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Delivering Science for Wales 2013-14

Annual Report on our Strategic Agenda for Science in Wales

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Foreword

This report covers the second year since the Welsh Government's strategic agenda for science – *Science for Wales* was launched. I have been encouraged by the progress made by the Welsh Government, working with our partners in higher education and business, to progress the actions set out in *Science for Wales*.

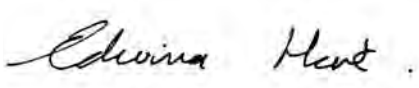
There is a lot more to do. Although we have started many of the activities we said were needed, they now have to bed in and develop. Many of them are going to take some years to produce the desired results. I am delighted that we have managed to appoint three Sêr Cymru Research Chairs of the extremely high calibre that was sought. I wish them well in developing their research and research teams in Wales. The complementary National Research Networks are also beginning to develop and I have high expectations of these too. *Innovation Wales* is now in place, bringing more detail to the calls to promote business innovation, first made in *Science for Wales*.

I was also very pleased to learn from the Elsevier Report, partly Welsh Government-commissioned, that research in Wales is better and stronger than we had felt was the case and enjoys a strong reputation far beyond our shores.

Since the last Annual Report, the second of two educational reviews of great significance has been published. These are important to the vital business of encouraging sufficient young people to want to study science and to study it to a high enough level to become researchers and to work in the technology and knowledge-based businesses, so vital to Wales' future success. The Qualifications review has introduced a new pairing of Mathematics GCSEs. The Curriculum and Assessment Review's first phase focused particularly on literacy and numeracy. The second (which will cover science in our curriculum) will now be independently led, with a further period of consultation ahead of proposals later in 2014. I look for both these reviews to help raise our game in STEM qualifications, in an increasingly competitive world, where knowledge-based businesses really matter to our future prosperity.

The National Science Academy (NSA) completed another major competitive funding call during the year and is now monitoring the successful science engagement projects.

Looking back over the second year of activity, I see the positive progress we have made. The Chief Scientific Adviser is looking at what further steps the Welsh Government can add to help deliver this long-term strategic agenda. I recently chaired a meeting of the *ad hoc* Ministerial group on Science – all those Cabinet colleagues with an interest in science in the broad sense, to monitor progress. Such progress meetings will be held through the life of the *Science for Wales* strategy.



Mrs Edwina Hart MBE CStJ AM
Minister for Economy, Science and Transport

Introduction from the Chief Scientific Adviser for Wales

When I took up my appointment in September, I undertook to meet the commitments made in *Science for Wales*. I am pleased with progress against the main actions by the Welsh Government to achieve the ambitious targets we set ourselves, but there is still much to do. One notable aim is to bring our share of competitively-awarded research funding won by researchers in Wales up to 4.9 per cent, which represents what would be expected, given our population size. Indeed, I am now examining a range of new actions we can develop to add to the delivery arrangements already in hand to make *Science for Wales'* goals a reality.

I am greatly heartened by the Elsevier Report, which we jointly commissioned, showing that we can be really proud of the quality, efficiency and influence of the research we undertake in Wales. Wales has 0.14 per cent of the world's researchers but produces 0.3 per cent of the world's published articles (2011). Citations of articles written by our researchers make up 0.49 per cent of the global total. When it comes to the top 1 per cent most highly cited articles, researchers in Wales produced 0.7 per cent, a figure much higher than would be expected from the current research base. Measuring all journal publications with associated patent applications, Wales manages a healthy 0.85 per cent. This is all encouraging evidence of the efficiency of Welsh research and the world-leading nature of a significant proportion of that work.

Our scientists also make a major contribution to the Welsh economy, through understanding diseases; producing new targets for treatments; exploring novel ways to combat climate change and inventing new materials and technologies. They also act as entrepreneurs in their own right. For example, in 2013 the 240 scientists from one School in Cardiff University produced 500 research posts through success in competitive grant funding.

So scientists in Wales are productive, efficient and in some cases world-leading. They contribute valuable jobs to our economy. The bad news is that there are not enough of them. That is why our current Sêr Cymru scheme and future initiatives are so important to significantly increase research capacity and to facilitate greater success.

I am passionate about recognising the contribution that women can and should be making to our research profile throughout Wales' universities and research bodies. A recent House of Commons Science and Technology Committee report *Women in Scientific Careers* highlighted the hurdles women can face in pursuing fulfilled and long-term research careers and scaling the academic heights through those careers. I am taking steps to improve this situation, which is holding us back.

One reason I became a scientist was that science was fun and stimulating, but another was that I had an excellent Biology teacher, who showed me what was possible. Enthusiastic, well-informed teaching of a stimulating curriculum, leading to rigorous and well-regarded qualifications is what we need to keep working for, to feed the pipeline of enquiring minds which science will need

to thrive in future years. Wales' economy needs more young people skilled enough to join the research effort and contribute to the success of our scientific and technical businesses. We also need all our young people to be better-informed about the world we now live in, as science plays an increasing role in all our lives, in medicine; finance; transport and the environment we live in. That is why a scientific education is so vitally important.

I am reviewing the processes by which we achieve the best scientific and technical advice for Ministers and policy officials. I am also cementing effective links both with UK and European sources of scientific advice, including other Chief Scientific Advisers. I now chair meetings of senior staff from scientific and analytical areas of policy and evidence across all the Welsh Government. I am particularly keen to support ambitious projects, like greater NHS participation in research, as well as those which could bring large-scale investments into Wales such as Catapult Centres and significant European Horizon 2020 funding.

Professor Julie Williams CBE

Strengthening Universities and the Research Base

Image courtesy of Cardiff University

Science for Wales has set out the Welsh Government's strategy for science for two years now. Already we have seen good progress, with many of the early actions called for now completed or under way. We said then that we needed more and better evidence to understand and benchmark the research sector in Wales and how it is performing. *International Comparative Performance of the Welsh Research Base 2013* was published in February 2014. Prepared by Elsevier, and commissioned jointly by the Welsh Government, the St. David's Day Group and the Higher Education Funding Council for Wales (HEFCW), it gives current detailed evidence of research performance in universities, research institutes, industry and the NHS in Wales. By comparing their publication rates, citations and impacts with comparative countries it demonstrates the benefits and return on public investment. It is published on the Higher Education Wales (HEW) website.

Wales has **0.14** per cent of the world's researchers but produces **0.3** per cent of the world's published articles (2011). Citations of articles written by our researchers make up **0.49** per cent of the global total. When it comes to the top **1** per cent most highly cited articles, researchers in Wales produced **0.7** per cent, a figure much higher than would be expected from our current research base. Measuring all references in journal publications with associative patents Wales manages a healthy **0.85** per cent. This is all encouraging evidence of the efficiency of Welsh research and the world-leading nature of a significant proportion of that work.

Wales is outward-facing too. It enjoys the highest percentage of all parts of the UK, for collaborations with researchers from countries outside Wales (60.5 per cent in 2007-11, up from 44.7 per cent in 1997-2001). Such collaboration also brings to Wales the highest field-weighted citation impact – it is a real benefit for Wales' top 25 collaborator countries to work with Wales, since it gives them above average citation impact: you do well to collaborate with Wales. Wales is further an attractive place to do research. We have a highly mobile research population, with researchers coming into Wales having a citation impact which stands 80 per cent above the world average. Of our active researchers, the smallest percentage across the UK have not published with other researchers outside Wales – 11.8 per cent (1996-2011). For Scotland that figure is 14 per cent, for Northern Ireland 16.8 per cent and for England 23.3 per cent.

So in this first all-encompassing evidence-based analysis of Wales's research activity and relative research impact for over a decade, Wales is shown to be one of the most efficient countries in the world, when compared with countries of a similar size. Wales makes good, efficient use of its resources to produce research. It outranks most countries of a similar size that it was compared to.

Above: Ken Skates AM, Deputy Minister for Skills & Technology, with Professor Colin Riodan, Chair of Higher Education Wales, Professor Julie Williams, CSAW and Dr David Blaney, Chief Executive of HEFCW at the launch of the Elsevier Report.

