the star they originate.

Mapping the Universe

Sarah Bridle is Professor of Astrophysics in the Extragalactic Astronomy and Cosmology research group of the Jodrell Bank Centre for Astrophysics, and she joined the University from UCL in January. She is the recipient of many prizes for her work, including the Royal Astronomical Society's Fowler Award for Astronomy. She spoke to us about why she joined Manchester, and what projects she is currently involved with.

"Manchester was a natural progression for me; I know many colleagues in the Cosmology group, and the University is a well-known centre for astronomy with the Lovell telescope and its associated history in radio astronomy.

"I am continuing my research on weak gravitational lensing with the Dark Energy Survey, which is an international collaboration led in the US, with around 300 international participants. We are taking images of 1/8th of the whole sky and measuring the shapes and distances to three hundred million galaxies. I lead the work measuring precise shapes of galaxies, and producing a three dimensional map of all of the dark matter in the universe.

"Ninety per cent of the mass in the universe is invisible, and we are able to use this technique to make a map of that material. In addition, seventy per cent of the total energy in the universe seems to be dark energy, and what it's made of is still a mystery. By studying the map of dark matter as a function of time we can learn about the properties of this dark matter; the biggest mystery certainly in cosmology, and perhaps in physics today.

"In September 2012 we had first light of the telescope and the camera, and have since been taking scientific verification data, analysing the data, and in January we were able to present our first dark matter map of a small area of the sky. We will begin surveying proper in September this year; a study that will continue for five years."

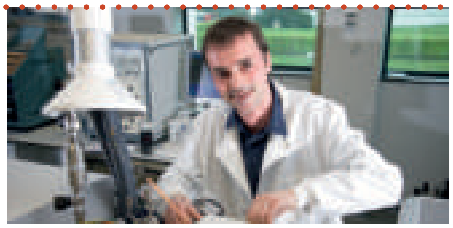
90%

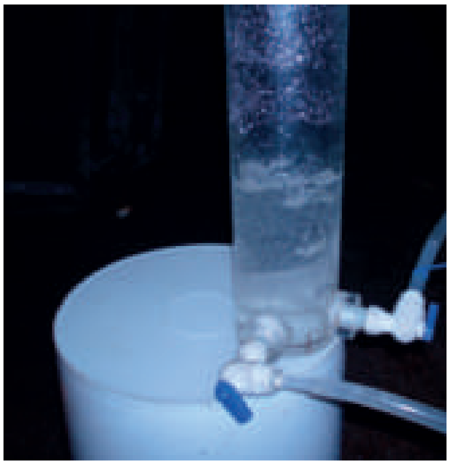
of the mass in the universe is invisible

Not content with discovering what constitutes dark matter, Sarah is working with colleagues in computer science to accurately analyse shapes of galaxy images. "I am leading an ERC funded, interdisciplinary project using techniques from computer science to solve this astronomy problem. It turns out that we can write our problem without using astronomy or astrophysics, but through the analysis of images which is where computer science helps. Ten years ago we were all trying to solve this problem within astronomy, but discussions with computer scientists led to the creation of a dataset of 30 million galaxies, which they were able to analyse."

Talk turns to further projects, and Professor Brindle is keen to look at the long term possibilities of her research, and the question of where will the field of weak gravitational lensing go after the Dark Energy Survey ends in five years time? "We're getting involved in a project called the large synoptic survey telescope (LSST) – an international effort involving a large aperture telescope and a 3,200 megapixel camera to image faint astronomical objects. It's hoped that the images will trace billions of remote galaxies, providing probes of dark matter and dark energy. I'm currently carrying out calculations for that. One of the big questions is 'how much do we need to know about the shape of galaxies in order to be able to perform weak gravitational lensing?' The shape of galaxies can vary, so we may need a new instrument to produce high resolution images from the ground."

> FIND OUT MORE
www.jb.man.ac.uk





Billion-year-old water could hold key to sustaining life

Collaboration between scientists at The University of Manchester, Lancaster University, University of Toronto and McMaster University has discovered ancient pockets of water, which have been isolated deep underground for billions of years and contain many chemicals known to support life.

The findings were published in Nature in May, and could force us to rethink which parts of our planet are fit for life, as well as reveal clues about how microbes evolve in isolation.

The team analysed water pouring out of boreholes from a mine 2.4 kilometres beneath Ontario, Canada. The water is rich in dissolved gases like hydrogen, methane and different forms – called isotopes – of noble gases such as helium, neon, argon and xenon. Indeed, there is as much hydrogen in the water as around hydrothermal vents in the deep ocean, many of which teem with microscopic life.

The hydrogen and methane come from the interaction between the rock and water, as well as natural radioactive elements in the rock reacting with the water. These gases could provide energy for microbes that may not have been exposed to the sun for billions of years.

This water could be some of the oldest on the planet, may even contain life, and the similarity between the rocks that trapped it and those on Mars raises the hope that comparable life-sustaining water could lie buried beneath the red planet's surface.

The crystalline rocks surrounding the water are thought to be around 2.7 billion years old. But no-one thought the water could be the same age, but ground-breaking techniques developed at The University of Manchester has allowed the team to ascertain that the fluid is at least 1.5 billion years old, but could be significantly older.

Professor Chris Ballentine of The University of Manchester, co-author of the study, and project director, said: "Our finding is of huge interest to researchers who want to understand how microbes evolve in isolation, and is central to the whole question of the origin of life, the sustainability of life, and life in extreme environments and on other planets."

Dr Greg Holland of Lancaster University, lead author of the study, said: "Our Canadian colleagues are trying to find out if the water contains life right now. What we can be sure of is that we have identified a way in which planets can create and preserve an environment friendly to microbial life for billions of years. This is regardless of how inhospitable the surface might be, opening up the possibility of similar environments in the subsurface of Mars."

David Willetts, Minister for Universities and Science, said: "This is excellent pioneering research. It gives new insight into our planet. It has also developed new technology for carbon capture and storage projects. These have the potential for growth, job creation and our environment."

This work was funded by NSERC Discovery and CRC grants, a NERC grant and Deep Carbon Observatory (DCO) support.

The North Pole area, Pilbara, Western Australia, where the samples came from.

Clue to first ice age

Tiny bubbles of water found in quartz grains in Australia may hold the key to understanding what caused the Earth's first ice age. The collaborative project between The University of Manchester, the CRPG-CNRS, University of Lorraine and the Institut de Physique du Globe Paris. The Anglo-French collaboration was recently highlighted in Nature.

The scientists analysed the amount of ancient atmospheric argon gas (Ar) isotopes dissolved in the bubbles and found levels were very different to those in the air we breathe today. They believe that their findings help explain why Earth didn't suffer its first ice age until 2.5 billion years ago, despite the Sun's rays being weaker during the early years of our planet's formation.

Their research has revealed that the ratio of two argon isotopes – 40Ar, formed by the decay of potassium (40K) with a half-life of 1.25 billion years, and 36Ar – was much lower than present-day levels. This finding can only be explained by the gradual release of 40Ar from rocks and magma into the atmosphere throughout Earth's history.

