Institution: Bangor University

Unit of Assessment: 08, Chemistry

a. Context

The School of Chemistry at Bangor University aims to produce research which benefits the economy and the people of Wales, the UK and the World. The chief non-academic beneficiaries include businesses ranging from small local SMEs to large multinational companies in the manufacturing and research sectors, along with the health of the population via UK hospital trusts, Public Health Wales, and the World Health Organization. The main types of impact that result as a consequence of the School's research include technological breakthroughs in the low-carbon economy and steps towards new diagnostic tests and treatments for infections and diseases in humans and animals.

b. Approach to impact

Our approach to impact is based upon communication, collaboration and commercialisation.

Communication. We fully embrace the mission to advance public understanding of science and the cultural needs of the region as valuable aims in themselves, but we also regard communication of our research as providing strategic opportunities to build partnerships with industry and other potential end users. We have appointed a school outreach officer, Dr Wheldon-Williams, and a marketing officer, Ms Stevie Scanlan (who serves the whole College of Physical and Applied Sciences). The school actively promotes its research and uses a wide range of media including television, radio, press releases and social media, such as the Alumni Facebook network. Ms Scanlan is one of the co-ordinators of the Bangor Science Festival, which is attended by 3,000 people annually. Dr Wheldon-Williams, as a Welsh speaker, has a particular role in liaison with local schools and co-ordinates our presence at the National Eisteddfod of Wales (~150k visitors annually). An excellent forum for dissemination of suitable aspects of our research through the medium of Welsh, Bangor University organises the Science Pavilion at this event every year. Press releases, radio and television coverage are managed by Ms Scanlan in concert with the University's marketing team. Our work on the reuse of tyres as diesel fuel featured on ITV (March 2008), trial of an 'explosives detector' at Schiphol airport was covered by BBC news (Nov 2010), and the development of the SPECIFIC project, which includes our work on photovoltaics, featured on BBC News (Oct 2012). A BBC 'Countryfile' programme has covered our work on bluebells (April 2013). Our work on diagnosis of tuberculosis was presented in 2008 as a keynote lecture by Prof Mark Baird at the first South African TB conference to an audience of some 1650 health workers and politicians setting the policy for dealing with drug resistant TB and HIV co-infection.

Collaborations with industry and other potential end users have long played a major role in our research strategy. This has been facilitated by industrial sponsorship, EPSRC Industrial CASE studentships and by various European Union initiatives. Industrial CASE studentships have included partnerships with large multi-national companies, such Pilkington (a subsidiary of NSG), TATA, and, formerly, ICI Wilton. European Regional Development funding has been used to foster collaboration and partnerships with SMEs, along with other HEIs in Wales and Ireland. We have participated in the Centre for Advanced Functional Materials and Devices (CAFMaD, 2006-2011), Low Carbon Research Institute (2009-2013), Wales Ireland Network for Scientific Skills (2011-14), Welsh Institute of Sustainable Environment (WISE 2005-2015), and the Bio-refining Centre of Excellence for Wales (BEACON 2010-2015). The Knowledge Exchange Scholarship Scheme is administered by Bangor University, supporting MRes and PhD projects in collaboration with industrial, charitable and governmental partners, while 'Access to Masters' funding supports taught masters students in programmes with industrial partners. In all, during the census period, our staff have worked with over 50 different SMEs ranging from to long term collaborations, such as PhD projects, to consultancies, training and investigative laboratory work. To highlight one example, as a direct result of our advice, a local company, Phytovation increased its turnover by £600k and created seven new jobs. Their overall increase in turnover for the period 2008-2013 is estimated to be in the region of £2million.

We have worked with major international companies such as GSK, Pilkington, AMRI, TATA, ICI and DSM. For example, DSM have benefited by our guidance on developing lead structures for improving animal health, and Pilkington worked with us on research into additives for fire-retardant glazings.

Our unique synthetic mycolic acid derivatives have proved to be highly selective immune signalling agents: these have been used by our collaborators at the Pasteur Institute of Public Health in Brussels to develop an *in vitro* mouse model for disease progression and virulence and by the Southampton Hospital Trust to test if they can be used to monitor the progression of tuberculosis. The molecules have been shown to be good vaccine adjuvants in Wellcome Trust-funded cattle trials in South Africa. Our work on glycoconjugates of synthetic saccharides that correspond to fragments of structures surrounding bacteria, has led to the successful development of a fully synthetic vaccine candidate using a minimal sugar epitope on a gold nanoparticle platform designed for use in young children against *Streptococcus pneumoniae* infections. This has been validated in animals by colleagues at the Eijkman Institute for Molecular Biology, Jakarta. We are also working with colleagues at Utrecht Hospital to test the efficacy of our saccharide analogues in *E. coli* infections in human trials. Applications in biocompatible medical devices related to blood clotting are being developed in collaboration with Carmeda AB, in Sweden. Imino-sugars have been examined as activators of enzymes used in the clinic to treat glycogen storage diseases such as Fabre, Tay-Sachs, Pompe, and Polysaccharidosis in partnership with the New Queen Elizabeth Hospital Birmingham and Phytoquest Ltd. Two of our staff (Baird and Gwenin) have been invited to join a WHO Expert Group in November 2013 to set the policy for diagnosis of Buruli ulcer, a major mycobacterial infection in Africa.