There is widespread agreement that one pound spent on biomedical and health research will yield a large and positive rate of return. A good part of this will not be captured within the outputs of the organisation that spent that pound. A 2008 study (*Medical Research: What's It Worth?* – Wellcome Trust) found that one pound increase in public spending on biomedical and health research can be expected to increase private pharmaceutical industry R&D (Research & Development) spending by £2.20 to £5.10 in the UK. The UK economy then earns respectively a return equivalent to an extra £1.10 to £2.50 per annum of GDP after this. The social rate of return, then, to the total (public and private) investment stimulated by the initial one pound of public or charitable investment is around 30 per cent. So every pound spent on public or charitable medical research yields additional GDP for the UK equivalent to a net return of around 30 pence per year in perpetuity (range 20–67 pence per year). Similar studies could be done to show the beneficial effect of other areas of scientific or technical research, although the long-term return rates would vary.

A study in the School of Medicine at Cardiff University showed that, in 2013, the 240 academic researchers produced 500 research posts from their success in winning competitive funding.

Recent research has suggested that graduates in science, technology, engineering and mathematics or STEM subjects can expect to continue to be more employable and attract higher salaries as the UK economy moves towards having more science and technology-related businesses.

In April, CaSE – the Campaign for Science and Engineering published a report, *The Economic Significance of the UK Science Base*. This provides current and robust evidence, supportive of the previous points, for the importance of scientific and technical research to the UK Economy. Universities which receive public research funding create additional research in the private sector, better enabling businesses to take up and commercialise the findings of more public-sector research, which benefits the overall economy of the UK – a virtuous circle. Universities which receive larger allocations of QR, the core research funding and win more from the research councils tend then to bring in more research income from charitable, business and other external sources. The report also shows that public and private research expenditure is complementary. They are not substitutes for each other in the drive to enhance the UK's productivity.

Strategic Aim: To secure 4.9 per cent of competitively funded research income in the next 5-10 years.

Achieving this 4.9 per cent of the competitively-awarded research funding is ambitious because, despite the above positive results, the research base in Wales is too small, a point the Elsevier report also makes. Our present positive figures are achieved by high productivity per researcher – above the UK average for publications per researcher at 0.65 against 0.59 and outperformed only by Scotland at 0.77. Professor Robin Williams, former Vice Chancellor of Swansea University, published a report, first presented to HEFCW, through the Learned Society of Wales in February 2013, entitled *Recognising the Quality of Research at Universities in Wales*. In it he argues that researcher quality had been underestimated in Wales and that research outputs in Wales were of high quality in most cases. The

problem, demonstrated by failure to gain a sufficient share of competitive Research Council grants, is that there are too few researchers within Wales in medicine, engineering and the physical sciences. These subjects are supported by two of the highest-spending Research Councils (Medical Research Council or MRC and Engineering and Physical Sciences Research Council or EPSRC) making larger grants, because of the nature of the research undertaken. The analysis suggests that Wales needs at least 200 additional scientists in these fields to achieve the results desired, although others may argue the figure is much higher.

How then are the Welsh Government and its partners delivering *Science for Wales* working to address this deficit to ensure universities and other research bodies can move towards 4.9 per cent of competitively-awarded research funding? Increasing capacity is beginning to be tackled by our major investment in the Sêr Cymru Research Chairs and new National Research Networks. These are now in place and reported on below. The table below shows that the broad trend is now going in the right direction.

Year	Percentage of competitively-awarded research funding won
2009-10	3.3 per cent
2010-11	3.4 per cent
2011-12	3.4 per cent
2012-13	3.7 per cent

Amount of research funding won by Welsh Higher Education Institutions by percentage of population share (4.9 per cent of UK total)

Plans are now being considered for further measures to build on our existing work in order to foster excellence, build capacity and research infrastructure.

Strategic Aim: To focus on our research strengths, build up research capacity and facilities.

In September 2012, the Minister for the Economy, Science and Transport launched the £50 million Sêr Cymru programme, a major initiative to attract new scientific talent to Wales. Sêr Cymru is strengthening Wales' research base in two ways:

- By providing funding (up to £30 million over 5 years) for the recruitment of new Research Chairs in the three Grand Challenge areas – academics with a global reputation – together with their supporting teams and equipment.
- By providing funding (up to £20 million over 5 years) to set up three National Research Networks, one in each of the Grand Challenge areas, each led by a specialist director. The networks will 'pool' research expertise across our universities and organise new graduate schools for PhD training to support research fellows.

Sêr Cymru is a programme of real merit and international reach. A call for expressions of interest in Sêr Cymru chairs was advertised internationally in journals including *Nature*, *New Scientist*, *The Economist* and *Times Higher Education*. Expressions of interest in the Research Chairs were considered by a delivery board, including high-profile scientists and scientific administrators from within and outside Wales, some of whom hold positions in the Research Councils.

National Research Networks (NRNs) have been established in the three Grand Challenge areas: – Life Sciences and Health, Low Carbon, Energy and Environment and Advanced Engineering

and Materials. These are areas where we have existing academic and commercial strengths. We have worked with our partners in the research-intensive universities across Wales to put in place these NRNs. In March, they were officially launched by the Minister for Economy, Science and Transport. It is only early days yet for the NRNs, as they seek to build the strong connectivity and close working relationships, needed for greater efficiency.

The Chief Scientific Adviser for Wales (CSAW) is currently considering the scope and means for investment in future capacity building and in facilitating the success of our research groups.

NRN Life Sciences and Health

The network in Life Sciences and Health is led by Cardiff University, in partnership with Aberystwyth, Bangor and Swansea Universities. The focus will be drug discovery and development for unmet medical needs. It aims to co-fund up to 80 PhDs and 30 short-term fellows over the period 2014-19. The network is led by Professor Chris McGuigan, Scientific Director, well known for his anti-viral drug development work and Professor Malcolm Mason, Clinical Director, a leading oncologist, known for pioneering research in the treatment of prostate cancer. The network has already part-funded 15 studentships and 2 'endeavour' projects ('endeavour' funds research development activities to build consortia).

NRN Advanced Engineering and Materials

The National Research Network for Advanced Engineering and Materials is hosted Swansea University, and its principal partners include the Universities of Cardiff and Bangor, and the Welsh Technology Centre of TWI (a multinational research and technology organisation). This network is directed by Professor Javier Bonet, a world-leading expert in computational modelling and its application in engineering. The network aims to fund up to 40 PhD students and 16 Research Fellows. The network will be looking to deliver high quality, collaborative research that engages with the ultimate end user. This could be anything from manufacturing industry or the NHS to the European Space Agency or MOD. The research will focus on new materials and innovative manufacturing processes, advanced sensors and devices and novel modelling technologies. The network has already funded 8 PhD studentships.

Above: Mrs Edwina Hart, Minister for Economy, Science and Transport with Professor April McMahon, Vice Chancellor of Aberystwyth University, Professor John Hughes, Vice-Chancellor of Bangor University and three of the four National Research Network Directors, Professor Malcolm Mason, Professor Javier Bonet and Professor David N. Thomas and Professor Julie Williams, CSAW.

NRN Low Carbon Energy and Environment

The National Research Network for Low Carbon, Energy and Environment is hosted by the Aberystwyth-Bangor Strategic Alliance, at Bangor University and is led by Professor David N. Thomas, a prominent polar marine biologist, with considerable experience of leading successful multinational teams. It is a major new initiative for research into the interactions between land, water, the provision of food, and also energy production. The network is a partnership with the Universities of Cardiff, Swansea and Glamorgan, the Centre for Ecology and Hydrology at Bangor, the UK Met Office and British Geological Survey – Wales. The network will fund up to 10 PhD students and 20 Research Fellows who will be embedded into National Research Network research clusters.

Over the past year we have also been fortunate in attracting three Sêr Cymru Research Chairs of the highest international standard, which our ambitions sought for Wales.

Professor Yves Barde is a Swiss academic, previously at the Biozentrum at the University of Basel, widely renowned for his discovery of a brain protein. He named this protein 'brain-derived neurotrophic factor (BDNF), and in 1989, he published the complete nucleotide (DNA) sequence in *Nature*. BDNF is vital to memory and other neurological processes. These findings have cemented Yves Barde's name into neurobiology history and researchers from all over the world have worked with him, mainly in relation to this growth factor. Professor Barde has now come to Wales to continue his research into neural proteins and their links to neurological disease, providing a superb addition to Cardiff School of Bioscience's existing strength in neuroscientific research. Already he has attracted several highly-regarded younger researchers who are widely reckoned to have bright futures in life-science research, to join his team in Cardiff.

Above: Professor Yves Barde with the First Minister of Wales.

Professor James Durrant, from Imperial College London, was appointed to the new Sêr Cymru Solar Energy Research Chair in October 2013. He is a leader in his field – the development of new chemical approaches to solar energy conversion. He now leads the new 'Sêr Solar', a world-class dedicated solar futures research facility, co-located to work closely with Swansea University's SPECIFIC project, at the Innovation and Knowledge Centre (IKC) on Baglan Energy Park.