The team used the argon isotope ratio to estimate how the continents have grown over geological time and found that the volume of continental crust 3.5 billion years ago was already well-established being roughly half what it is today.

Dr Ray Burgess, from the University of Manchester's School of Earth, Atmospheric and Environmental Sciences commented: "The water samples come from the Pilbara region in north-west Australia and were originally heated during an eruption of pillow basalt lavas, probably in a lake or lagoon environment. Evidence from the geological record indicates that the first major glaciations on Earth occurred about 2.5 billion years ago, and yet the energy of the Sun was 20 per cent weaker prior to, and during, this period, so all water on Earth should already have been frozen.

"This is something that has baffled scientists for years but our findings provide a possible explanation."

All of a flutter with graphene

Wonder material graphene, when combined with other graphene-like materials, paves the way for vast new areas of scientific discovery and previously unheard-of applications.

Writing in Nature, a large international team led by Dr Roman Gorbachev from The University of Manchester shows that, when graphene is placed on top of insulating boron nitride, or 'white graphene', the electronic properties of graphene change dramatically revealing a pattern resembling a butterfly. The pattern is referred to as the elusive Hofstadter butterfly that has been known in theory for many decades but never before observed in experiments.

The team included scientists from the University of Lancaster, Instituto de Ciencia de Materiales de Madrid and the National High-Field Laboratory in Grenoble.

Graphene is the world's thinnest, strongest and most conductive material, and promises a vast range of diverse applications; from smartphones and ultrafast broadband to drug delivery and computer chips. It was first demonstrated at The University of Manchester in 2004, and initial trials of consumer products are being carried out by major multinational companies.

Graphene has high conductivity - thousands of times higher than copper - due to a special pattern created by electrons that carry electricity in graphene. The carriers are called Dirac fermions and mimic massless relativistic particles called neutrinos.

Manchester scientists have found a way to create multiple clones of Dirac fermions where graphene is placed on top of boron nitride so that graphene's electrons can 'feel' individual boron and nitrogen atoms. Moving along this atomic 'washboard', electrons rearrange themselves once again producing multiple copies of the original Dirac fermions.

The researchers can create even more clones by applying a magnetic field. The clones produce an intricate pattern; the Hofstadter butterfly. It was first predicted by mathematician Douglas Hofstadter in 1976 and, despite many dedicated experimental efforts, no more than a blurred glimpse was reported before.

In addition to the described fundamental interest, the Manchester study proves that it is possible to modify properties of atomically-thin materials by placing them on top of each other. This can be useful, for example, for graphene applications such as ultra-fast photodetectors and transistors, providing a way to tweak its incredible properties.

Dr Gorbachev said: "We prepared a set of different atomically-thin materials similar to graphene then stacked them on top of each other, one atomic plane at a time. Such artificial crystals would have been science fiction a few years ago. Now they are reality in our lab. One day you might find these structures in your gadgets."

Professor Andre Geim, Nobel Laureate and co-author of the paper, said: "Of course, it is nice to catch the beautiful 'butterfly' whose elusiveness tormented physicists for generations. More importantly, this work shows that we are now able to build up a principally new kind of material by stacking individual atomic planes in a desired sequence.

"This is an important step beyond 'simple graphene'. We now build foundations for a new research area that seems richer and even more important than graphene itself."

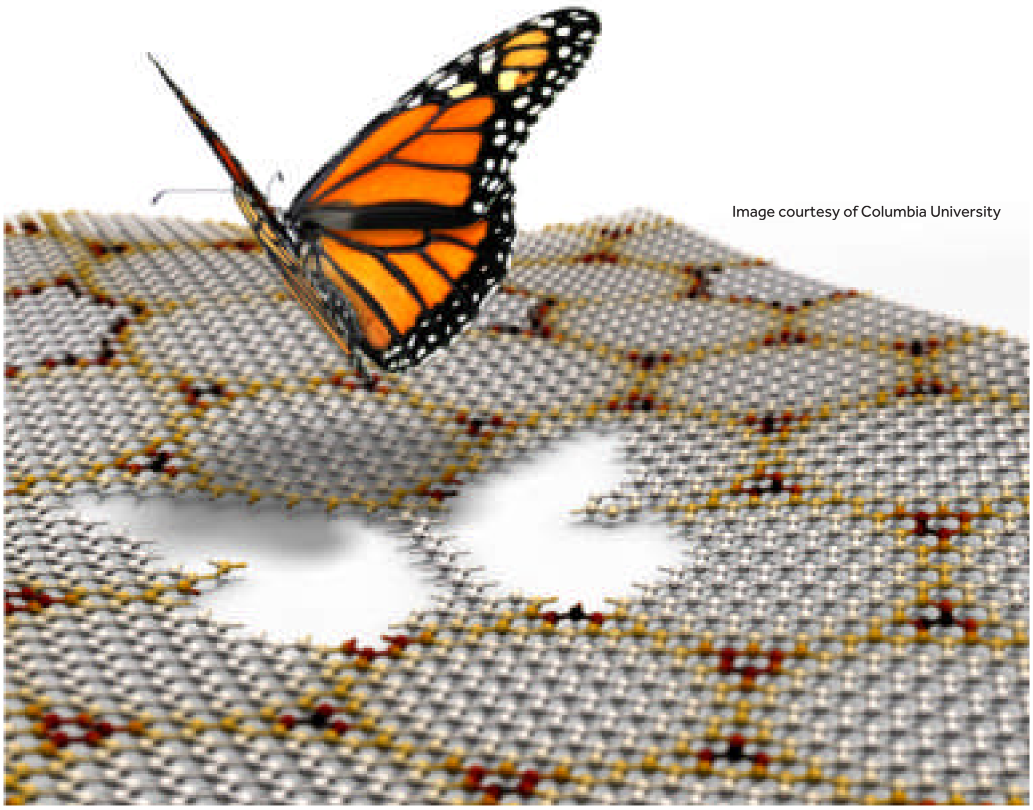


Image courtesy of Columbia University

EPS SUCCESS

Royal Society Wolfson Research Merit Award

Professor Stefan Söldner-Rembold, from the School of Physics and Astronomy, has been named one of just 24 new Royal Society Wolfson Research Merit Award holders.

Jointly funded by the Wolfson Foundation and the Department for Business, Innovation and Skills (BIS), the scheme aims to provide universities with additional support to enable them to attract science talent from overseas and retain respected UK scientists of outstanding achievement and potential.

Professor Söldner-Rembold, who is Professor of Particle Physics, will use the award to continue his studies of the origins of mass.

He said: "I feel honoured and excited about receiving the award which will support my research in Manchester. We try to understand the origin of the vastly different mass scales of fundamental particles – from the almost massless neutrinos to the top quark with a mass similar to a gold atom".

Can grids cope with electric cars?

Some say they are the green, clean and quiet answer to traffic pollution; others deride them for their slow speeds and limited range. One thing is certain, however: electric cars are beginning to sell; stay on the lookout and you will probably soon spot one on the street.

