



The research commercialisation office of the University of Oxford, previously called **Isis Innovation**, has been renamed **Oxford University Innovation**

All documents and other materials will be updated accordingly.
In the meantime the remaining content of this Isis Innovation document is still valid.

URLs beginning www.isis-innovation.com/... are automatically redirected to our new domain, www.innovation.ox.ac.uk/...

Phone numbers and email addresses for individual members of staff are unchanged

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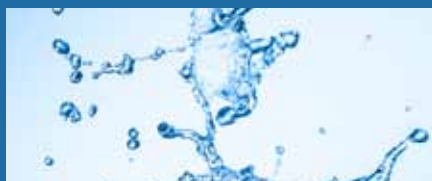


VITAL SIGNS

Early detection
and monitoring
applications



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14 A new approach to removing pollutants from water



20 Will automation replace humans in the workplace?

The latest innovations, collaborations and technology transfer



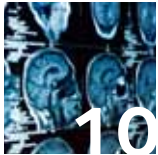
Isis
INNOVATION



Issue 80
Summer 2015

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Isis Innovation is the research and technology commercialisation company of the University of Oxford.

NEWS

Spin-out successes

Several Oxford University companies created through Isis Innovation announced funding rounds, including **Oxford PV** (£8m Series B funding) and **Onfido** (\$4.5m Series A funding).

Oxehealth reported successful trials of its baby monitoring software, demonstrated in the neonatal intensive care unit of the John Radcliffe Hospital. **Oxbotica** will provide control systems for 40 autonomous pods as part of the UK Government's multi-million pound driverless car challenge. **Oxford Biotrans**, a 2013 spin-out, announced enzyme technology that can generate commercial quantities of nookatone, which gives grapefruit its distinctive flavour, using entirely natural processes. **Nightstar** achieved has received both U.S. FDA and European Medicines Agency (EMA) Orphan Drug Designation for its lead programme, a gene therapy to treat blindness caused by Choroideremia.



Grapefruit flavouring from Oxford Biotrans

Spin-out company financing

Oxford Sciences Innovation plc (OSI), a new investment company, has been formed to back and support spin-outs from Oxford's Mathematical, Physical, Life Sciences and Medical Sciences Divisions. The £320m fund is the world's largest university venturing fund and is backed by Invesco, IP Group, Lansdowne Partners, Oxford University Endowment Fund, the Wellcome Trust, Woodford Investment Management, Google Ventures and Charles Dunstone.

Tom Hockaday, Isis Innovation CEO, says, "We have already started discussing the first investments with OSI, who are working in an inclusive manner with our existing investor community, recognising the importance of all those involved in supporting the Oxford innovation community."

Queen's Award for Isis Enterprise

Technology and innovation management consultancy Isis Enterprise has won a 2015 Queen's Award for Enterprise, International Trade. The award recognises Isis Enterprise's growth into a £2.8m business with over 88 per cent of its revenue coming from working with clients outside the UK.



Working with our peers

We published two briefing papers with colleagues in the Technology Transfer Offices of five other research-intensive UK universities. Intended to shed light on the complexities and driving forces behind university technology transfer, both "UK Technology Transfer: behind the headlines" and "Golden Shares & Anti-dilution Provisions" can be downloaded from our website.

We are moving

After fifteen years in Ewert House, Isis Innovation is moving to newly renovated offices off Botley Road, on the west side of Oxford. Our new address, from 3rd August, will be:

**Isis Innovation Ltd.,
Buxton Court,
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All other contact details are unchanged.

The portfolio

The latest **spin-out** and **investment** news

Get the most out of your image collection

Capable of sorting and filtering over 100,000 images in real-time, Zegami is a data visualisation tool set that allows users to view large collections of images and associated metadata in a single field of view. Although similar technologies exist within the market place, all are limited in their commercial application and usability. Zegami has been built utilising cutting edge web technologies. It is designed as a practical and visually intuitive way to sort, search and filter large amounts of image data that is truly dynamic and unique.

The visual search tool

The real beauty of Zegami is that it easily lends itself to just about every type of industry today, from image rich social media to high throughput microscopy image management and analysis.

The aim of the company is to sell, market, develop and support the application in conjunction with our implementation partners, globally. The company will develop a platform from which specific industry verticals and products can be created.

Over the next 5 years, the company plans to go from an Oxford start-up with a MVP (Minimal Viable Product) to a company with a presence globally. The product can be the standard for image collection visualisation software and establish sustainable revenues in the tens of millions.

Aid with machine learning

Generally Zegami will be a product that compliments or enhances an organisation's database usability. There are currently limited product offerings that allow users to display information from multiple data sources in one clean clear and concise user interface.

Aside from the product opportunities, Zegami provides an amazing business opportunity in that the business can



continually innovate and evolve as Zegami itself evolves.

Filter, sort and group

With the increasing need to manage growing collections of images and the lack of adequate tools, Zegami is uniquely positioned to become a leader in the market. Zegami is based on the most recent browser technology which has only become widespread in the last 1–2 years. Previous versions lacked the platform and structure to support modern browsers and large collection sizes.

Zegami addresses all of the limitations of the previous software and yet provides so much more application with its plugin model architecture.

With limited competition in the market, Zegami can complement other business intelligence tools (BI) and reporting solutions. Zegami is in a prime spot to capitalise on this niche. We are keen to engage with partners to refine the sales and implementation pipeline.

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Improving healthcare through innovation

Shanghai RAAS is the leading blood products company in China. The company recently joined the Oxford Innovation Society with the aim of strengthening commitment to innovation and developing new ties in Oxford and globally

Shanghai RAAS's global innovation team is keen to connect with university researchers as well as industrial partners. The company is well established in China and is gaining global recognition. Over the last 27 years the company has grown to expand interests and markets.