They have formed a unique partnership of Swansea University leading a consortium of Welsh universities and Imperial College – home to the UK's largest research group dedicated to the development of new solar technologies. Others from the Imperial team, such as leading solar energy researcher Professor Jenny Nelson are joining this research centre, led by Swansea University and including Bangor University and the Welsh School of Architecture in Cardiff. James Durrant's appointment is the first step in building a world-leading capability in emerging solar energy technologies, putting Wales at the heart of the clean energy revolution.

Above: Professor James Durrant and Professor Jenny Nelson.

Above: Professor Andrew Barron.

Professor Andrew Barron was appointed as Sêr Cymru Research Chair in Low Carbon, Energy and Environment, based with Swansea University, early in 2014. Recruited from Rice University in Houston, Texas, he holds the Charles W. Duncan Junior-Welch Chair of Chemistry and is Professor of Materials Science there. He is founding Director of the Rice University – Energy and Environmental Systems Institute (EESI) and also a senior member of the Richard E. Smalley Institute for Nanoscale Science and Technology – a world-leading Nanoscale research Institute, founded by a Nobel Prize-winner working in the field. Professor Barron has started to work at Swansea and will be leading Swansea University's new Energy Safety Research Institute (ESRI). His research crosses all three of our Grand Challenge areas. For details on the breadth of his interests see his research pages at Rice.

Strategic Aim: The proportion of research in Wales' universities achieving 3* and 4* quality and impact levels to reach the highest UK level.

Results for the Research Excellence Framework (REF) exercise are being released from December 2014. Wales stood at 49 per cent compared with England's universities at 55 per cent in the last such exercise – the Research Assessment Exercise (RAE) but this was back in 2008. This is a long-term target and can only be assessed every few years. It is, however, a focus for all of our work in bringing in Research Chairs; building networks; encouraging collaborations and promoting and supporting researchers. It will contribute to this longer term aim of improving research excellence.

Strategic Aim: Facilitating the success of women in science and engineering.

The House of Commons Science and Technology Committee's recent report *Women in Scientific Careers* (HC701, February 2014) recently showed the hurdles women can face in pursuing fulfilled and long-term research careers and their difficulties progressing through the academic hierarchy to leading positions in research and governance. Too few women are choosing to study and have careers in science, engineering and technology. We need to cut a high attrition rate from leaving research and not being able to find a way back in, after a period of time away.

The CSAW is concerned to address this and other challenges, and has established a 'Women in Science' group, bringing together a number of influential scientists who will develop actions to address this issue. We are also discussing potential joint funding of Daphne Jackson Fellowships. These have an over 90 per cent success rate in bringing women scientists back into research careers.

Sêr Cymru already contains key performance indicators relating to encouragement of under-represented groups into the research fields concerned. The Athena Swan awards scheme already encourages and highlights best practice in universities in promoting female research careers and we strongly support the scheme.

The Welsh Government plans to hold a conference for young women in September to encourage them to consider less traditional roles and instead look to roles in Science, Technology, Engineering and Mathematics and as decision makers in public service.

The CSAW has already spoken to a number of groups with an interest in this imperative and her team are investigating further effective means to convey positive messages about women's careers in science, including communication by senior role models. Actions to encourage more girls to study scientific subjects are discussed below at page 31.

Strategic Aim: Underpinning Science, Technology, Engineering and Maths (STEM) outreach; e-infrastructure; exploitation of intellectual property and fundamental research.

Activities which are supportive of underpinning fields of activity are reported on under the appropriate section below. For e-infrastructure, however, *Digital Wales: A Review of Delivery* (2013) sets out progress across a range of initiatives designed to widen and deepen e-infrastructure across Wales. Probably the most significant progress to note since then is the continued rapid roll-out of super-fast broadband across all of Wales, both through private-sector providers and

through the Superfast Cymru partnership between the Welsh Government and BT. A further update on overall progress on *A Digital Wales* is expected later in the year.

It is important to remember the context within which *Science for Wales* was adopted. The Welsh Government's overarching *Programme for Government* set out the wider commitments and goals for the present term of government. *Science for Wales* has clear ambitions for our scientific and technical resources to be applied to support and contribute directly to the economy of Wales. Two particular goals are supported:

- 'The building of strong links with our anchor companies…embedding them in the Welsh economy by developing close links with our further and higher education institutions.'
- 'Encouraging collaboration between our universities and the best universities outside Wales…and the scientific knowledge and expertise of our world-leading academic groups to be made available to support innovation and job creation in Wales.'

Beyond these, *Science for Wales* actions also support a number of goals in the health, education and environmental elements of the *Programme for Government*.

The ‘Grand Challenge’ Priority Programme

Image courtesy of Project Beacon. Swansea University Researcher examining Protein Gels.

Science for Wales conceived these three areas, where Wales and the wider world had to surmount considerable challenges but where we had both objective academic strength and further potential as well as businesses which were or could exploit the knowledge emerging from research within these broad fields.

The Life Sciences and Health Grand Challenge

The Welsh Government and the Life Sciences Sector Panel have committed to making Wales the best possible environment for Life Sciences innovation and business growth.

Their vision concentrates on facilitating the growth of a dynamic life science ecosystem, leveraging financial investment where industry, academia, clinicians and government collaborate and delivering a sustainable economy and excellence in healthcare innovation.

Above: BioWales 2014 – trade stands.

BioWales, the signature event for the Life Sciences sector in Wales and the vehicle for Welsh companies and academic departments to exhibit their expertise to an international audience, continues to grow in reputation and scale. Around 600 delegates attended BioWales 2014, which focussed on growth and delivery within the Sector and brought together an international line-up of industry experts to discuss advances in regenerative medicine and diagnostics. The event also hosted around 1,000 one-to-one technology brokerage meetings, where collaborations, licensing and manufacturing deals were discussed.

The Welsh Government, through the National Institute for Social Care and Health Research (NISCHR), is establishing a health research register. It will act as a resource to support population – based research and recruitment to studies and trials. It will facilitate the participation and engagement of large numbers of individuals who are part of the NHS in Wales. Creating a community of 'research-ready' individuals in this way will also enable the provision of opportunities for the public to be partners in priority setting and knowledge creation.

Life Sciences Investment Fund

A £100 million fund dedicated for the life sciences sector in Wales is operational and is being used to invest in the most promising life sciences businesses in Wales and to attract life sciences companies and entrepreneurs to Wales.

In May 2013, the Merthyr-based Simbec Research Limited, one of the UK's leading clinical research organisations, benefitted from the first investment of the Fund. The leading Stem Cell company ReNeuron became the second recipient of investment in August 2013 and as a result will be setting up its headquarters, R&D and manufacturing operations in south Wales. In March 2014, the fund announced a third investment into the AIM-listed pharmaceutical firm Verona Pharma who specialise in medicines to treat respiratory diseases. They will also relocate their headquarters to Wales.

Arthurian Life Sciences, the fund management team, continue to develop a strong deal-flow pipeline report and further investment are expected.

Life Sciences Hub

Life Sciences Hub Wales Limited, tasked with operating the Life Sciences Hub has been established. The Hub, based at 3 Assembly Square, Cardiff Bay, is a key element of the Life Science Sector Panel's vision to grow the sector and establish Wales as one of the best environments in the world for Life Sciences innovation.

The Company will deliver the Hub's three key themes – to connect and concentrate Life Sciences in Wales, to attract new opportunities and investment to Wales and to accelerate the growth of Life Sciences in Wales. There is significant interest from stakeholders in taking up core occupancy and membership at the Hub. In December 2013, Johnson & Johnson Innovation became the first private sector tenant to have taken a place at the Life Sciences Hub. At BioWales 2014, it was announced that GE Healthcare will also take up membership. The Life Sciences Hub is due to open in summer 2014.

Other News and Developments

There have been a number of other key initiatives in life sciences and health that underline its importance to Wales and the commitment shown by the sector.

PRA International, a leading clinical research organisation, supported by £1.29 million business finance from Welsh Government have announced that it is expanding its Clinical Informatics Team in Swansea by establishing a new multi-lingual Help Desk that will create 100 new graduate jobs.

Construction work has commenced on the new Data Science @ ILS building at Swansea University. It will house the £5 million Farr Institute of Health Informatics Research, the £4.3million Centre for the Improvement of Population Health through e-Records Research (CIPHER); and the new £8 million Administrative Data Research Centre Wales (ADRC Wales). There is more information on this at page 15.