But Dr Luis (Nando) Ochoa, Lecturer in Smart Distribution Networks in the School of Electrical and Electronic Engineering, is worried: "Electric cars may still be rare, but what if a cluster of owners all charge their cars at the same time off the same local electricity grid?"

A typical overnight charge for an electric car draws about 3 kW of power – twice the average power consumption of a domestic residence. So you only need to plug in few electric cars on the street to create a huge surge in consumption. No-one really knows how this might affect network performance.

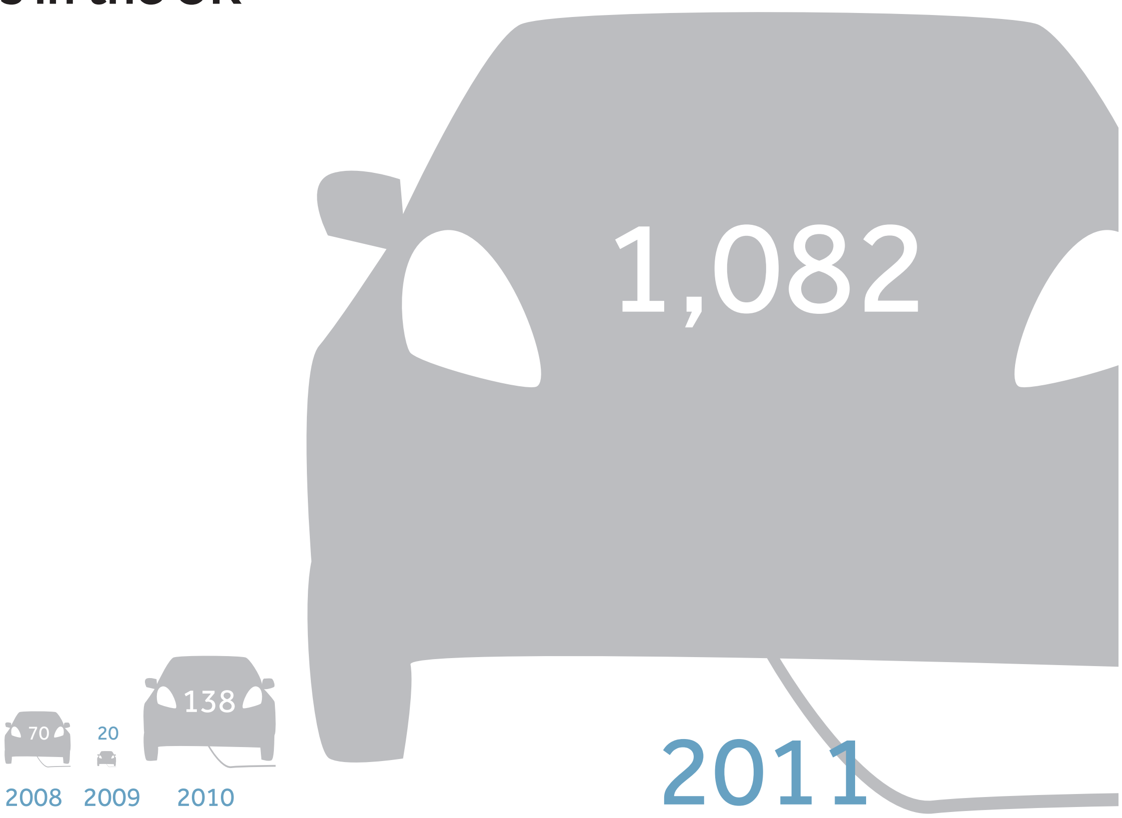
Network nuances

Dr Ochoa is set to provide his insights into this problem as part of a major project, My Electric Avenue, supported by Ofgem's Local Carbon Networks Fund. Groups of 10 neighbours will all be given subsidised Nissan LEAF cars to drive for 18 months; their charging patterns and the performance of their local electricity networks will be monitored during this period. The trial will also test a system to allow direct control of charging of EVs that have been developed, called 'Esprit'.

The University of Manchester's expertise in network modelling stems from on-going research with electricity distributor Electricity North West. Dr Ochoa's research team has already created a powerful probabilistic model of local network performance, using information such as the geographic layout of the network, its construction, consumption patterns and consumer types.

"Our knowledge will help My Electric Avenue partners to develop cheap and affordable charging control systems," Dr Ochoa explains. "We already have one very simple solution: when power demand reaches safety thresholds we just switch off some charging points. Our modelling will help to refine this rather blunt approach. How many charge points should we switch off, and when do we turn them on again? Is it OK to turn off points at random when consumption peaks, or should we be

Electric Car Sales in the UK



Source: SMMT.

These figures are for pure electric cars only and exclude quadricycles.

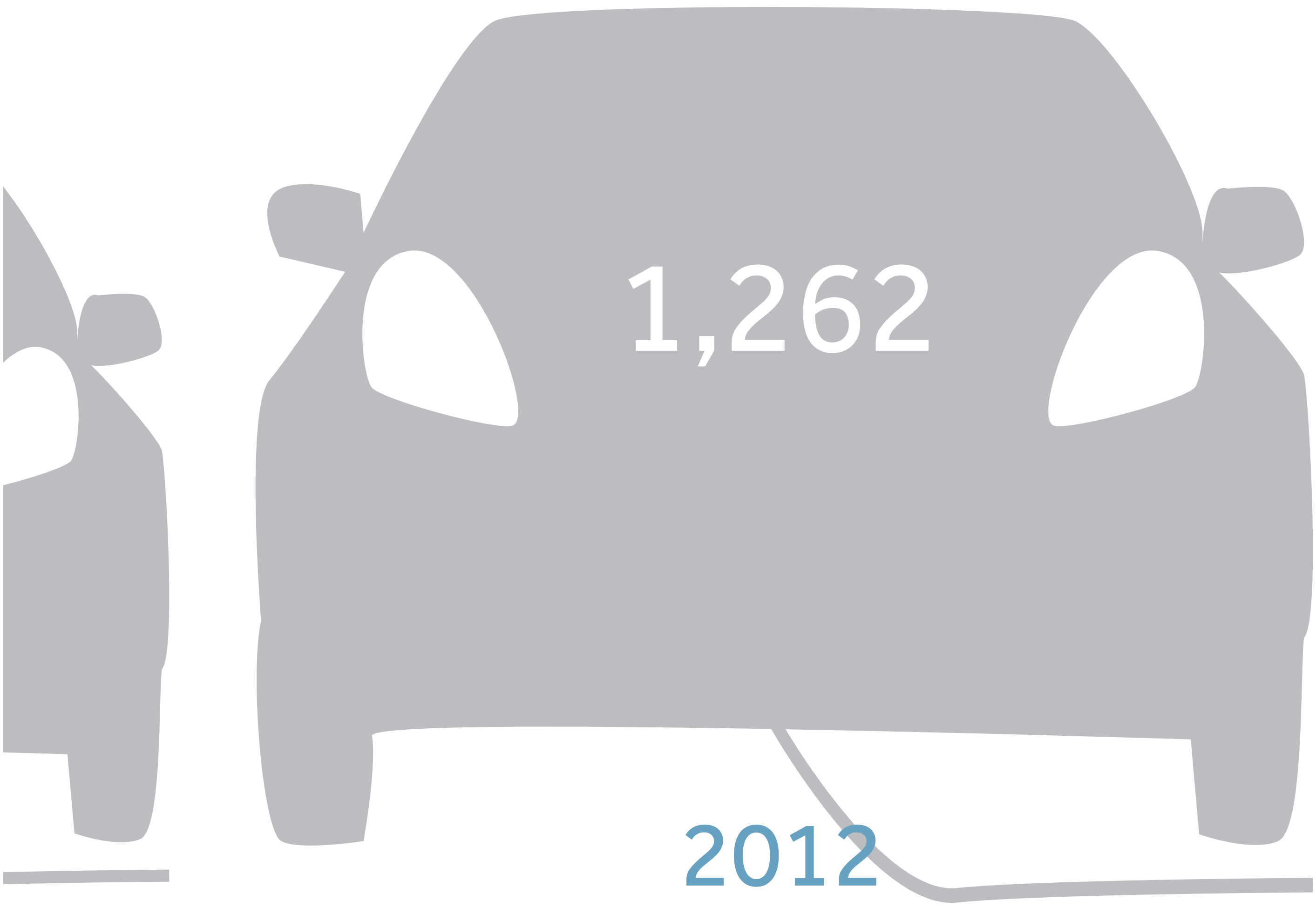
In 2012 there were also 24,086 petrol-electric hybrids and 1,284 diesel-electric hybrids sold; these types of vehicle will increasingly include plug-in versions, which will also have an impact upon local electricity networks. There are various forecasts for the future growth in electric car sales. An average figure is that there may be 1 million electric vehicles on our roads by 2020.
Source: **www.green-car-guide.com**