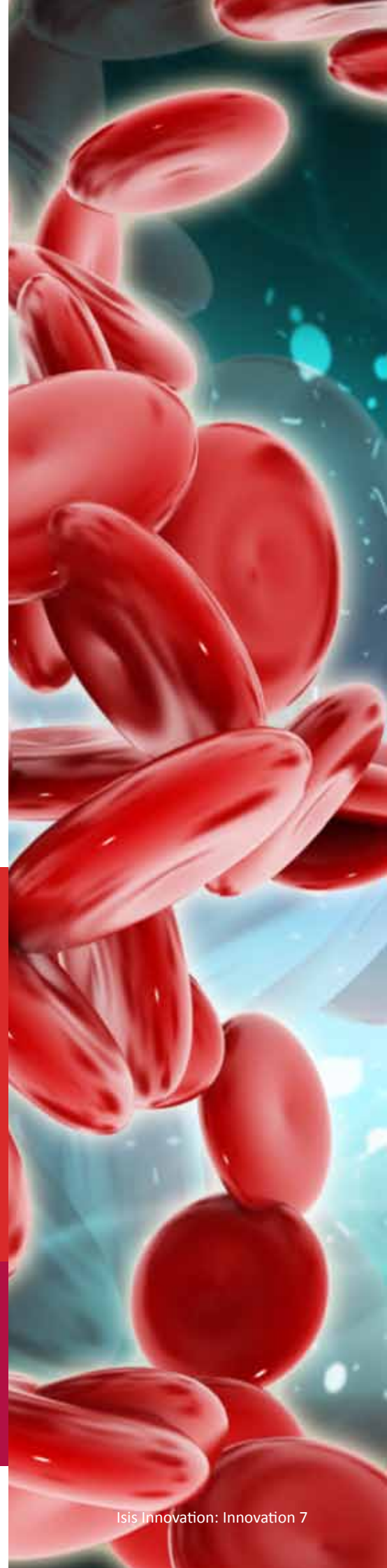
Shanghai RAAS was the first Sino-American joint venture to manufacture plasma-derived products in China, established in Shanghai in October 1988. In 2007, Shanghai RAAS was transformed into a limited share-holding company. In June 2008, the company was listed on the Small and Medium Sized Enterprises Board of Shenzhen Stock Exchange. In 2014, Shanghai RAAS acquired 100% of Zhengzhou BangHe Biological Pharmaceutical co., Ltd. and nearly 90% of Anhui TONROL Biological Pharmaceutical co., Ltd. as its subsidiaries. Zhengzhou Banghe Biological Pharmaceutical's line of business includes the production of bacterial and viral vaccines, toxoids, and analogous products.

Complete management system

The Company's main products include human albumin and human

immunoglobulin for intravenous injection, as well as human coagulation factor, human prothrombin complex, human fibrinogen, human thrombin and human fibrin sealant, among others. Since the establishment of the organisation, over 25 million vials of their products have been used and there is no single viral contamination reported or any adverse reactions due to the quality of product. Shanghai RAAS has maintained its position in the high-end blood products market due to its reputation of "Safety, Quality, and Efficacy".

Shanghai RAAS has 28 plasma collection stations across China with a plasma collection capacity of 900 tons, making it the Chinese blood product leader. Shanghai RAAS has developed a complete management system for the collection and screening of raw plasma, as well as the manufacturing process for blood products, which strictly follows Chinese Pharmacopoeia and current GMP regulations from SFDA, and also refers to the guidelines from FDA, EMA and WHO. In addition to the Chinese market, Shanghai RAAS products have been registered in over 20 foreign countries. Currently, Shanghai RAAS is one of the very few



domestic manufacturers that are able to export blood products with enduring brand recognition.

Future development

In order to fulfill new development goals and meet the new GMP standards, Shanghai RAAS invested in a new plant in Feng Xian Economic Zone. In April 2013 the company started trial production. In November 2013, Shanghai RAAS obtained GMP certification and started formal production. The new plant is equipped with well-designed production lines and state-of-the-art technology.

Competitive products, excellent personnel, and unwavering commitment to market demand have been key to the company's success. Shanghai RAAS feel that research and innovation will help them continue to grow globally. The company are constantly on the lookout for exciting new ways in which they can improve healthcare. Shanghai RAAS see their new ties with Oxford as part of those efforts and are open to new opportunities.

“Shanghai RAAS has a plasma collection capacity of 900 tons, making it the Chinese blood product leader”

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Industrial aspects of cutting-edge diamond science and technology

For over 50 years Element Six, a DeBeers Group Company, has been at the forefront of industrial diamond synthesis and technology.

Dr Chris Wort describes the company's products and techniques at a recent Oxford Innovation Society event

Synthetic diamond first synthesised in the 1950s, diamond grit was subsequently commercialised by Element Six in 1960, using High Pressure High Temperature (HPHT) presses. Element Six was also able to use novel HPHT technology combined with clever high pressure crystallisation chemistries to then synthesise cubic boron nitride (CBN), second only to diamond in terms of hardness, and large diameter polycrystalline diamond (PCD) ceramics that opened up new precision tooling applications. PCD materials are now commonly used as rock "cutters" for the oil and gas (O&G) industry, now a \$0.6B market. Element Six is recognised as the innovation leader in the field of "super-materials" and synthesis technologies consolidating its extensive R&D activities into the Global Innovation Centre (GIC) based at Harwell, Oxfordshire.

High Pressure High Temperature technology

In order to synthesise diamond in the region of its thermodynamic stability, (graphite is the stable phase of carbon at room conditions) it is necessary to maintain pressures in excess of 5GPa to allow crystallisation of diamond at temperatures circa. 1500°C. The Berman-Simon diagram (Figure1) is used to determine what pressure is required to maintain temperature without diamond graphitising.