Ortho Clinical Diagnostics, Pencoed and Packaging Coordinators, Hay-on-Wye were announced as Welsh Government 'Anchor companies' in January 2014, joining the existing five in the Life Sciences Sector. The Welsh Government has committed to working closely with Anchor companies to create jobs, growth and wealth in their respective sectors.

Above: Courtesy of Institute of Life Science at Swansea University – Researcher from the College of Medicine, based within the Institute of Life Science at Swansea University.

NISCHR

The Welsh Government's National Institute for Social Care and Health Research (NISCHR) is at the forefront of research and development in health and social care in Wales.

NISCHR is carrying out a review and restructuring of NISCHR-funded infrastructure and programmes. Consultation on the new proposals has now finished and plans are in place to issue calls for proposals during May and June 2014.

'Health Research Wales', the one stop source of information for industry, was

established by NISCHR and celebrated its first birthday at BioWales 2014.

In July 2013, NISCHR launched the new Research for Patient and Public Benefit Wales funding scheme, for NHS based researchers to conduct high quality patient and public focused studies in Wales. Nine awards have been made with a total value of £1.7 million.

The NISCHR Faculty, to support and recognise researchers in Wales in health, social care and life sciences, is now established. It has over 180 members, including 21 Senior Faculty members. NISCHR looks forward to working with this community, through a programme of activities including training and mentoring programmes.

12 NISCHR Social Care research awards were made in 2013, totalling the value of £2 million.

Researchers in Wales were involved in 3 successful applications from the NIHR Invention for Innovation scheme 2013 (NIHR is the English NHS National Institute for Health Research). This supports collaborative research between NHS, academia and industry for the development of innovative healthcare technologies and their translation into the clinical area, for the benefit of patients.

Medical Research Council Centre of Excellence: Farr Institute, Swansea University

Following a national, open competition, a Swansea University-led collaboration was awarded status as one of four UK Centres of Excellence for e-health research. The four centres (Swansea, Dundee, Manchester and London) form a coordinated network – the Farr Institute. They are expected to develop a critical mass of academic talent, expertise and research outputs, to establish the UK as a world leader in e-health research. The Centre for Improvement in Population Health through E-records Research (CIPHER), led from Swansea University, is the co-ordinating centre in Wales. The total funding for this institute is a £17.5 million research award from a 10-funder consortium. The Farr Institute aims to deliver high-quality, cutting-edge research linking electronic health data with other forms of research and routinely collected data, as well as build capacity in health informatics research. The Medical Research Council (MRC) has also made £5 million capital funding available to each of the four Centres. Swansea University will use £2.5 million of this to design and build new technology that will provide cutting-edge IT tools for e-health research. The other £2.5 million will be match-funded with £3.5 million from Welsh Government, and used to fund a new building for e-health ventures in Wales.

Above: Professor Nazar Amso demonstrates Medaphor's ScanTrainer simulator which teaches complex ultrasound scanning skills.

Medical Research Council Centre of Excellence: Centre for Neuropsychiatric Genetics and Genomics, Cardiff University

The first centre of excellence in Wales – the MRC Centre for Neuropsychiatric Genetics and Genomics at Cardiff University is dedicated to harnessing the genetics revolution for research into mental illnesses; degenerative brain disorders and developmental disorders. It is building on existing strength as a world leader in neuropsychiatric science and, in the last few years, has identified over 100 genes contributing to disease. Since its foundation in 2009, the Centre has attracted £64 million in research income.

The Low Carbon, Energy and Environment Grand Challenge

Energy Wales: A Low Carbon Transition and a recently published Delivery Plan, in addition to the Energy and Environment Sector Framework, set out the achievements and actions required to deliver a low carbon, low waste economy.

Welsh Government recognises the cost of energy as one of the key issues affecting business competitiveness in Wales and as such it is a defined priority. Through innovation and green growth we can not only make companies more efficient but competitive.

BEACON

Led by IBERS at Aberystwyth University in partnership with Bangor University and Swansea University, BEACON operates through research partnerships, dedicated to developing industrial products from plants to reduce reliance on fossil based resources such as coal and gas. BEACON has worked with over 180 SME's to date, including 20 research and development (R&D) collaborations, creating 36 new jobs, inducing some €4.3 million investment and producing seven new products, processes or services.

BEACON recently won the prestigious European Commission's (EC) top award for innovative regional development, at the Regio Stars Awards 2014. They won in the 'Sustainable Growth' category for contributions to sustainable growth in West Wales and the Valleys, against competitors from right across Europe.

Above: Image courtesy of Project Beacon. PhD Student Researcher working with a Centrifuge – Beacon, Aberystwyth.

SEACAMS

Seacams is a Welsh research project that offers marine businesses access to research facilities, expertise and knowledge from Welsh universities, including Bangor. Seacams have been working with Minesto, an ocean power company, providing detailed data on the seabed conditions and tidal currents, which have been studied by Minesto.

Minesto's Deep Green resembles a sweeping underwater kite, comprised of a wing and a turbine, which is secured to the seabed with a tether and moves with high speed in an 8-shaped path in the tidal or ocean current. It is the only known technology in the world that is capable of producing energy in a cost-efficient manner in slow currents (1.5 – 2.5 m/s).

Technology Innovation Needs Assessment

The study commissioned in May 2013 identified Wales as having particular strengths in nuclear, offshore renewables including marine and electricity networks.

To maximise the economic benefits in terms of jobs, growth and wealth the Welsh Government has commissioned a nuclear capability study, is engaged with Bangor University and SEACAMs in developing the activity to support offshore renewables and is also working closely with organisations engaged in smart networks.

CSER

The Centre for Solar Energy Research (CSER) is a Centre of Expertise of Glyndŵr University and part of the Low Carbon Research Institute (LCRI) which collaborates on renewable energy R&D across Wales. Working in collaboration with industry and other academic partners, they have proven expertise and a world class reputation in researching novel photovoltaic materials and devices.

Enterprise Zones

Wales has over 41,000 people employed in 2,200 companies in the Energy and Environment Sector, contributing over £5.5 billion to the economy.

The scale of investment required to reach the UK government's 2020 offshore wind targets are estimated as being between £70 billion and £100 billion. Currently, more than 85 per cent of wind turbine/ on and offshore hardware is imported. The opportunities and challenges facing Welsh supply chains are therefore significant.

The Anglesey Enterprise Zone Board has identified the supply chain as one of its overriding priorities. This is in recognition of the major opportunity new-build nuclear presents on Anglesey. In addition, significant opportunities exist for joint working with the other Energy Enterprise Zones at Snowdonia and the Haven, for example, on skills. Welsh Government are also exploring opportunities for collaboration with a range of partners in North Wales, who have identified 'Energy' as one of three priority sectors for economic development activity in North Wales.

Low Carbon Vehicles

The existing automotive base in Wales is significant: over 250 automotive companies are based in Wales. Together they form around 40 of the top 100 global leaders employing around 25,000 people and bringing an estimated £3 billion to the Welsh economy annually. This places Wales in a good position to develop as a centre of excellence for low carbon vehicles, stimulate new growth opportunities and capitalise on the economic benefits. To this effect, the Welsh Government has set up a low carbon vehicle steering group, to provide advice and recommendations on developing this exciting sector.

Pwllpeiran Upland Research Platform

Aberystwyth University's Institute of Biological, Environmental and Rural Sciences (IBERS) has been successful in securing a lease of the Pwllpeiran farm estate to develop its Pwllpeiran Upland Research Platform, to focus on opportunities for the upland farming community in the UK and further afield. It's agricultural science research will contribute to the University's new Innovation and Diffusion Campus. The Biology and Biological Sciences Research Council or BBSRC has awarded £2.5 million to the project.

Above: Image courtesy of IBERS, Aberystwyth University. Site of the Pwllpeiran Upland Research Platform.

Arbed

The Welsh Government's energy efficiency programme includes the Arbed and Nest schemes. Arbed improves the energy efficiency of homes and helps development of the energy efficiency supply chain. Arbed phase 1 improved over 6,000 homes' performance across Wales. £26 million of external investment was secured, beyond the Welsh Government capital funding. In early 2012, a £6.6 million funding extension to phase 1 saw a further 1400 homes receiving measures and over £5m of external investment levered in. Arbed phase 2 builds upon the success of phase 1 and runs 2012-15 at a total cost of £45 million (£33 million ERDF and £12 million Welsh Government funding). It will install energy efficiency measures and renewable energy technologies to a minimum of 4800 existing homes in deprived areas of Wales, which will also benefit from local jobs and training in these measures and technologies. So far, all of the phase 2 schemes have been contracted to Welsh based SMEs or companies with established bases in Wales.