“We need to find a solution that does not damage consumer confidence.”

more systematic? Do we need to know how much each car’s battery is charged? There are many different options to investigate; that’s why modelling is so important.”

My Electric Avenue will try out Esprit as it cycles EV charging to manage and alleviate the stress on the network. “The key measure here is not really limited to the network performance – it is easy enough to switch off for more cars to cut demand,” Dr Ochoa continues. “Rather, we need to find a solution that does not damage consumer confidence. Imagine discovering one morning that your car is flat, but your neighbour’s has full power! Our models should help us to identify a range of possible control methods for optimal network performance; the project will then find out which are best for consumer experience.”

> FIND OUT MORE
myelectricavenue.info



Getting clever with composites

In the shadows of soaring skyscrapers, the red brick chimneys of Manchester's nineteenth century cotton mills are modest relics of their former triumphs. Once drivers of the industrial revolution, the mills which remain today stand quiet, converted into the apartments and offices of Manchester's new economy.

The National Composites Certification and Evaluation Facility is an independent ISO 17025 accredited test laboratory, which is run as the commercial arm of the North West Composites Centre (NWCC). It responds to short term industrial needs that could lead to longer term research contracts and partnerships. The facility uses state-of-the-art Instron testing machines, equipped with environmental chambers (-100ºC to 350ºC) and extensive non-destructive evaluation facilities, to characterise the performance and properties of a full range of novel composite materials and components for more than 30 clients, including Airbus, Rolls-Royce and BAE Systems.

But in the laboratories of the North West Composites Centre (NWCC) on Sackville Street the clatter of weaving looms continues; Manchester finds itself yet again at the centre of a weaving revolution.

From delicate cotton, specialist looms now weave super-tough carbon fibres, using both traditional patterns and new ones inspired by the latest textiles research within the School of Materials. These carbon fibre sheets will be infused with polymer resins and cured to create the very latest high-performance carbon fibre reinforced plastics (CFRPs).

CFRPs are composite material systems which combine the strength of the carbon fibres with the versatility and variety of different polymers. The synergy of these components produces materials that are stiffer, lighter and stronger than most traditional materials, including advanced aluminium alloys.

3D weave

Professor Constantinos Soutis, Director of NWCC, sweeps through the laboratories where rolls of black carbon fibre matting, called ply, contrast with the bright coloured yarns that once crammed the local warehouses. He points proudly to a strange looking device; a long black tube is being knitted together, threads of carbon protruding and winding around it from all directions. "This is our nine-axis robotic complex winding machine, developed here by my colleague Dr Prasad Potluri. It can produce 3D objects like pipelines and barrels with highly complex fibre architectures," he says as he pulls out another piece of pipework, this time in black and white. "We can even mix glass and carbon fibres together," he smiles. "We make components with unique properties that can withstand compression, stretching and shear stresses due to twisting forces."

Professor Soutis explains how more conventional Jacquard looms can also produce 3D weaves as they are programmed to stitch plies together. "We typically make composite materials from many thin layers or plies, 0.125 mm thick, each orientated to give the overall material its specific characteristics. To prevent these layers coming apart, or delaminating – a common problem – we are looking at how to stitch the ply together with carbon or glass fibre threads. Mathematical models help us to create specific weave architectures that can give the material a characteristic stress resistant profile, for example to withstand the twisting forces experienced by wind turbine and jet fan blades without delaminating."

Aircraft repair

As he often likes to do with the students around him, Professor Soutis now throws out a question: "Everyone from luxury car makers to aircraft manufacturers, are using composites for their strength and durability, but what do you do when the material is damaged?"

He elaborates on the problem, describing how the composite material of an aircraft may be dented or damaged by a clumsy mechanic or an unfortunate goose. Traditionally, the maintenance team can remove a damaged section of metal and simply rivet a new panel in place. "You can't do that with composites," Soutis points out. "They are incredibly hard to cut and you can't use rivets, since drilling holes damages fibres and hence weakens the structure. So what do you do?"

He pulls out the answer from his pocket: a small piece of blackish-grey plastic with some oval holes. "This is what we have done in the lab," he proclaims. "This really is the cutting edge of composite repair."

Cool lasers

The dull piece of plastic is a piece of aircraft composite. The holes have been cut with a powerful 'cool' laser, one of many at The University of Manchester. Research at NWCC has shown how a laser can precisely cut a shaped section from composite material with an extremely smooth, undamaged edge. The high power (400 W) short pulse laser prevents the composite material from heat damage which would normally lead to delamination.

The width of the cut is also so fine that new material will fit tightly within the hole. The same cool laser can even 'burn off' a single ply from the surface of a composite, making it possible to remove superficial damage and replace it with a small section of new 'skin'.

Wielding his plastic trophy, Professor Soutis talks about how ground crews at airports could use a laser on a robotic arm to cut out damaged material and slot in replacement 'patches'. "We'll put sensors across the join or between plies to monitor the integrity of the repair and provide maintenance staff with information on local stresses that can be used to estimate residual strength and fatigue life."

In just a few steps, Professor Soutis moves from Jacquard looms to robotic repairs. But this is the essence of NWCC, he exclaims: "We can take the most mundane of materials – simple plastics, basic carbon fibres – then bring them together in clever ways to create new materials and structural components with exciting, even spectacular thermo-mechanical and electrical properties and performance."