To achieve such pressures and temperatures (the equivalent of an

inverted Eifel tower pressing on a soft drink can and melt steel), Element Six developed a novel "Belt Press" technology where steel belts confined and compressed tungsten carbide (WC) "dies" allowing the extreme pressures required to synthesise diamond. Over the period of 50 years, belt presses have allowed >75mm diameter PCD discs to be fabricated in a single press run. Such discs can be subsequently cut and shaped into precision tools or O&G cutters (which are typically 15-20mm in diameter). Element Six also employs an alternative press technology called a "cubic press". This differs from a belt press in that rather than constraining the pressure within a capsule using massive steel and carbide die sets with the pressure applied in one axis, the cubic presses apply the pressure along three axes. Cubic presses can achieve higher pressures hence higher reaction temperatures but cannot realise the same reaction volume.

Polycrystalline Diamond (PCD) fabrication and applications

HPHT presses can be used to liquid phase sinter diamond particles into a congruous, well intergrown ceramic. To do this, diamond micron powders are placed in a container on top of a WC/Co substrate and returned to the HPHT system. The pressure is then raised to >5GPa, effectively "cold compacting" the powders to a reasonably dense body. The temperature is next increased to >1500°C (further compacting the diamond body, causing graphitisation within the body). At around 1600°C, the

INTRODUCING THE BERMAN SIMON LINE

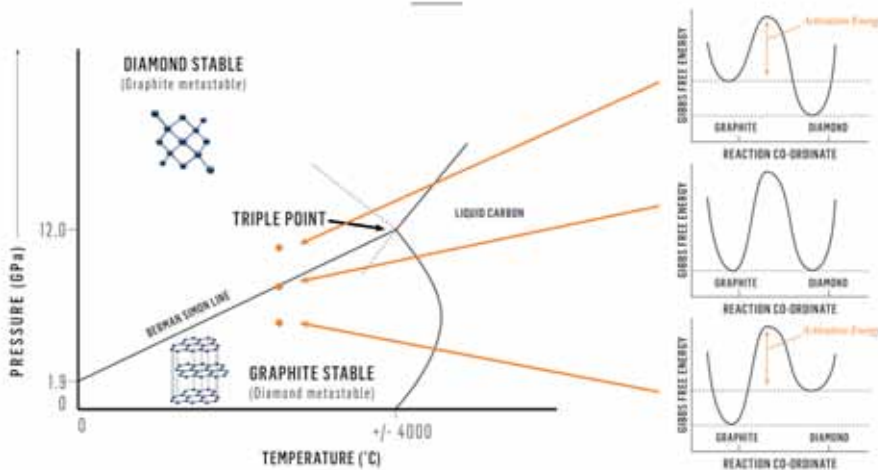


Figure 1. The Berman-Simon diagram showing the region of diamond stability

WHAT IS POLYCRYSTALLINE DIAMOND SINTERING?

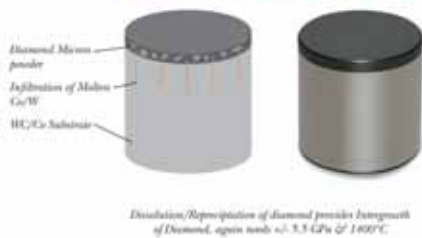


Figure 2. Schematic showing the liquid phase sintering of PCD and a processed O&G cutter

cobalt from the WC/Co diffuses into the compacted diamond body dissolving some of the finer diamond and graphite as the cobalt passes through the body. The saturated cobalt then redeposit new diamonds onto the surfaces of the original diamond and sinters the diamond into a dense, intergrown ceramic. Figure 2 shows this schematically and a photograph of a sintered and processed O&G cutter.

PCD uses in the Oil and Gas Industry

Prior to the mid 2000's, oil and gas drilling was performed using WC "roller-cone" technology. However, in the mid 2000's, roller-cones were rapidly displaced by fixed-head drill-bits employing PCD cutters as these allowed rig operators to drill faster, longer and deeper than previously possible. Today the O&G cutter market is highly competitive as the rig owners want as much up-time as possible to reach reserves at ever increasing depths. Element Six needs to innovate on a short time-scale to stay ahead of the competition. As users in the O&G industry become more familiar with the outstanding performance possible with

ELEMENT SIX OIL & GAS

A complete supermaterials product offering

DRILLING/ CUTTING INSERTS



CHUCKS AND DRILLS

- Chucks
- Drills
- Reamers
- Turns

SLEEVES & RINGS

FRICITION STIR WELDING

SENSORS & DETECTORS

WATER TREATMENT

CUSTOMISED PRODUCTS



Figure 3. Element Six offer a complete range of supermaterials for O&G applications

well sintered PCD, new applications within the industry are becoming established. Some of these are shown in as a schematic in Figure 3.

Future Development

The Industrial diamond business has evolved over the past 50 years from small volumes of grit, through materials optimised for the precision machining of wood, metals and new advanced materials. This has only been possible through innovative R&D and production technologies. Element Six has established a world class Innovation Centre based at Harwell in Oxfordshire, dedicated to all aspects of supermaterial technology, from advanced numerical modelling, through synthesis and processing techniques and on to application testing for customers.

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Faster functional MRI

Dr Gareth Smith describes techniques for the acceleration of functional MRIs after (fMRI) data acquisition using matrix completion methods

Functional MRI (fMRI) has become a widely used tool for imaging studies of the human brain. It does not require a contrast agent injection and does not expose patients to ionising radiation. Imaging is achieved using conventional MRI scanners found in many hospitals.

Conducting an fMRI scan generates a huge amount of data through sequential scanning of the brain. This process is time consuming and can result in the need for multiple scans, which often distresses patients and takes up valuable scanner time. A number of methods, such as compressed sensing exist to accelerate MRI data collection and processing; however, there is difficulty in the application of such methods to fMRI. Oxford scientists have developed methods which achieve faster fMRI data acquisition.