The Advanced Engineering and Materials Grand Challenge

The Welsh Government are working closely with Control Techniques (a leading company in AC and DC variable-speed drives, servos and power conversion technologies) to develop a multi-million pound, state-of-the-art R&D facility in Newtown which will create forty highly skilled technical jobs with construction due to commence in Summer 2014.

IQE – Vertical Cavity Surface Emitting Laser (VCSEL)

This project with IQE (a leading semi-conductor wafer supplier) will bring VCSEL manufacturing to a level comparable to LED manufacturing. VCSELs are key components that drive and enable a number of fast growing markets, including data transmission, camera surveillance, optical sensors, reduced energy consumption in data centres digital industrial thermal processing, high speed data communication and 3D recognition. It is a €23 million EU-funded ENIAC project, of which nearly €6 million will be spent in Wales. ENIAC is a public-private partnership focusing on Nanoelectronics. See also page 24 below for consideration of this as a strategic project.

Aberystwyth University Innovation and Diffusion Campus

Aberystwyth University announced, in July 2013, plans for an investment of £35 million in the development of a new UK Innovation and Research Campus at Gogerddan. It will be known as the Aberystwyth Innovation and Diffusion Campus or AIDC.

The development is funded by a £14.5 million investment from the Biotechnology and Biological Sciences

Research Council (BBSRC). Contributions from other stakeholders, including Welsh Government input, will bring the total investment to over £35 million.

The investment forms part of a larger, UK-wide Agri-Technology strategy. The UK Government believes Britain has the potential to be world-leading in agricultural science and technology. The Welsh Government is actively considering ways to exploit these opportunities.

AIDC will include a commercially focused training centre. It will enable departments within the University to work with IBERS to develop the bio-economy. It will also involve an upland research platform for the UK and a Public-Private-Producer Partnership for Food and Energy Security, built around an innovative, business facing plant breeding facility incorporating national capability for independent evaluation of new products.

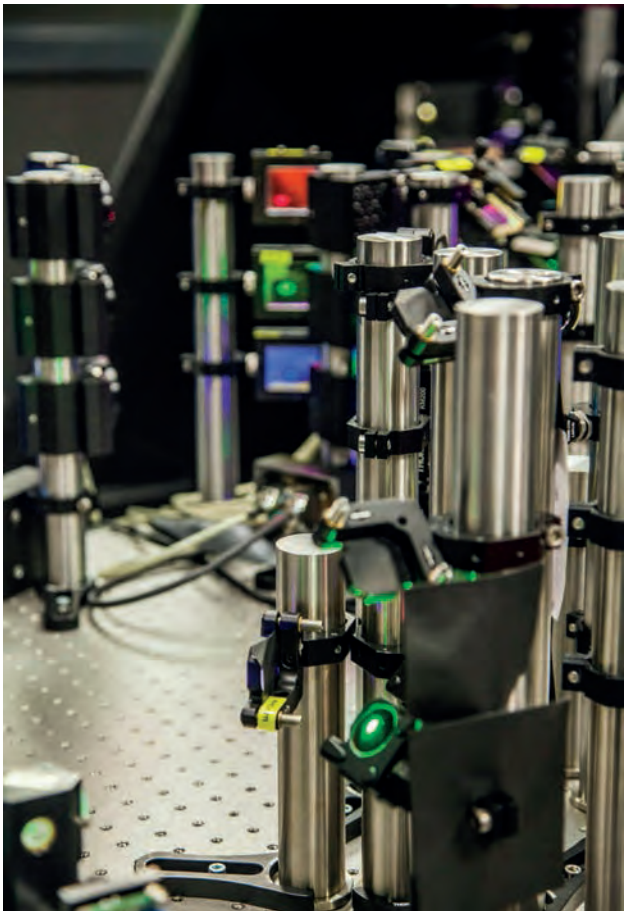
A4B Project – University of South Wales Knowledge Transfer Centre for Advanced Anaerobic Processes and Biogas Systems (AAPBS)

An A4B (also known as Academic Expertise for Business) grant of £889,220 into this project enables the Wales Centre of Excellence in Anaerobic Digestion to significantly raise its capability to work with industry, ensuring that the take up of Anaerobic Digestion as a sustainable waste treatment process and source of energy is accelerated throughout Wales and the UK.

The project supports two of *Science for Wales'* Grand Challenges by promoting links between the research base and industry through strategic collaboration, and enabling innovation and commercialisation to take place in Wales. This project will also allow Wales to develop a major strength in collaborative R&D in the low carbon, low waste economy.

More generally, a review of the A4B programme has been completed during the year. A number of changes have been made, to widen the scope of projects that universities can apply for and to simplify the process. This has resulted in an increase in the number and quality of applications, including improved SME and large company engagement from all sectors, in particular in the Advanced Engineering and Materials Grand Challenge sector.

In addition, a review of Intellectual Property (IP) Commercialisation is underway and a steering group established. Initial research and scoping of the review are complete. The plan is for the review to be completed and a draft report available in June 2014.



Above: Holographic Equipment – View Holographics.

Fujitsu e-KTP Case Study

Knowledge Transfer Partnerships (KTPs) place a student or graduate, with more senior academic support available to them, into a company to undertake a given project or piece of research. Fujitsu need to acquire and accumulate knowledge and expertise in numerical weather prediction and climate modelling, utilising its High Performance Computing (HPC) platforms. This will involve the capability to port, validate and optimise software such as the UK Met Office Unified Model and will support Fujitsu's strategic commercial expansion into the weather/climate markets. It will also improve Wales' capability in HPC and provide enhanced service level provision for the Met Office, impacting on high-resolution weather forecasting for the country as a whole.

The outcome of the project, which will be a fully-fledged Unified Model residing on HPC Wales, will be able to stimulate further first-class research and downstream applications on topics such as extreme storm prediction; urban planning and climate change adaptation. It will render the HPC Wales–Swansea University partnership as a new Wales-based knowledge hub.

European Funding

Strategic Aim: Facilitate greater synergy between EU Structural Funds and research programmes in Welsh universities and industry. Improvement of technical and peer review of Wales European Funding Office (WEFO)-funded research proposals.

Since taking up her post last September, the Chief Scientific Adviser for Wales has been leading the development of an application to the European Union, Marie Skłodowska-Curie 'COFUND' call for proposals. The vision is that this will be a Wales-wide bid, attracting Research Fellows into Wales working within our strategic themes, helping to build research capacity. If successful, there will also be opportunities to support Welsh researchers to spend time overseas to learn new skills and bring them back to Wales. An application will be submitted in September 2014 and funding decisions made in March 2015.

Co-ordination of the Structural Funds with other relevant funding streams is being given greater importance in the 2014-2020 period. The expectation is that these funds will be delivered in a more integrated manner across all Horizon 2020 activity. In line with this, for example, the Chief Scientific Adviser's Division in Welsh Government is working closely with colleagues in WEFO to develop a parallel strand of fellowship funding, to complement the COFUND application.

The 2014–2020 Structural Fund programmes have now started, with many opportunities for activity to further research, development and innovation. WEFO staff and stakeholders across Wales are in detailed discussions to develop projects and programmes, under both the new Structural Funds programmes and Horizon 2020. The European Commission's 'smart specialisation' approach, like *Science for Wales*, encourages a focus on areas of competitive strength. The related strategy *Innovation Wales* will now be used for guidance on investments under the innovation strand. Proposals for European Regional Development Fund (ERDF) investments in research and development focus on opportunities for the commercialisation of research, research infrastructure, and capacity

building. The CSAW has addressed European officials in Brussels to promote Welsh science and has developed a relationship with Professor Ann Glover, the Chief Scientific Adviser to the EU Commission and its President.

Strategic Aim: Working more closely with the higher education sector in improving research effectiveness and encouraging deeper and broader engagement with the UK Research Councils and the Technology Strategy Board (TSB).