PROFESSOR CONSTANTINOS SOUTIS DIRECTOR NWCC

Professor Constantinos Soutis joined the University of Manchester as Director of the Northwest Composites Centre in October 2012. He has over 25 years of experience in working with composite structures and designs and an international reputation in the field of composites research.

Full of infectious enthusiasm for this rapidly developing field, Professor Soutis provides new vigour to NWCC as it builds its reputation for partnership and commercial research, especially in the automobile and aerospace sectors. A firm believer in open collaboration, he is strengthening the original NWCC partnership between The University of Manchester and the universities of Bolton, Lancaster, Liverpool and Glyndwr to provide industry and academia with local access to research expertise as well as the laboratory facilities and staff based in Manchester.

> FIND OUT MORE
futurecomposites.org.uk

EPS SUCCESS

Student Action wins award

James Gill, a final year Mathematics student has been nominated for a Volunteer of the Year award for his work with the Student Action Manchester's Conservation Club. Working with refugees, the weekly club provides opportunities for them to practise their English skills. Some of the refugees, who come from across three continents, have been in the UK for a number of years, others have arrived recently. James' role is to plan and lead the session and liaise with external organisations such as the national charity Student Action for Refugees.

The club has been running since January, and has seen a successful few months, with one of its volunteers, Egle Peleckaite, winning Student's Union Volunteer of the Year!

James said: "I was delighted to be commended at the University Awards. It is a great testament to the many wonderful volunteers I have worked with this year, and also the excellent support provided by the Students' Union, particularly Jack Burke, the outgoing Student Action Intern.

I have just finished my final year and I will be participating in Teach First's Leadership Development Programme this academic year, teaching mathematics at a secondary school in Bolton. I got involved with Student Action in my second year because I wanted to gain more teaching experience, and help those in need in our community."

Major New Innovation Programme for Cumbria with Innovus project

Ealier this year, Dalton Nuclear Institute was involved in the launch of Innovus - a brand new Cumbria based technology development programme focused on taking bright ideas in the field of technology and making them a commercial success.

A result of funding through Britain's Energy Coast and the Nuclear Decommissioning Authority, Innovus plans to encourage and support the connection of a 'bright idea' with a 'real need' in the marketplace. It will offer connections to market demand, access to world class facilities, funding, technical skills and business support through its key delivery partners, The University of Manchester and the National Nuclear Laboratory.

Kevin Warren, Commercial Director at The University of Manchester's Dalton Nuclear Institute said: "Innovus has evolved from a shared belief at the University and NNL that Cumbria has a unique research and development capability and the opportunity to use technology as a driver for significant economic growth".

In parallel with the main conference teams of local school pupils who were invited to take part in the 'Innovus Challenge'. Pupils competed in a series of 24 tough interactive challenges, which were specially organised for the day.

There was a rare opportunity for pupils to have a go on some of the world's most cutting-edge technological advancements, like the Brokk Simulator, which involved students constructing a virtual building, and Aquaball, an underwater robotics innovation. Many of the challenges at the event were borne out of ideas from research students or businesses and have gone on to solve 'real' business issues and needs within the marketplace - Innovus aims to support innovations just like these. It also has long term aspirations and aims to encourage and support innovation among the young people of Cumbria, to ensure a long term pipeline of talent and opportunity.

The Innovus programme is a key part of the plan and aims to connect individuals and small to medium sized enterprises (SME's) who have ideas, with end users, support and funding. The National Nuclear Laboratory and The University of Manchester, both run highly successful technology commercialisation programmes of this nature. Since 2004, The University of Manchester has seen 2,300 invention disclosures, 30 new start up companies, 310 licence deals, 120 projects financed and over £55 million generated by Intellectual Property Enterprises. The aim is to capitalise on this experience, track record and high profile.

Teams of local school pupils took the 'Innovus Challenge' – a series of 24 tough interactive challenges including building a hydro car.

Nuclear funding awards for Dalton Nuclear Institute

Business Secretary Vince Cable announced major new funding awards in March, which will enhance the supply chain and increase commercial opportunities for new technologies in the civil nuclear sector.

The announcement has been made alongside the publication of the government's nuclear industrial strategy, which sets out the objectives to develop a strong and sustainable nuclear industry in the UK.

The Dalton Nuclear Institute (DNI) has been granted seven awards in the announcement, which will be used to support the development of new technologies for the construction, operation and decommissioning of nuclear power plants. The projects will see the University working alongside innovative small to medium sized enterprises and other institutions.

The funding comes from a coordinated R&D competition co-funded by the Technology Strategy Board with the Department for Energy and Climate Change (DECC), the Nuclear Decommissioning Authority (NDA) and the Engineering and Physical Sciences Research Council (EPSRC).

The Dalton Nuclear Institute was awarded three Knowledge Transfer Partnerships (KTPs) which, when added to industry contributions, is worth around £500K, as well as four large-scale R&D projects, with a total value of around £6 million including industry contributions.

The KTPs awarded to the University include: a partnership with BEP Surface Technology Ltd and the School of Materials on copper electroplating and electrodeposited layers for high-level nuclear waste containment; a partnership with Heat Trace and the School of Electrical and Electronic Engineering to develop trace heating products for the nuclear industry; and a partnership with M Wright and Sons Ltd and the School of Materials to develop a design methodology to relate weaving patterns and aspect ratios to mechanical performance for structural 3D composites.

The successful R&D research projects with the School of Mechanical, Aerospace and Civil Engineering include: three separate partnerships with EDF Energy R&D on 'Fracture of Graphite Fuel Bricks', 'Environmental Impact on the Structural Integrity of Nuclear Components', and 'The Influence of Graphite Irradiation Creep on Plant Life Optimisation' which will help provide support for the next generation graphite moderated plant; and a partnership with Bradtec Decon Technologies Ltd called 'Treatment of Irradiated Graphite – 'From Core to Capture' which will explore a new and innovative method of graphite management by converting graphite to carbon dioxide gas for carbon capture and storage.

Minister for Universities and Science David Willetts said: "The Technology Strategy Board is playing a vital role in making sure innovative SMEs across the UK can bridge the valley of death between the research stage and the market place. These businesses are setting the pace for others to follow and making sure the UK stays at the front of the global race for technology and innovation in the nuclear industry."

> FIND OUT MORE
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Quantum challenge

"Academia has to work in a way that responds to the needs of industry."

Professor Melissa Denecke took up her position as Co-Director of the Dalton Nuclear Institute in July 2013, where she will work alongside Professor Andrew Sherry to strengthen the delivery of the UK's new nuclear R&D strategy and skills development programmes. She is internationally renowned for her work around actinide speciation on a molecular scale, and an expert in the application of synchrotron-based x-ray to such investigations. We spoke to her about her passion for nuclear research, and where she sees the future of UK nuclear research and development.

What attracted Melissa to the role at the Institute? "On a global scale Manchester is an excellent University, and I have already had the fortune to work on some successful collaborations with academics from the Dalton Nuclear Institute. When paired with the current positive political stance in nuclear research in the UK, I didn't hesitate to apply for the role".