Enabling acceleration of fMRI acquisition

“Low rank” data refers to matrices that have small numbers of signal components in the presence of noise. The low-rank property has been exploited in the acquisition of Magnetic Resonance Imaging (MRI) data and in particular to accelerate the data acquisition process. Owing to the large amount of data acquisition required, this approach is particularly suited to fMRI data.

MRI data is stored in a matrix of digital signals known as “k-space” during data acquisition. By applying Fourier

transform to this data, an image of the signal variation across space can be reconstructed. Further to this, a time series of MRI data may be collected as a data matrix to extend into the temporal dimension or “k-t space”. In MRI, the time required to fully sample signals in the k domain and in turn produce a complete image limits the resolution in the k-t domain.

Various attempts have been made to accelerate MRI data. One method is to undersample signals from k-space in order to reduce the data required to form an image. Gaps in data are filled by combining signals from multiple magnetic coils in the MR scanner or simply building an image based on the undersampled data. By reconstructing each time point independently these methods fail to take advantage of any temporal structure in the data.

An alternative approach is to apply matrix completion methods that do not presume a particular form for temporal data, but instead are driven by the structure of the data itself. Matrix completion techniques have been applied to medical imaging to take advantage of the inter-dependence of spatial and temporal domains. However, direct application of existing methods has been found to perform poorly on fMRI data in particular owing to the nature of its signal properties.

Oxford scientists have been able to collect fMRI data up to 8-times faster

than previous methods, by undersampling MRI datasets before application of a series of algorithms to complete matrices and reconstruct low-rank datasets. This approach should lead to more efficient use of MRI scanner time whilst alleviating, and in some cases completely eliminating, problems encountered using previous acceleration approaches.

Clinical applications which could benefit from the Oxford methods are not limited to fMRI and a range of procedures where reduced scan time would improve patient experience could include; dynamic angiography, MR elastography and dynamic contrast enhanced MRI (DCE-MRI).

Commercialisation

Software for the recovery of undersampled low-rank MRI data has been coded and a patent application has been filed covering methods used. Methods developed have been tested on retrospectively undersampled MRI data using numerical phantom simulations. Excellent results have been demonstrated in the recovery of low rank approximation of undersampled MRI data.

Isis Innovation would like to speak with parties interested in further validation of valuable new tool for fMRI.

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The Health Emergency Learning Platform

– HELP

A role playing game designed to challenge community health volunteers to solve real world health emergencies through scenarios.

Dr Sarah Deakin explains

The birth of a child should be a time of great celebration. Yet it is a sad fact that during the human life span the day of birth is also the day of greatest risk of death. In Africa, 470,000 babies die each year on the day they are born. This figure increases to over 1 million deaths within the first 28 days (the neonatal period) (World Health Organisation 2014).

Applying a different method

For generations this litany of loss has been considered the norm, but this is changing. The World Health Organisation estimates that over two thirds of new-born deaths in Africa could be avoided through existing maternal and child health care programmes if they were taught and implemented effectively. This could save 670,000 lives a year.

In conjunction with the Kenyan Government and the Paediatric Association, Professor Mike English, Dr Chris Paton and Dr Hilary Edgcombe are leading the way in developing the training of healthcare workers to improve the quality of care given to mothers and new-borns. In 2006, Professor English designed the ETAT+ training programme in conjunction with Kenyan colleagues.

The system uses face-to-face lectures and a range of practical exercises to ensure that healthcare workers are trained in evidence-based, best practice guidelines. To date, this training has been exceptionally well received and highly successful as shown by its adoption beyond the borders of Kenya into Rwanda, Uganda and Myanmar. Over 5000 healthcare workers have been trained in up-to-date care techniques using this method.

However, this is still only a tiny percentage of the 2.5 million healthcare workers in sub-Saharan Africa that need to receive regular training on new methods of care. Although highly effective, the face-to-face format of the training will not allow the programme to be scaled to this capacity. More needs to be done to develop the programme into an easily accessible training tool, available to workers even in the poorest, most vulnerable and remote locations.

A serious game

To address this need, Professor English and his team are currently developing The Health Emergency Learning Platform (HELP). HELP has the potential to present



“470,000 babies in Africa die each year on the day they are born. This figure increases to over 1 million deaths within the first 28 days – the neonatal period (World Health Organisation 2014)”

the ETAT+ course in a “serious game” format that healthcare workers can access from their mobile phones or other devices. Much the same way as a child thrives and learns through repetition, the game format embeds knowledge about care techniques into the player so that when faced with an emergency situation they instinctively follow the correct sequence of clinical decision making. Healthcare workers learn by having to navigate changing scenarios that reflect the real life choices they will have to make to save lives using an engaging and interactive game format.

Commercial potential

The Kenyan Government and partners have helped to fund the provision of the face-to-face training (ETAT+). However, this essential training is still not available to over 90% health care workers because of the cost of delivery. The team now needs to raise funds to build a beta test version of HELP and to look beyond this to implementation and adoption of a fully functional game.

Any philanthropic donations to help achieve this goal would be warmly welcomed.



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Making water clean and the contaminants a resource

A research group from the Oxford Engineering Science Department has found an inexpensive, reliable way of removing up to 99% of pollutants, such as heavy metals, from water.

Dr Chandra Ramanujan explains

With over a billion people relying on potentially contaminated water for drinking and nearly 1.6 million children dying each year as a result, removing contaminants is a priority. These contaminants, such as heavy metals, can then be recovered from water in a concentrated and reusable form, both saving the environment and turning the problem of effluent disposal into resource recovery.

Current waste water treatments

Industrial processes can result in contaminants in the effluent stream. For example, zinc, cadmium and chromium ions result from plating processes. Current cleaning techniques involve expensive and inefficient chemical precipitation and adsorption processes. Alternative treatments like ultrafiltration, reverse osmosis and ion exchange are time consuming, require expensive equipment and have significant energy requirements.