We have developed an engagement plan to strengthen our dialogue with the Research Councils. This plan looks to maximise the quality, quantity and impact of research in Wales. Our objective is to position the Welsh Government as a credible partner for the Research Councils; promote the strengths of Welsh research; promote Research Council investment in research capacity and talent in Wales; develop jointly-funded projects; and draw on Research Council expertise and advice in delivery, priority setting, and information on emerging programmes. We held a number of meetings with several Research Councils in 2013 and 2014, including the Arts and Humanities Research Council (AHRC); Engineering and Physical Sciences Research Council (EPSRC); Economic and Social Research Council (ESRC); Natural Environment Research Council (NERC) and Research Councils UK (RCUK), the umbrella body. Work with the TSB, whom we also met, is reported under the Innovation section below at page 25.

Strategic Aim: Commission of a detailed study to establish the factors which determine our performance in winning competitive research grants and research funding in Wales.

Addressing this commitment in *Science for Wales* this report was published in February 2014 by global scientific publishing company Elsevier. Key aspects of it have already been considered above at page 5 above. It assesses the international comparative performance of the Welsh research base – the first wholesale independent analysis of Wales' research performance since devolution. *International Comparative Performance of the Welsh Research Base 2013* was commissioned jointly by the Welsh Government, the Higher Education Funding Council for Wales and the five research intensive universities in Wales. Its tracking indicators include published articles in scientific journals and the citation and usage of those articles. Using these, it addresses questions about the productivity and efficiency of Wales in its use of research inputs – both funding and researchers; how mobile is the research base in Wales; how does our research base compare to other UK constituent countries and comparable-sized research countries; has our volume of research and its impact changed over time; how good is our research base, using citation-based metrics relative to comparator countries and how collaborative internationally are Wales' researchers and with whom?

Overall, as noted above, it was an extremely positive picture. Business R&D in Wales is not extensive but measures of knowledge transfer and commercial impact of research are relatively strong, with positive figures for start-up and spin-off companies and intellectual

property. For its size, Welsh research has a high impact. It has a disproportionately high share of the world's published academic articles, global citations and highest-cited articles. It is both very productive and efficient, compared with countries of a similar size. Indeed, Wales is one of the most efficient in the world, counting academic publications per unit of Gross Expenditure on R&D.

Wales performs strongly in the social sciences and humanities – long known as areas of traditional strength in our universities. However, despite the existence of some objectively excellent research departments, science and engineering research does not perform so strongly. This is a key reason why Wales does do not win the 'population equivalent' share of UK Research Council grant funding which *Science for Wales* aspires to achieving. This is discussed on page 6 above.

We are concentrating on where change has occurred in this report. The Chief Scientific Adviser for Wales is investigating how we can build upon the initial success of Sêr Cymru with future initiatives to improve the Welsh research community's ability to win competitive grants. Her initial focus is on new ways of attracting and retaining promising research talent for Wales.

Strategic Aim (longer term):
Promotion of more effective research collaboration and use mergers between departments to form stronger research entities of sufficient size.

The Welsh Government's Higher Education reconfiguration agenda, running through the past decade, has affected the larger research institutions rather less than smaller, teaching-focused universities.

Of the research-intensive universities, Cardiff has significant subject range and broad research strengths. It is a member of the Russell Group of leading research universities and accounts for around half of Wales' total Research Council income. Swansea, Aberystwyth and Bangor all have a moderately extensive range of subjects and particular research strengths, for example, engineering at Swansea; environmental sciences at Aberystwyth and psychology at Bangor. All three, however, remain relatively small institutions, by UK and global standards. The challenges of geography and the need to maintain a regional balance mean that it would be difficult for our four research-intensive universities to merge departments. It is essential, however, that they all seek to collaborate with the best, within and outside Wales and there are numerous examples of this happening:

- As noted, the strategic alliance between Aberystwyth and Bangor, which includes a joint Centre for Advanced Functional Materials and Devices, Centre for Catchment and Coastal Research, Centre for Integrated Research in the Rural Environment, and an Institute of Medieval and Early Modern Studies.
- HEFCW-funded pan-Wales research collaborations, such as Wales Institute of Cognitive Neuroscience and the Wales Institute of Social and Economic Research, Data and Methods (WISERD).
- The National Research Networks created as part of our Sêr Cymru programme.
- Cardiff's collaboration with partners in south-west England through the Great Western Four (GW4) structure.

- Recent AHRC and NERC doctoral training partnerships involving Cardiff, Aberystwyth, Bangor, Swansea and other partners across the UK.
- New Research Council centres including the EPSRC Centre for Innovative Manufacturing in Large-Area Electronics, in which Swansea is working alongside Imperial College, Cambridge and Manchester Universities.

Promoting Business Innovation and the Exploitation of Science

Image courtesy of Centre for Nanohealth in the Institute of Life Science at Swansea University. Microneedle Array Wafer.

It is of note that the two main *Programme for Government* commitments which *Science for Wales* supports have a focus on improving the economy of Wales. This chapter acted as a catalyst for more detailed work to develop best practice innovation actions, which will have that effect. *Innovation Wales* is now in place and will report separately as it goes forward, taking responsibility for innovation metrics. We plan for activity in innovation to be closely aligned with the future activity on the science side.

Strategic Aim: Development of a new national innovation strategy, based on the framework laid out in chapter four of *Science for Wales*.

Innovation Wales was formally launched on 15 July 2013. It recognised the commonly-held view of innovation as being technology focused but pointed to the far wider possibilities for creativity and innovation that exist. It was prepared using the EU's 'Smart Specialisation' approach, which calls for plans and investments to build on clearly evidenced strategic priorities. We can promote innovation across all sectors of the Welsh economy, but must recognise and prioritise strengths. In Wales' case, Life Sciences and Health, Low Carbon Energy and Environment, Advanced Engineering and Materials, ICT and the Digital Economy were the areas of excellence identified in *Science for Wales*.

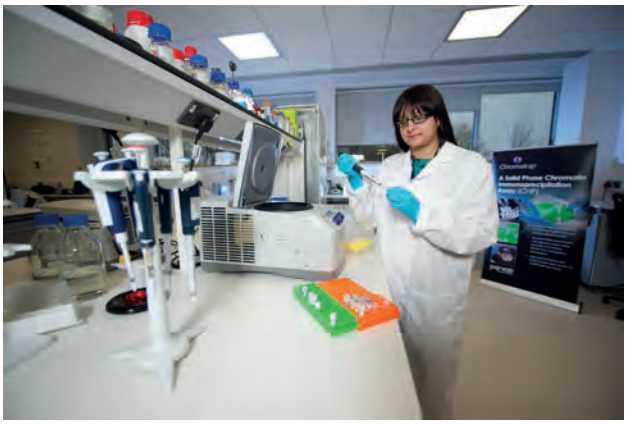
To promote such broader innovation, which benefits the economy in Wales, *Innovation Wales* calls for forward-looking, more flexible ways to nurture business innovation. It looks for improved public procurement and effective collaboration by all levels of government and of businesses, academia and others looking to access UK and EU funding streams.

Strategic Aim: Depending on the new innovation strategy development, we would consider an over-arching innovation strategy board, to advise the Minister for Economy, Science and Transport.

Science for Wales already has existing processes for monitoring and governance, through reports to Welsh Ministers and advice from the Science Advisory Council for Wales (SACW).

The 'Smart Specialisation' process similarly requires *Innovation Wales* to have a robust monitoring and governance system, including meaningful representation from the 'Triple Helix' of Government, Higher Education and Business.

A light touch arrangement, similar to that of the sector panels, will be adopted. A Chair and Vice Chair will be appointed for a period of three years. These two appointees will then invite up to twelve suitable representatives of business, higher education, government and third sector bodies to form the Innovation Advisory Council or IAC.



Above: Epigenetics academic/business collaboration of Swansea University with Porvair Filtration Group and Ig Innovations, developed with A4B funding.

The IAC will meet twice a year, monitor progress against the delivery plan of *Innovation Wales* and provide advice, both to the Minister for Economy, Science and Transport and to officials.

Strategic Aim: To support priority funding and investment opportunities and work with existing strategic projects such as in high performance computing, to ensure Wales takes full advantage of the investment.

The IQE Vertical Cavity Surface Emitting Laser (VCSEL) project described at page 17 above is one such priority project. Each £1 of Welsh Government contribution will leverage £1.86 of investment into Wales. Although it is a stand-alone R&D project, it is part of IQE's strategic plan to establish Europe's fifth semiconductor cluster, Foundation and Foundry in Compound Semiconductor Technology. Thus, support for the R&D project has significant potential to leverage investment into Wales and to enhance Wales' reputation as a leader in the emerging area of VCSEL manufacturing in the medium and long term.