Commercialisation is achieved through licensing of patents for product development or by the formation of spinout companies. We have patented seven processes during the census period, with assistance from the University's Research and Enterprise Office. The spinouts Diagnostig and Naturiol are being licenced to develop diagnostic kits for tuberculosis and to develop lead molecules from common indigenous plants for treatment of human infections, respectively.
For the TB tests, in 2010, we presented interim results on 100 human samples to the World Health Organisation. This led to the Bangor diagnostic method being validated in a blind study on 350 human samples in collaboration with the WHO. The results, independently assessed by a clinician, were encouraging, for both TB positive and TB negative samples. Therefore, we decided to form a spin-out company, Diagnostig Ltd, in 2012. In partnership with the SMEs Gwent Electron Materials, and Biocheck Ltd, we initiated a prototype delivery phase for a point-of-care TB diagnostic test. By June 2013 this was giving a result in 10 minutes with no requirement for sophisticated laboratory facilities. The current 'gold standard' laboratory culture method can take several weeks to yield a result, which may exceed life expectancy in cases of TB/HIV co-infection.

Ethical approval was granted in 2012 to test our diagnostic tests with samples from different population groups within Wales in a study overseen by Public Health Wales. This has shown high levels of antibodies to mycobacterial lipids in selected population groups, such as farmers. This initial study, with great relevance to public health, is being validated on a much more extensive population group before it can be released. We have also collaborated with experts in bovine diseases at the Animal Health and Veterinary Laboratories Association (Defra) and the Pasteur Institute for Infectious Diseases (Brussels) on trials for diagnosis of bovine TB and *Mycobacterium avium* paratuberculosis, the cause of Johne's disease in cattle and linked by some sources to Chron's disease in humans. The success of these trials has led to the Welsh Government providing support to work with three companies- AET, Biocheck, Diagnostig- to develop the route to market of an animal diagnostic product.

The spinout company Naturiol has been set up to exploit patents for the development of novel lead molecular from indigenous plants, such as common ivy and horse parsley, with potential for uses against leishmaniasis and acanthamoeba, and also as human antifungal agents. Naturiol has been provisionally offered TSB funding to further develop this research in partnership with Unilever and Croda.

c. Strategy and plans

We aim to continue our successful approach of communication, collaboration and commercialisation.

The University Research Strategy and Task Group provides a co-ordinating hub for research activity within all 5 colleges in the University. The “Champions of Impact” at each College (at present, the College Directors of Research) are supported by the University’s Research and Enterprise Office and Communications and Marketing Team to ensure an institutional and co-ordinated approach. College champions are responsible for integrating research impact into school planning processes through the annual planning round and individual staff performance reviews.

Communication strategy will remain important. In addition to our core-funded marketing and outreach staff, the major research projects we are currently involved with (LCRI, BEACON, WINSS, WISE) all have dedicated staff with remits to maximise public engagement and publicise the project successes.

In terms of collaboration, the WISE, WINSS and BEACON programmes are funded until 2014-15 and further ERDF funding will be sought. The Welsh government has invested heavily in the Ser Cymru programme and Bangor Chemistry will feature strongly on all three programmes, Health (Prof Baird is on the steering committee), Environment and Advanced Materials (Dr Holliman’s work in collaboration with Swansea, TATA and other companies will play a key role). Industrial collaboration will be prioritised in all three programmes.

In terms of commercialisation, Diagnostig and Naturiol have been recognised (2011 and 2012) by the Welsh Government as “High Potential Start companies”, expected to grow to a turnover of £750,000 within 3 years, and placed on a mentoring scheme to assist their development.

d. Relationship to case studies

The two case impact studies presented, 'Dye-sensitised Solar Cells' and ‘Cervical Cancer Diagnostics’ both represent examples of how our collaborations with industry have generated impact, although at very different stages of development. Our research on optimising novel approaches to development of dyes for rapid diagnosis of cervical cancer was carried out in response to a global shortage of one of the dyes needed for the traditional Pap test, and so was driven by a clear market need. We worked with a local SME to develop an optimised and economical process, which was rapidly brought to market resulting in substantial economic benefits to the company, which have been maintained to this day. Likewise the development of dye-sensitised solar cells has been intimately collaborative, working with engineers at Swansea and with companies including the multinational TATA to develop efficient and economical approaches to manufacture of photovoltaics for the capture of solar energy. In this case, the global market is vast, and we will ensure that we benefit from the intellectual property through patents and a spinout company.