Advantages of the new Oxford process

Compared with existing treatment solutions, the Oxford system has:

- an efficient removal system
- low cost – components used can be recycled
- reliable performance
- easy to use
- fast reaction times

The system is capable of removing a high percentage (95- 99%) of multivalent metal ions, such as Zn(II), Cd(II) and Cr(III), contained within dilute (10mg/L) solutions by using a small amount of polymer and surfactant. The soluble polymers and surfactants (surface-active agents, also used as cleaning agents) employed are commercially available, safe and inexpensive.

The substrates used in this process are economical compared with chemical precipitation and adsorption. In addition, the process uses less energy than other membrane filtration methods, such as ultrafiltration. The capital cost is relatively cheap compared to that of ion exchange, ultrafiltration and reverse osmosis.

Expanding the scope

Additionally, for performance stability and complexity of the process, this method is much more reliable, robust and simpler than biosorption. Thus, it could be applied to a wider range of situations. For treatment speed, the self-flocculation allows the recoverable material to be settled out quickly. If coarse microfiltration is used, this offers much higher flux than ultrafiltration or nanofiltration membranes. Moreover, it operates much quicker than the adsorption method, since the surface area of the polymer-surfactant aggregates is larger and the intrinsic removal process is rapid. Finally,

	Capital cost	Operational cost	Complexity of process	Performance stability	Treatment speed
Ion exchange	High	High	Medium	High	Medium
Membrane filtration	High	High	Low	High	Medium
Biosorption	Medium	Low	High	Medium	Low
Adsorption	Medium	Medium	Medium	High	Low
Chemical precipitation	Low	High	Low	High	High
Polymer-surfactant method	Low	Medium	Low	High	High

Table 1: The current industrial treatment methods

the cost and sustainability can be further reduced and enhanced via recycling of the polymers, surfactants and heavy metals. A brief comparative summary of the current industrial treatment methods is in Table 1.

Novel materials used to pull contaminants out of solution

At the heart of this technology is a novel material that comprises a complex of polymers and surfactants, known as polymer-surfactant aggregates, that trap contaminant ions. This process is known as complexation and flocculation. Gravity then settles the flocculates, separating the contaminants from the water. The flocculates can then be treated separately to recover the contaminants in a concentrated form. The polymer and surfactant can also then be recycled without a deterioration of removal ability in the next cycle.

Further potential for this technology

This technology can also be used for isolating other charged species of chemicals. This opens up the potential applications in many industries, such as textiles, fine chemicals, pharmaceuticals, mining, and semiconductors.

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Interactive software for diabetic trials and research

Dr Weng Sie Wong presents an interactive Homeostatic Model of Assessment software package which allows users to examine and assess insulin resistance and β -cell functions in the fasting state

Diabetes is a chronic condition affecting on average 6% of the UK population, equivalent to approximately 3.2 million diagnosed patients in 2013 (QOF figures published in Feb 2014). In 2012, 29.1 million, or 9.3% of the US population, were estimated to have diabetes. Over 95% of this figure have type 2 diabetes (National Diabetes Statistics Report, 2014).

Type 2 diabetes is caused by a combination of progressive pancreatic β -cell dysfunction, reduction in the amount of insulin produced, and variable degrees of insulin resistance that lead to dysregulation of glucose homeostasis. Understanding the biochemistry, phenotypic details, and genetic mechanisms contributing to this can yield important information on pathophysiology. The progressive nature of the disease, as well as measurement of the rate of deterioration, has presented an ongoing challenge to clinicians and scientists alike. Tools which are available to track β -cell functional changes and insulin resistance fall into three broad categories: measures of glycemic status (e.g., fasting glucose, HbA1c), physiological investigations (e.g., clamp techniques, glucose tolerance tests), and mathematical modelling (e.g., minimal model, Mari model, homeostasis model assessment (HOMA)).

No single approach has proved sufficient, for a comprehensive quantitative description of either β -cell dysfunction or insulin resistance.

Oxford technology

HOMA and the subsequent HOMA2 are mathematical models, developed in Oxford from the mid-1980's onwards, that have been used extensively in diabetes research to model physiology and treatment effects. Both models have drawbacks - for example they are not appropriate for use when evaluating treatments that have similar functional effects on blood glucose but different modes of action. A further drawback is that they do not allow individual compartmental or biological variables to be specified even when these are known. iHOMA2 is a 23-variable interactive software model for the assessment of insulin resistance and β -cell function in the fasting state. By using simple visual controls, iHOMA2 allows users to examine and modify the mathematical functions that describe the glucose and hormonal levels in a patients organs and tissues.

The software allows descriptions of different states of type 2 diabetes to be modelled. It can be used to simulate the effects of individual therapeutic agents or a combination of therapeutic agents on fasting glucose and insulin levels, β -cell function, and insulin sensitivity. The input into the model can either be fasting insulin and glucose values (functional insulin secretion capacity) or percent β -cell function and percent insulin resistance (functional activity of insulin).