High Performance Computing or HPC Wales is making progress towards achieving the targets required of it by the funding bodies, principally WEFO. So far, HPC Wales' main activity has been the procurement, installation and commissioning of its main high performance computing hardware so that it has now got two fully functioning HPC hubs in Cardiff and Swansea Universities, with several spoke access nodes in other institutions in Wales. The focus now is on developing the applications and user base. Although HPC Wales has made modest advances hitherto, it has demonstrated quite clearly the potential for pure research, collaborative industrial research and development and commercial services which HPC offers. The current funding regime will end in May 2015 and HPC Wales is now embarking on development of the business plan, to sustain it beyond this date. A multi-funding model is envisaged combining public, private and collaborative research sources of funding.

Above: © HPC Wales 2013 – The HPC Wales Swansea Hub, part of the UK's largest distributed computing network.

Strategic Aim: To encourage Welsh involvement with the Small Business Research Initiative (SBRI) of the Technology Strategy Board (TSB).

A first Welsh-orientated Small Business Research Initiative (SBRI) Catalyst fund has been established during the year, with a total of £3 million, jointly funded by Welsh Government and the TSB. The programme is raising the profile and engagement across Welsh public sector bodies in the national SBRI programme, and encouraging Welsh businesses to apply to national competitions. The goal of the SBRI Catalyst Programme is to lead a change across the Welsh public sector in innovative procurement, by specifying outcomes rather than products. Ultimately, it aims to bring about a culture change, using the public sector as an intelligent lead customer to help

grow the Welsh R&D industry, increase commercialisation of new technologies and create jobs and wealth for Wales.

In the first round, from 27 public sector expressions of interest, an assessment panel recommended four for approval. These four Welsh public bodies receive £1.2 million in support from the TSB and launch SBRI Competitions offering £2.5 million in pre-commercial procurement contracts to the business community. Challenges included retro-fitting of energy efficient solutions for historic buildings, protecting rivers and young trees from environmental damage caused by cattle, and better use of hospital data to help inform health service planning, as well as freeing up nurses' time for patients. Work on developing the most promising solutions is ongoing. Details of the four are listed further down in this section.

A second round of SBRI Catalyst fund discussions are well advanced and we expect to launch a call for expressions of interest during May 2014.

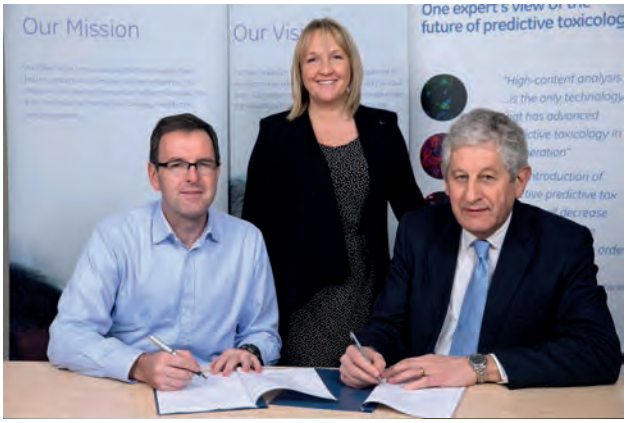
Strategic Aim: Conducting an options review to maximise overall impact of public funding for commercialisation and university engagement with business in Wales.

Strategic Aim: Undertaking a review of intellectual property commercialisation models, the emerging collaborative approaches between major research-led universities and implications of the Hargreaves review of intellectual property, and recommend the best option for maximising the economic benefit from intellectual property in universities, the NHS and businesses in Wales.

The intellectual property review has been commissioned, with a steering group established. Initial research and scoping of the review are complete, with meetings with key stakeholders arranged. It is planned that the review will be completed and a draft report available in June 2014.

Strategic Aim: With EADS, rigorously evaluating their foundation model and taking steps to disseminate what has worked well, encouraging anchor companies adopt 'open innovation' models.

Seven anchor companies – Cassidian; General Dynamics; IQE; Norgine; Pure Wafer; Tata and Wales and West Utilities are accessing a total of up to £3 million Welsh Government funding in an 'open innovation' pilot scheme. Each is developing a bespoke programme of activity, with its Welsh supply chain and other SMEs, aimed at new product development, academic engagement and collaborative working. A key requisite of the scheme is the obligation to meet regularly, to share best practice and to disseminate their successes and ideas to other Welsh companies.



Above: Professor Julie Williams, CSAW witnesses Ger Brophy, Chief Technology Officer of GE Healthcare and Swansea University Vice Chancellor, Professor Richard B. Davies signing

the Memorandum of Understanding between Swansea University and GE Healthcare, to collaborate on science research and development projects.

SME Participation in, and feedback on, innovation programmes:

Business Innovation Programme

This programme offers support for new product development and best practice development in manufacturing, design and intellectual property.

In the financial year 2013-14, the programme has assisted 316 businesses, with 73 receiving financial support. 151 new products, processes or services were launched and 190 registered, with a direct profit benefit of £5 million to date. £7 million of investment was induced and 78 new jobs created.

	Business Innovation in the Structural Funds Convergence Area (West Wales and Valleys)	Business Innovation in the Structural Funds Competitiveness Area (East Wales)	Total
Grants Paid (£)	2,363,407	1,703,668	4,067,075
Private Sector Investment (£)	1,087,895	898,150	1,986,045
Enterprises Financially Supported	40	33	73

SMART Cymru

SMART Cymru supports a full range of innovation activity from conceptualisation to market placement for products, processes or services. This begins with technical and commercial feasibility, through industrial research and experimental development, to commercial exploitation. SMART can also fund larger enterprises (such as anchor companies). For the period April 2013-February 2014:

Grants Paid (£)	1,350,474	725,179	2,075,653
Private Sector Investment (£)	1,495,139	802,570	2,297,709
Enterprises Financially Supported	22	13	35

Small Business Research Initiative (SBRI)

Results for the initial round of challenges are:

SBRI Challenge Owner	Project	Total Project Cost (£)	Welsh Gov./TSB Input (£)	Status
Betsi Cadwaladr University Health Board	Improving patient care – Seeking to reduce the transactional overhead, address data entry challenges / workflow automation – enabling nurses and care givers to spend more time with patients.	£1.2m	£500k	**Approved** Finalists selected
Natural Resources Wales	Controlling livestock access around watercourses and riparian zones to reduce the impact of agriculture on the water environment.	£191k	£80k	**Approved** Finalists selected
Cardiff Council	Energy Efficiency in Traditional and Historic Buildings – sensitive and affordable retrofit solutions for the historic built environment.	£550k	£275k	**Approved** Launched Applicants being reviewed
ABMU Health Board	Improve the health and well-being of our population through the better use of population health information (SAIL Databank)	£958k	£400k	**Approved** Finalists selected

New RD&I projects undertaken by Anchor / non-SME businesses – 2013 – 2014

Company	Sector	Partner(s)	Type
Cassidian*	ICT	Welsh Government	Open Innovation Pilot
Admiral	F&PS	Welsh Government	SMART Cymru
General Dynamics	ICT	Welsh Government	SMART Cymru
General Dynamics	ICT	Welsh Government	Open Innovation Pilot
Airbus	AM&M	Technology Strategy Board (TSB), Welsh Government	Sectors & Business – Collaborative R&D project
IQE	ICT	Welsh Government	Open Innovation Pilot
IQE	ICT	Welsh Government, EU-funded ECSEL	Sectors & Business – Collaborative R&D project
Norgine	LS	Welsh Government	Open Innovation Pilot
Pure Wafer	ICT	Welsh Government	Open Innovation Pilot
Tata Steel	AM&M	Welsh Government	Open Innovation Pilot
Tata Steel	AM&M	Swansea University	SPECIFIC – Innovation & Knowledge Centre
Welsh Water	E&E	University of South Wales	Anaerobic Digestion project
Quotient Bioresearch	LS	Welsh Government	SMART Cymru
International Rectifier	ICT	Welsh Government	SMART Cymru
Celsa Holdings	AM&M	Welsh Government	SMART Cymru
Wales & West Utilities	E&E	Welsh Government	Open Innovation Pilot

Key

AM&M – Advanced Material & Manufacturing Sector
E&E – Energy & Environment Sector
F&PS – Financial & Professional Services Sector
LS – Life Sciences Sector

* (now Airbus (Defence & Space))

Increasing the Science and Engineering Talent Pool

Image courtesy of Techniquest. Pupils at Blaengwawr Secondary School choosing music acts at the 'Backstage Challenge' workshop.