Melissa began her academic career with a masters and PhD on systems with 4f elements from the periodic system, but moved to 5f elements (actinide series of the elements; the f block elements at the bottom of the periodic table which includes uranium and plutonium) after she secured a postdoctoral job. "I found 5f element research very exciting as there's so much that is unknown; it's exciting as there's lots of room for discovery and for impacting on society and sustainable energy which makes it a gratifying place to be. It was a departure from what I had done up to that point; interesting research themes can attract people that don't necessarily come from the nuclear sector. Young people come from different themes and their knowledge adds something to the mix."

A key aspect of Professor Denecke's role will be to enhance the Institute's already strong industrial partnerships. "Coming from Europe I am looking forward to meeting the movers and shakers in industry, and my calendar is already full. Co-operation between industry and academia is paramount as we have quite a challenge on our hands in the future to meet the urgent needs of government and industry, and to educate a sustainable and responsible workforce. Academia has to work in a way so as to respond to the needs of industry, and industry must be in a position, with the help of research, to be able to define those needs. I believe my role will be to facilitate that exchange of information".

What is Melissa most looking forward to? "My previous role at the Karlsruhe Institute of Technology in Germany was method development, so facing new challenges is what I do. I like the idea of having a leadership role, but I'm also excited about teaching and combined research; I believe I have the best of both worlds. I hope to make a mark and increase the Institute's international profile, and I hope my international experience will add to the Institute's already world-class reputation".

When asked about the future of nuclear research, Melissa is clear "It's important to have a fuller understanding of the 5f elements in the nuclear fuel cycle and electronic structures in order to predict their reactivity and behaviour in different contexts; industrial nuclear aspects through to waste disposal and contamination legacy. The heavier elements are difficult to model with quantum chemical tools, so it's important to be able to provide spectroscopic data as a driving force in this understanding, and fine tuning the tools of quantum chemical calculations is imperative. Those kinds of themes often attract the best students, and they will become the future academic and industrial leaders of tomorrow".

Finally we asked about being a woman in a man's world; is that the case? "I hope I am a role model for young women who are embarking on a career in nuclear research. I have just left a department where a female researcher said she was disappointed not to be working with me anymore because it was the first time she had ever had a female boss. That makes me feel good".

> FIND OUT MORE
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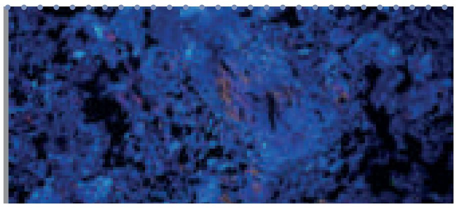


State-of-the-art Multidisciplinary Characterisation Facility gets the green light

£18 million funding from the UK Research Partnership Investment Fund has been secured to set up the new facility which will focus on the UK's strategic development in advanced materials and manufacturing and will provide the necessary expertise to accelerate innovation from the laboratory to market.

This will be supported by an additional inward 10-year investment of more than £100 million from founding partners BP plc; Rolls-Royce; AMEC; Sellafield; NNL; FEI Company; Xradia; Rapiscan Systems; AREVA; Westinghouse; EDF; and TISICS.

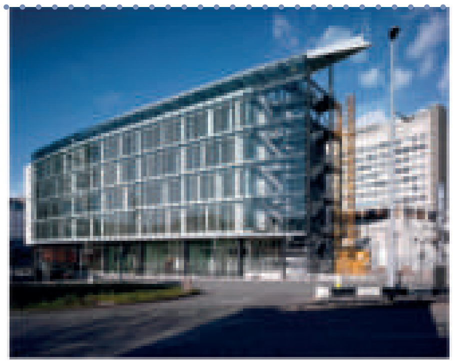
The facility will support research and development into advanced materials, which underpins all manufacturing sectors, and is essential to UK economic growth. Currently, UK businesses that depend on the production and processing of materials represent 15% of the UK's GDP, have a turnover of approximately £170 billion and have exports valued at £50 billion.

The facility will be operational by 2014 and will provide the North West and the UK with a distinct advantage in the global research and development into advanced materials and manufacturing, which is vital to socio-economic improvement.

Vice President and Dean of the Faculty of Engineering and Physical Sciences, Professor Colin Bailey, said: "We are delighted to be awarded £18 million from the UK Research Partnership Investment Fund, which will allow us to obtain the required infrastructure to fully utilise the current expertise at Manchester in advanced materials and manufacturing.

"Working with existing and new industrial partners we will be able to accelerate innovation from the laboratory to market which will be of long-term benefit to the North West and the UK economy more widely."

The Chancellor of the Exchequer said: "By bringing together our Nobel Prize winning scientists, our world-class companies and our entrepreneurial start-ups, we can drive innovation and create the economic dynamism Britain needs to win in the global race."



Idea to industry; collaboration key in multi-million pound project

CHEM21, Europe's largest public-private partnership dedicated to the development of manufacturing sustainable pharmaceuticals was launched at the end of 2012. Led by The University of Manchester and GlaxoSmithKline the €26.4 million (£21.2 million) project brings together six pharmaceutical companies, 13 Universities and four SMEs from across Europe.

The aim of the partnership is to develop sustainable biological and chemical alternatives to finite materials, such as precious metals, which are currently used as catalysts in the manufacture of medicines. Plans are in place to introduce biotechnology to the manufacturing processes for medicines, limiting the drain on the world's resources and benefitting the environment long term.

CHEM21 will run for four years initially, with funding from the Innovative Medicines Initiative. The project will establish a European research hub to act as a source of up-to-date information on green chemistry, as well as developing training packages to ensure that the principles of sustainable manufacturing are passed on to future scientists.

Professor Nicholas Turner from The University of Manchester commented "This is a unique opportunity for academic groups to work alongside pharmaceutical companies and specialist SMEs to develop innovative catalytic processes for pharmaceutical synthesis. We believe that challenging problems of this nature are best solved on a pan-European basis by bringing together, under one roof, the combined expertise of many groups to establish a world-class research hub in catalysis and sustainable chemical synthesis."

John Baldoni from GlaxoSmithKline said: "Improving the sustainability of our drug manufacturing processes through collaborations such as CHEM21 will not only reduce our industry's carbon footprint, but will provide savings that can be reinvested in the development of new medicines, increase access to medicines through cost reduction and drive innovations that will simplify and transform our manufacturing paradigm"

www.chem21.leeds.ac.uk

New Jodrell Bank Orrery

The University of Manchester's Jodrell Bank Discovery Centre has recently showcased its newest exhibit – a unique mechanical orrery.

The Jodrell Bank orrery is a five metre in diameter moving model of the Solar System which is believed to be the largest of its kind in the world. The intricate work includes a complex system of 52 brass gears that ensure that the planets orbit around the Sun at exactly the right rate in relation to each other.

It was recently installed in the Discovery Centre's Planet Pavillion, and the hands-on exhibit can be driven by a large winding handle, allowing visitors to orchestrate the motion of the planets themselves.