The iHOMA2 model has multiple modes of use including default, analytic and predictive modes:

- **default mode** - for comparison of new treatments with all published data using the earlier HOMA and HOMA2 models
- **analytic mode** - allows β -cell function and insulin resistance to be calculated from the fasting insulin and glucose levels
- **predictive mode** - allows fasting insulin and glucose levels to be estimated and modelled from the β -cell function and insulin sensitivity parameters

Proof of Concept

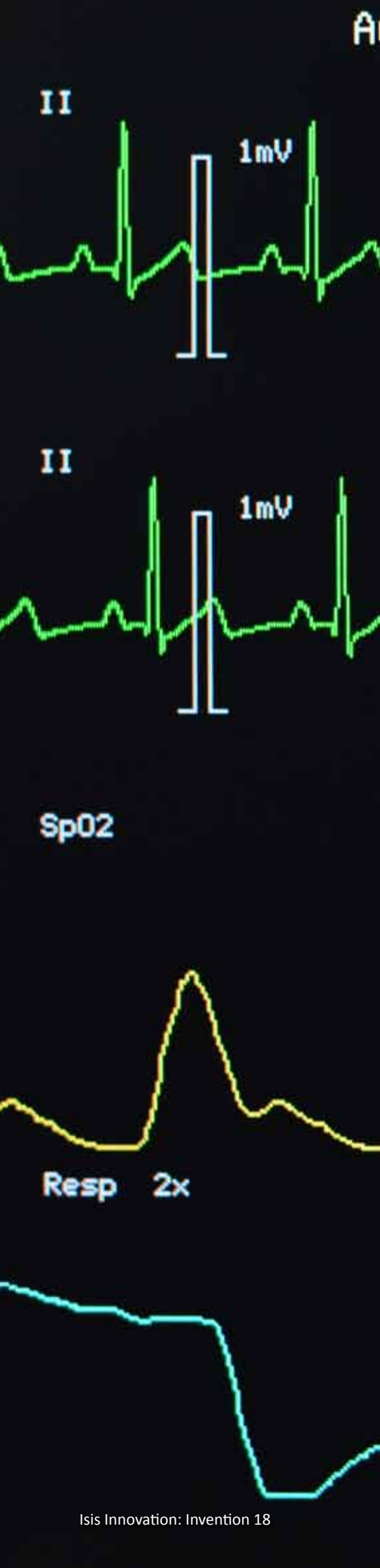
The Oxford team has successfully exemplified the iHOMA2 software and model in a research paper (Diabetes Care 36:2324–2330, 2013) using two diverse scenarios:

1. modelling the changes in insulin sensitivity with a class of drugs known as thiazolidinediones (also known as glitazones);
2. modelling the changes in renal threshold following inhibition of the sodium glucose transporter2 (SGLT2) which leads to blockade of renal glucose reabsorption



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Robust estimation of respiratory rate using probabilistic methods

Oxford researchers have developed a probabilistic approach that measures the respiratory rate whilst calculating the confidence of the measurement. **Dr Nikolaos Chalkias** explains

Respiratory rate has been shown to be an important indicator of patient deterioration in cardiac arrest and unexpected death. Extreme values of respiratory rate are associated with an increased risk of adverse events in hospital patients. The importance of respiratory rate in prevention of adverse events is highlighted by its inclusion in early warning scores (or EWS). An EWS score is based on the principle that clinical deterioration is noticed through changes in multiple physiological measurements, as well as large changes within a single variable. The use of EWS is now widespread in hospitals and emergency services.

Current methods of estimating the respiratory rate are often manual. The attending clinician counts the number of movements of the chest wall within 15 or 30 seconds. This number is then multiplied by a factor of 4 or 2, respectively, to estimate 'breaths per minute'. Recent studies have shown this method is unreliable, with the actual respiratory rate often different to that estimated by a clinician. Current automated methods for estimating

respiratory rate from physiological signals (i.e. Electrocardiogram – ECG or photoplethysmography – PPG) are often unreliable when applied to patients. Studies in the literature demonstrate candidate automated methods using healthy, usually young, volunteers whereas actual patients are typically elderly and unhealthy, which makes the problem of robust estimation of respiratory rate particularly difficult for existing algorithms.

The Oxford Invention

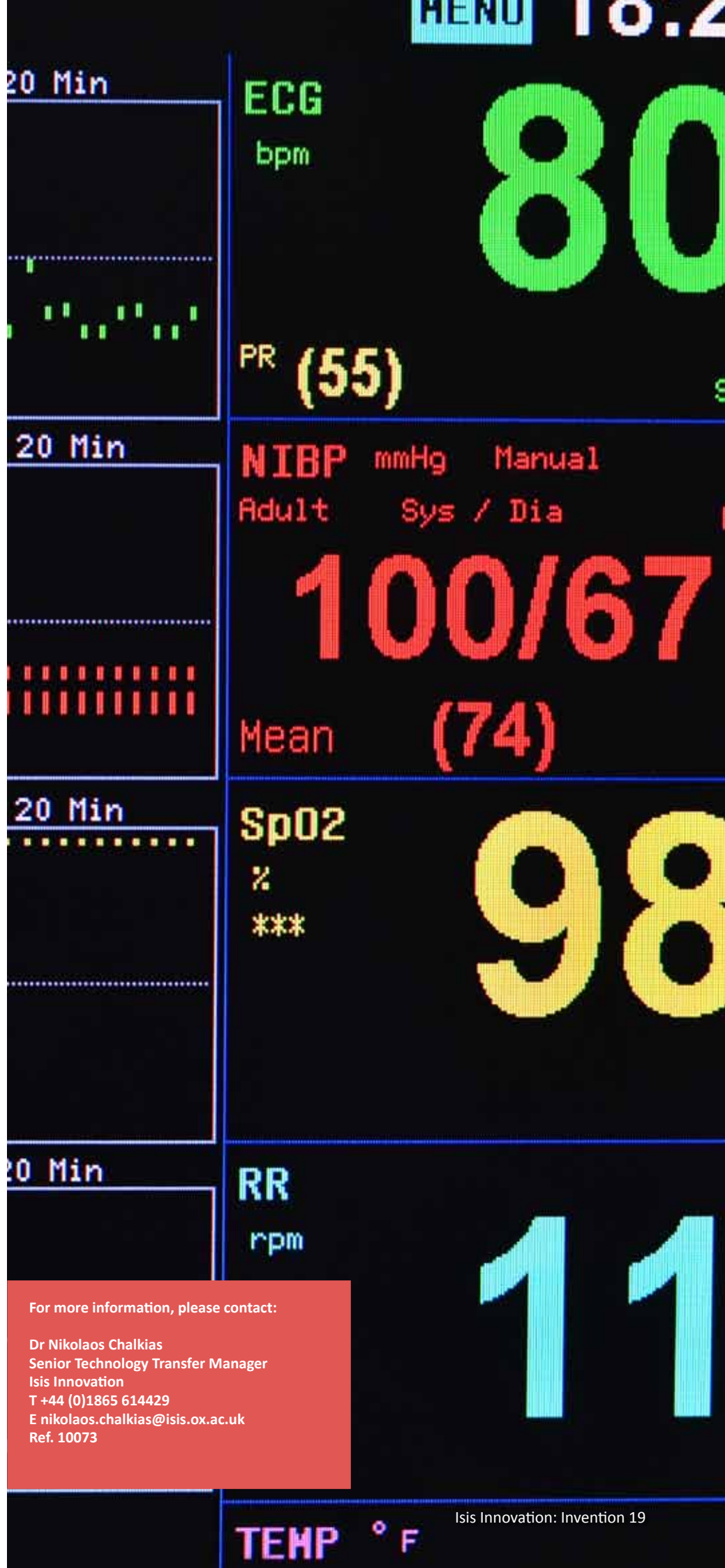
Researchers at the University of Oxford have developed a probabilistic approach to measure the respiratory rate of a patient. The technology gives a probability distribution of likely respiratory rates, rather than a single estimate. This allows the system to produce robust estimates in the presence of noise and artefacts, providing outputs that are useful for patient monitoring systems that take a probabilistic approach.

Respiration modulates a number of physiological processes which is evident from the ECG, PPG or even video signals of a patient's face. The new method

constructs a probabilistic model of time-series extracted from the ECG and PPG signal. This allows for a natural and elegant estimation of respiratory rate directly from patient data.

This invention can be applied to all existing respiratory rate monitoring equipment whether contact based (ECG, PPG) or contactless (i.e. camera based). The methodology has been validated using data from healthy volunteers, and the results published at a peer-reviewed conference. The performance of the method matches that of the state of the art, whilst bringing the benefits of a probabilistic framework and estimates of confidence.

Although the immediate application of this new technology is in primary care hospitals and clinics, with the emergence of e-Health and remote patient monitoring, it can be readily applied to e-Health applications such as handheld devices, smartphone applications and in-home monitoring for the elderly population.



Are the robots taking over? – The creative economy and the future of employment

Gurinder Punn of Oxford University Consulting describes a recent project undertaken by Oxford academics that reveals the potential of computerisation to replace jobs in many sectors

Have you ever complained about the fact that your work is repetitive or not creative? Well, be careful of what you wish for because you might find that a robot can do what you do sooner than you might think. The remarkable growth of machine learning, mobile robotics and big data areas of research in which Oxford is heavily involved, all contribute to the concerns of policy makers as to how the future jobs market will evolve and how susceptible many of the occupations are to automation.

Oxford University Consulting (OUC) worked with Hasan Bakhshi from Nesta, the UK's innovation foundation based in London, and two academics from the University of Oxford to publish a report which investigates the probability of computerisation of many USA & UK's creative occupations in the not too distant future. Previous research¹ using detailed task descriptions from 702 occupations from O*Net had shown that in the USA 47% of existing jobs in 2010 are at risk of computerisation within the next 10-20 years. Those most at risk are in transport, logistics, manufacturing production, construction, office automation and, more surprisingly, services and retail sales-related activities. If you happen to be a translator or performing artist or maybe a film or TV producer you can relax, for now at least. Work done in 2014² which built on the studies done in the USA extended the

research to the UK and concluded that 35% of jobs are at high risk of computerisation with similar occupations being affected as in the USA.

In a recent project undertaken with OUC, Prof Michael Osborne and Dr Carl Frey, co-directors of the Oxford Martin Programme on Technology and Employment, were asked to introduce an algorithmic classification methodology for the creative content of UK occupations to show the link between creativity and automatability. They first labelled 35 (out of 702) occupations that require creative intelligence and another 35 occupations that do not, and found that they were able to build a training set to train a non-parametric classifier and thereby assess the probability of any occupation being creative. Using the classifier, they determined the fraction of USA employment that was in 'creative' jobs according to this procedure, and the correlation between this assignment and the classification of USA jobs as automatable or not. Specifically, they calculated what fraction of the USA creative workforce is susceptible to automation, relative to the fraction for the non-creative workforce. Next they performed a crosswalk from USA SOC 2010 occupations to UK SOC 2010 occupations to classify UK occupations as being creative or not. This was followed by the use of Annual Population Survey data to express



the fraction of the UK workforce that is in creative roles from which they were able to determine the fraction of the UK creative workforce that is susceptible to automation, relative to the non-creative workforce. Finally they discussed how the classification of UK jobs as creative or not is related to Nesta's Dynamic Mapping methodology, which has now been adopted by UK policymakers.

So what did the findings show? The results published in Nesta's report *Creativity vs Robots: the Creative Economy and the Future of Employment*³ (April 2015) suggest that 21% of US employment is highly creative (i.e. it has a probability of >70% of being creative) including artists, architects, web designers & IT specialists. The results for the UK suggest that we have a slightly higher fraction of creative employment at around 24%. The results also strongly suggest that economies like the USA and UK with large creative workforces are potentially better placed than others to resist the employment fallout from future automation. The author continues to live in the hope that being a highly creative project manager at Isis Innovation is one occupation not due for automation anytime soon.

1) Frey & Osborne (2013), 2) Knowles-Cutler, Frey & Osborne (2014), 3) Bakshi, Frey, Osborne (2015), Also see <http://www.oxfordmartin.ox.ac.uk/research/programmes/tech-employment> for more information

on the Technology and Employment programme mentioned above.