Dr Teresa Anderson, Director of the Jodrell Bank Discovery Centre, said: "We've been planning this exhibit for almost two years so it's wonderful now to see it in place. It's completely bespoke and unique to Jodrell Bank and gives visitors the opportunity to interact with some of the UK's finest precision engineering and craftsmanship first hand."

Dr Tim O'Brien, Associate Director of the Jodrell Bank Observatory, added: "This is one of those rare occasions when doing lots of calculations results in the creation of something that is immediately appealing to everyone, regardless of their level of familiarity with physics. It's a handsome piece of engineering."

EPS SUCCESS

MBE for Teresa Anderson

Dr Teresa Anderson, Director of Jodrell Bank's Discovery Centre, was awarded an MBE in this year's Queen's birthday honours.

Teresa is Director of the Discovery Centre at the Jodrell Bank Observatory. The Discovery Centre opened two years ago and has been a huge hit with visitors to the famous Observatory in Cheshire, inspiring the next generation of astronomers, physicists and perhaps even astronauts.

She said: "I'm delighted and honoured to be awarded a MBE. The Discovery Centre has been open for just over two years now and has gone from strength to strength. Our core aim is to inspire the scientists of the future and, as the Director of the Centre, I'm immensely proud of what we have achieved in such a short period of time.

"The Centre has a wonderful set of exhibitions and a vibrant education programme that aims to reach out to the widest possible audience, especially local schools in our most disadvantaged communities. We already attract 15,000 school pupils each year and I'm incredibly proud of the team. This honour is for all of them who help enthuse our young visitors."

Defying definition

Professor Douglas Kell is EPSRC/RSC Research Chair in Bioanalytical Sciences, in the School of Chemistry and The Manchester Institute of Biotechnology, as well as serving for five years as Chief Executive of the Biotechnology and Biological Sciences Research Council (BBSRC). Last November he was named a Fellow of the American Association for the Advancement of Science (AAAS).

Professor Douglas Kell describes himself as a "biologist in a chemistry department who does computing".

Professor Kell began his career as a biochemist, but insists he's a "biologist in a chemistry department who does computing". His current research focuses on a number of areas, including mapping human metabolism and exploiting that knowledge for health and in disease, and here he discusses his work on the development and application of novel analytical methods to solve complex biological challenges.

"In 2000 the human genome was mapped (final version in 2003) and that massive breakthrough tells us about the potential of what is there in terms of genes; but it doesn't tell us about what they do. Some of our genes are involved in metabolic pathways – the business end of biochemistry – where nutrients go, how we are able to do all the things we do and, if you are a plant or an animal, the significance of that for agriculture.

"In the case of humans most diseases are a result of something going wrong in the metabolism of the cell, and yet in order to understand what processes are happening we need to make a model. An engineer would do so when designing a bridge or a car; in parallel to any measurements (and usually instead of or beforehand) they make a mathematical model to see what works, what is robust, what will break, how it does so, and what solution they can find to inherent problems; in short to understand how it performs and will behave.

"In engineering and physics it's standard to make a model as the problem is complicated, and difficult to understand. Famously the Boeing 777 was designed entirely in a computer before it went anywhere near a wind tunnel, let alone into the air. Historically, biologists haven't used models for many reasons including the prevailing culture and a lack of engineering process mindedness. We wanted to produce a wiring diagram and an engineering model of the metabolic network encoded by the human genome, and because it's large – more than 7,000 reactions – we enlisted a large community. We had already done this with baker's yeast, so we knew how to make it work.

"We applied the same 'trick' which involves partly automating the process – reading from a genome what a gene is likely to do – and if it's a particular reaction we listed that reaction. This gives us a computerised way of describing networks; XML – a markup language that can describe in a formal sense the content of a file or document, which can be read by other software. We made all of these networks available in a flavour of XML called the Systems Biology Markup Language (SBML) so others – and many pieces of software developed for this purpose – can read and write it in SBML.

"Accurate testing now becomes possible, and we can make hypothetical statements such as 'If we knock this gene out this bad thing would happen' using inborn errors of metabolism, so we can predict all of the inborn errors of metabolism. In addition we wanted to see if we made pathways that were connected in some sense, rather than have isolated reactions.

"Having the metabolic network will allow us to ask all kinds of questions about how things vary between individuals, tissues, how things such as drugs move around the body, and essentially to allow anyone to ask questions (such as the mode of action of particular drugs) through standardised processes.

"We also wanted to test how these reactions differed between different tissues; since we can actually measure in tissues which proteins are expressed at different levels, we looked at that too.

"One main area of interest, and of application, is medical; understanding what happens in a normal state and

“In synthetic biology, you make an organism that contains particular genes that you have synthesised, and ask it to perform certain tasks. All of the problems we face are essentially computational problems, and it is the job of the modern biologist to make use of that fact.”

what happens when things go wrong. Currently, for example, to diagnose a disease such as diabetes, clinicians would measure glucose levels. If it’s high, the patient probably has diabetes. However, of the several thousand metabolites that exist only about 20 are ever measured routinely in hospitals, so we are missing a huge trick as we could be measuring for all sorts of things to ascertain what has gone wrong when someone is suffering from a disease. This would also increase scientific understanding of diseases in older life and how to avoid them through diet and lifestyle, which is a hot topic.

“Since most diseases are diseases of old age, understanding why some people manage to retain their health is an important issue.”

“Longevity is increasing by five hours a day, on average, which is good news for us, but bad news for the pensions industry. Since most diseases are diseases of old age, understanding why some people manage to retain their health is an important issue. Clearly metabolism is an important part of that, and we need to know more about what happens at a real metabolic level.

“We use various types of software to interrogate the model, and thereby solve what is known as the inverse problem; what we would normally do is to measure the variables (those things such as metabolite concentrations and fluxes) that actually vary, but what we want to know is which parameters (such as enzyme activities) actually change and cause the changes in the variables. With specialist software we can do this.

“With many organisms, not just humans but here we are looking at microbes such as yeast, we can play in vitro and say ‘I want this organism to make a large batch of an interesting industrial product, say an amino acid’ and we can run the model, changing various things to see what we have to change in order to be productive. The number of experiments needed is then tiny compared to the number you could potentially perform, which is gigantic. This opens doors for industrial applications, and we are currently in talks with a variety of industrial collaborators.”

Collaboration is an important aspect of the work Professor Kell and his team carry out, and in their most recent paper in Nature Biotechnol there were 51 authors, of whom 12 were from The University of Manchester. “Most are from the Manchester Institute of Biotechnology, whose remit is precisely to facilitate this kind of multidisciplinary work; to bring the methods of engineering and physical sciences, including maths and computation, to attack complex biological problems.

“This joined-up way of thinking and application is vital. All cutting edge research is, by definition, at the edges of a subject. One of the most interesting topics currently is synthetic biology, where you make an organism that contains particular genes that you have synthesised, and ask it to perform certain tasks. The tasks could be relevant to materials, so require materials science input, some are drugs so pharmaceuticals experts are needed, or some may be related to enzymes, so this requires biologists and chemists. All of the problems we face are essentially computational problems, and it is the job of the modern biologist to make use of that fact. We are fortunate that e-science is pretty cutting edge here at Manchester.”