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Growing a technology and innovation management consultancy

Isis Enterprise (IE) has been awarded a Queen's Award for Enterprise – the UK's highest accolade for business success. **Dr Steve Cleverley**, Head of Isis Enterprise (UK), gives a brief history of the business and describes some of the services it offers

Over the last ten years, Isis Enterprise (IE) has grown from a small specialist unit based in Oxford, to an international business which provides expert consulting services in more than 50 countries. Today, IE is a £2.8m business which employs 17 full time consultants, and has staff and associates across the world. Over 88 per cent of its revenue comes from working with clients outside the UK.

How Isis Enterprise began

In the early 2000's, Isis Innovation was receiving an increasing number of requests from organisations outside Oxford keen to learn how it went about commercialising university research. Isis Innovation was acknowledged as a leader in its field, and others wanted to learn the secret of its success. The demand for advice led to the creation of Isis Enterprise, a consultancy unit within Isis Innovation that could offer training and assistance to organisations in the UK and internationally.

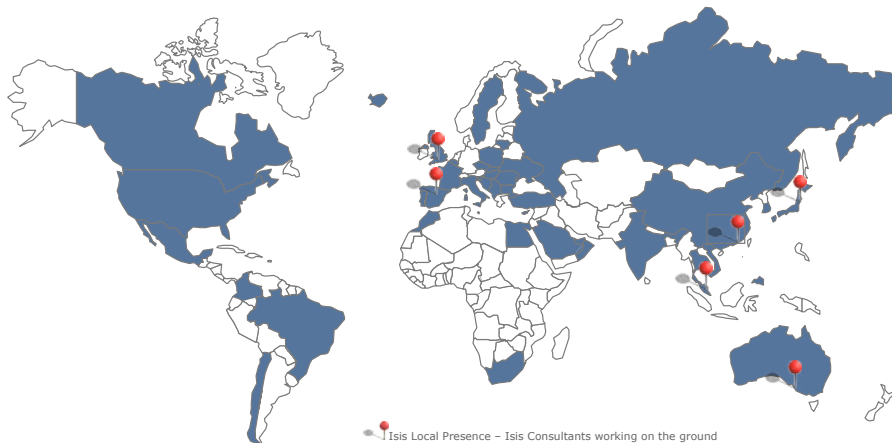
IE started by establishing relationships with a number of UK institutes and research centres, providing technology transfer services to clients such as the Natural Environment Research Council (NERC), Oxford Brookes University, and the Carbon Trust. At NERC, IE assisted the technology transfer team, advised and developed an innovation strategy and process, carried out portfolio reviews across 13 centres,

and provided one-to-one support to business managers to deliver licences and spin-outs. IE continues to provide such traditional technology transfer services to clients today.

International Expansion

In 2009-10, to mitigate the effects of the global economic downturn, IE took the decision to expand internationally. It selected markets based on three criteria: how developed technology transfer services were; the appetite for adopting new technologies; and the degree of openness to outside help. China lacked national innovation capability and was keen to license technologies and products from other parts of the world to manufacture and sell domestically. Much of IE's work involved seeking licensees for early stage technologies and products. In 2009, Isis Innovation set up a subsidiary office in Hong Kong, followed by a number of technology transfer joint ventures in mainland China. Isis Innovation (Hong Kong) provides consulting services to Chinese companies and technology transfer training for Chinese universities.

A second key market for IE was Latin America. There, many universities had funding for technology transfer work, and an extensive research base, but lacked the appropriate infrastructure to successfully transfer technologies to



market. In 2010-11, IE took on a number of technology transfer projects in Mexico, working with the Mexican Council for Science and Technology, to assist existing technology transfer offices (training staff and optimising portfolios) and to set up new ones. A program was designed for a small number of universities to maximise returns on their intellectual property (IP) portfolios, including technology portfolio reviews and advising on commercialisation strategies.

Current Activities and Markets

Today, Isis Enterprise has associate consultants in Spain, Latin America, UAE, Oman, Malaysia and Australia, as well as its subsidiary in China. These are our top performing international markets, a fact we put down to our local market presence enabling us to build strong client relationships.

IE's services have evolved to encompass a broad range of areas in addition to traditional technology transfer support. Clients now include corporates, investors and governments, in addition to academic institutions. IE is providing advice and support to the founders of Muscat University, Oman. In Malaysia, they are supporting the internationalisation of SMEs operating in the LED Lighting and Biotech sectors, and are participating in a number of Newton Fund programmes. IE provides training in technology commercialisation and practical entrepreneurship, licensing and negotiation support, and innovation management.

IE's Purpose

IE works to bring innovative technologies to market in order to produce new products and services that will benefit society. IE also has a role to play in supporting Oxford University. Oxford has a proud tradition of using its leadership position to support other organisations around the world. Not only do IE's activities contribute to this important tradition, its consultants also play a key ambassadorial role, with many introductions made to University colleagues following interactions with IE consultants.

IE also benefits the university financially. Profit from Isis Enterprise goes to Oxford University's Challenge Seed Fund (USCF) and the Oxford Invention Fund. These enable researchers to bring university research discoveries to a point where their commercial usefulness can be demonstrated and the first steps taken to ensure their adoption. This commercial return is evidence of IE's success in fostering innovation both in the UK and globally.

For more information about IE's consultancy services and how we may be able to assist technology commercialisation and innovation management within your organisation, please contact:

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Oxford Innovation Society

Forthcoming meetings of the Oxford Innovation Society will be held on the following dates:

- Thursday 17th September 2015
- Thursday 26th November 2015
- Thursday 17th March 2016

Meetings are held in Oxford for OIS members and invited guests, and are followed by a formal reception and dinner. Details on www.isis-innovation.com/ois.



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