> FIND OUT MORE
http://dbkgroup.org/

“Manchester Institute of Biotechnology, brings together the methods of engineering and physical sciences, including maths and computation, to attack complex biological problems.”

Mexico - making its mark on Manchester

Launched four years ago with eleven students from Mexico City, the Latin American Postgraduate Programme (LAPP) now welcomes over a hundred PhD students to Manchester. LAPP Director Professor Teresa Alonso Rasgado reflects on how her small idea has blossomed...

I've always tried to facilitate students from home coming to my research group to do PhDs. But a few years ago I wondered whether we could formalise an agreement. Colin Bailey, then Head of the School of Mechanical, Aerospace and Civil Engineering (MACE), was very supportive. We very quickly signed a three-way agreement between MACE, the National Polytechnic Institute (IPN) in Mexico City and the Mexican National Council for Science and Technology (CONACyT).

It was one of those agreements where everyone gave something and everyone had a lot to benefit. Manchester offered part scholarships and committed to fully supporting these Mexican students through their research studies. CONACyT provided full funding for four years covering all fees, travel and a living allowance. Their investment meant the country would receive back highly trained, knowledgeable researchers in new areas of engineering and physical sciences – people who could support Mexico's economic growth and development through R&D and innovation. Finally IPN promised to send the very best students, who would be selected on a competitive basis.

I quickly realised that this set up offered huge benefits for everyone. Within six months of launching the programme, we opened it up to all universities in Mexico and all Schools in EPS. We've been running for almost four years. We had 11 students at the start; we now have over a hundred and will welcome over 20 new students to the Faculty during the next academic year."

The structure of the programme and its clear success has provided a blueprint for internationalisation for others. Representing CONACyT, I have negotiated similar CONACyT-funded PhD programmes for Mexican students with more than 20 other universities in the UK. Manchester has pioneered the approach and our programme now embraces other countries in Latin America. We've signed virtually identical agreements with the research funding bodies and universities in Brazil, Chile and the Organization of American States (OAS) which represents all 35 independent countries of North and South America.

Supporting success

The amazing success of this programme boils down to the support we give to the students and the excellence of the supervisors. We also have a dedicated team based at The University of Manchester which deals with all the paperwork and liaises with all the school administrators, who have also provided wonderful support to the programme and its students. They are always on hand to deal with student enquiries.

Basically, we hold their hands and guide them through the entire process. The Vice President and Dean, Colin Bailey, and I travel to Mexico about twice a year, visiting the funding bodies and the universities to promote the scheme and meet with students. We tell the students how to apply and take them through the CONACyT paperwork to obtain the funding, help with visa applications, etc. In addition to this, I make frequent additional trips throughout the year to ensure the excellent relationships we have built up with Mexico remain strong.

We know that students must be happy to succeed. So we ask the LAPP students to submit a report every six months and we meet with them every four months or so to monitor their progress, and pick up on any issues. And every student knows that if they have any problems they can come and talk to me.

Culture shock is unavoidable. I often have people at my door missing home, their family, their friends. I listen to them, talk to them, help them. 'Give it a bit longer, you'll get used to the change,' I advise. After six months they are happy and settled.

With no dropouts in the first three years CONACyT once asked me whether I was making up the numbers! But this is reality: our students are happy and they make great progress in their research. More than half of the students on the programme so far have had papers published and

we've had nine prize winners. It is clear the students are thriving here – and their supervisors keep asking for more students like them!

The supervisors are excellent. They appreciate having skilled, motivated, resourceful and enthusiastic PhD students in their research groups. They provide key support for their studies and research, but also on a personal level, ensuring that they feel comfortable and at home. We couldn't run this programme – I couldn't do my job – without such excellent supervisors.

Motivation

The first students – those 11 pioneers – will complete their PhDs in bioengineering this year so I'm really excited. It will be the culmination of four years hard work for them and the fruits of all the input, support and negotiation from me and my team. All of the students from IPN have been given the option of taking up an academic position there upon completion of their PhD. They will return to Mexico as leaders in their field, building capacity for the country and raising its competitive position in R&D. I'm proud to have helped to create this opportunity. As one chapter closes another begins, and I am looking forward to receiving a new generation of PhD students in my bioengineering research group in the School of Materials.

> FIND OUT MORE

about the LAPP

teresa.rasgado@manchester.ac.uk

CASE STUDY

Tania Sanchez Monroy First year PhD in Bioengineering

"I've always been interested in biomechanics and bioengineering. A professor in Mexico with whom I was working told me about Professor Teresa Alonso and her research group in Manchester. Fortunately, she had projects which matched perfectly with what I wanted to do. At that time I was also looking at PhDs in Mexico and the United States, but they were all more focused on bioelectronics and image processing rather than joint engineering and rehabilitation; the Manchester project was perfect for me.

"Although I've spent time abroad before, I still experienced a big culture shock. When you arrive you know no-one, so your mentor, Teresa and the admin staff on the programme are a very welcome back-up – people you can turn to for help. Through LAPP I've met other Mexicans, so I haven't felt homesick. Now after six months I've also made some good British friends.

"For me, being in Manchester is all about my research. I'm working a lot and learning a lot and taking every opportunity to extend my knowledge.

"When I finish here I may carry on with research related to joint rehabilitation and orthopaedic devices, or even set up a business related to bioengineering. There's a real lack of technology, knowledge and research in rehabilitation in Mexico so this would be a good field to work in."

CASE STUDY

Edson Garduno Nolasco Third year PhD research on intermediate band solar cells

"I had already decided I wanted to do a PhD in Europe. I had options in France and Germany, but I went to a presentation by Teresa about the CONACyT programme with The University of Manchester. I saw the research project that I chose as my chance to do something new, something really state of the art. No-one was doing research like this in Mexico.

"I still felt nervous about coming to Manchester. I was going to the unknown, starting research in a field of applied physics that was completely new to me. But the programme and my mentor made everything very clear and it was easy to settle in – even if the weather and all the rain was a real shock! My supervisor, Professor Missous, gave me all the necessary material to start my research and made me feel very welcome. I had to adapt but I'm very happy here. All I've had to worry about is my research.

"All the conferences here have been a big highlight for me. I've had lots of contact with the European research community in my field which has really helped me to develop.

"The facilities are excellent too; the microelectronics and materials lab is an integrated facility that covers every stage of materials science from synthesis to device design and fabrication and finally testing. This is unique because researchers have control over the entire research flow; this helps enormously to come up with and test innovative ideas very quickly. There are very few institutions in either the UK or Europe that offer this flexibility. It has opened my mind to completely new avenues and ideas.

"Nanoelectronics and microstructures are really a new area of research for Mexico, but I've learned about design, fabrication and characterisation. My university in Mexico has just opened a new nanostructure facility, so this looks like a good opportunity for me when I go back home in a year's time."

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