STEM Education and Engagement

Strategic Aim: Developing a STEM (Science, Technology, Engineering & Mathematics) strategy.

We are developing our STEM strategy through implementing key actions, undertaking reviews of qualifications and the curriculum, providing longer term grant funding, enhancing teacher support and improving internal co-ordination. A survey of existing activity, while it proved a useful snapshot, showing the huge variety in both provision and providers, served to show just how hard it is to get a complete and up-to-date picture of the many different activities going on in this field. Because of this, it was not as useful as we had hoped for informing coordination work in the field.

The CSAW's Science Advisory Council for Wales (SACW) has examined science engagement activities and published a task and finish report on their website, with sixteen recommendations. Most are addressed to the NSA and are now being considered.

A key aspect of maximising our STEM talent, as already discussed, is bringing more women into long-term scientific and engineering careers. We must work to attract women into these areas and to increase the numbers of girls studying scientific subjects at school and college.

In November 2013, a review, commissioned by the then Minister for Education and Skills reported on gender differentials in science in schools, following work with the Institute of Physics and other concerned stakeholders. Physics is of particular concern. Since 2008 only around 20 per cent of 'A-level' physics students have been girls (the equivalent figure in England is 21 per cent and in Northern Ireland 29 per cent). Girls have performed slightly better than boys when they do take 'A' level physics. This is true too for 'A' level chemistry and biology, where the take up by girls is significantly higher than that for physics, at 46 per cent and 55 per cent of 'A' level students respectively.

Raising the numbers studying these subjects, but especially physics (where numbers of girls taking A-level are stubbornly low) depends on actions in schools and further education colleges, as well as on engagement activities out of formal education. Supportive activity from universities and research bodies is needed to maintain the 'pipeline' of candidates, as well as programmes by the business community to recruit and train more young women into scientific and technical careers.

Above: Image courtesy of Techniquest. Pupils at Blaengwawr Secondary School working with a heat-sensitive camera.

The Welsh Government has a vital role in encouraging support and promotion of women in all these areas. For example, we funded Advanced Materials and Manufacturing Sector schemes, such as The Ford Saturday Club and the Airbus Industrial Cadets scheme, helping to encourage girls into careers in engineering. Plans are being developed,

as this report goes to publication, to enhance efforts to make the case for more girls to follow physics and other science qualifications and consider progressing into scientific, engineering and technical degree courses and careers.

We have said that the CSAW is already engaged on this imperative. A role model herself for what women can achieve, Professor Julie Williams is extremely keen to see more role models and examples, at all levels and in all fields, to inspire and influence women into science. We are pleased that of some 1400 STEM Ambassadors in Wales 600 (43 per cent) are women. We need to keep countering the myth that science is difficult or exclusive and that long term careers in it are unattainable – especially for women.

Our National Science Academy (NSA) Grant Scheme has awarded grant funding to the Swansea University taster experience. This gives prospective university students a sample of the STEM subjects they could expect to study. We would hope to see many girls using this opportunity to investigate these subjects. Also funded by NSA are the 'Engineering Education Scheme Wales' (EESW) programmes, including their 'Girls into Engineering' Programme. Such schemes look to rectify the gender imbalance, not least by providing an insight into industry and manufacturing and raising awareness of career opportunities. EESW also now lead on provision of 'Big Bang Cymru', the popular science festival. Careers Wales provides an all age advice and guidance service to anyone considering STEM related careers. Activities include and have included, the 'Discover Saturday Clubs' and 'Steps to Work' STEM initiatives, all aimed at young people.

Review of Qualifications

The Welsh Government wants to see science qualifications, indeed all qualifications, aligned to an engaging and relevant programme of study, set at the right standard so that universities, employers and other 'users' of such qualifications remain confident of their rigour and robustness and the system of public examinations. That is why reform of A-levels and GCSEs is now underway, so students from Wales continue to have qualifications that are valued across all the nations of the UK and in the wider world.

The Welsh Government is currently working with awarding organisations and stakeholders to develop new specifications for the revised A-level science suite to be taught from September 2015. They will ensure that their content meets Wales' requirements for AS and A-levels. In Wales, practical elements are considered to be an important part of science, so assessment of practical skills should continue to make up part of the final grade.

GCSE science subject qualifications will be revised, for teaching from September 2016, to incorporate key scientific thinking and skills elements. Welsh Government staff are working with awarding bodies, among other stakeholders, to develop the new specifications.

To underpin common standards, it is likely that GCSEs in science will be the only science qualifications that will count towards key school performance measures in future. We will work with experts to ensure there is a suitable and coherent suite of science qualifications available at Key Stage 4.

Two new mathematics GCSEs are planned. The first will focus on numeracy

and the mathematical skills and techniques needed for everyday life. The other will incorporate other aspects of mathematics, including those needed for progression to scientific, technical or further mathematical study. We would hope that as many as possible of our Welsh cohort choose to study both GCSE courses, to allow them to progress to study of scientific and technical subjects.

Great consideration was given to including science as part of the requirement for the Welsh Baccalaureate pre-16. To keep a clear, simple narrative to explain the purpose and design of the Welsh Baccalaureate, science has not been made mandatory. The new model has been defined around the skills that all learners need to develop and progress to Further Education, Higher Education or work, as well as to function as active and engaged citizens. Welsh First Language/English and the mathematical elements of numeracy are included, as they contribute to developing general literacy or numeracy skills required for all manner of careers, not just scientific or technical ones.

Review of assessment and the National Curriculum

The Welsh Government recognises the critical role of science and technology in education. It is committed to ensuring that the curriculum reflects the needs of business and the economy. Science is a priority area and STEM subjects must be in the vanguard of modern, challenging curricula for students in Wales. The curriculum and schools must inspire young people in science, provide a firm grounding in key knowledge and skills and support a stronger progression pathway throughout the educational phases.

In October 2013, the Minister for Education and Skills announced that the Curriculum Review would now be taken forward in two phases, with consideration of science subjects forming part of the second. In March 2014, Professor Graham Donaldson was tasked with leading these independent considerations – putting forward recommendations for a clear vision for education in Wales, from Foundation Phase to Key Stage 4, by the end of this year. His recommendations will be linked to Wales' new Qualifications system. He will work with a wide range of stakeholders, considering a broad set of issues relating to curriculum and assessment arrangements in Wales. These will include the critical role of science and STEM subjects. He will consider, among other reports from independent task and finish groups, the ICT Steering Group's report to the Welsh Government. His work will complement the Welsh Government's recent consultation on strengthening and supporting the teaching of literacy and numeracy in the curriculum in Wales.

PISA 2012

PISA (Programme for International Students Assessment) is a survey of educational achievement run by the Organisation for Economic Co-operation and Development (OECD). PISA does not itself assess mastery of curriculum subjects. Assessments of the knowledge and skills of fifteen-year olds in participating schools on their competence to address real life challenges involving reading, mathematics and science are conducted every three years. Each test round majors on one of the three subject areas. In 2012 it was mathematical literacy and in 2015 it will be scientific literacy.

Year / Subject	Maths Mean Score	Science Mean Score	Reading Mean Score
Wales in 2006	484	505	481
Wales in 2009	472	496	476
Wales in 2012	468	491	480
Score change 2009 – 2012	- 4	- 5	4

Wales has been involved in the last three rounds. 3305 learners from 137 schools took the latest tests in late 2012. Learners also provided contextual information about themselves (social background, study habits) and participating schools provided information on their size, resources, organisation, etc. Wales' full results are on here, with English and Northern Ireland results here and the OECD website hosts the full results and reporting. It is of concern that scores for maths and science both fell. We do know that PISA-style questions demand high level literacy and numeracy skills and our young people can find reasoning and problem solving skills hard, so this is where we need to seek real improvements. Given that the next round majors on scientific literacy, all of our future actions will go towards trying to bring these scores, up in that round.

Above: Image courtesy of Techniquest. Pupils at Cardiff Sixth Form College working in a Laboratory.

STEM Skills, Apprenticeships and Foundation Degrees

Spending plans for an extra £40 million over the two years to April 2015 have been announced for apprenticeships in Wales. This includes facilitating the delivery of STEM apprenticeships. Opportunities exist in a range of relevant occupations – from aircraft engineer to pharmacy technician and software developer. All frameworks, including those in STEM-related occupations, include a competence-based element, a knowledge-based element and essential skills in communication, application of number and ICT.

We have recently invested in a specific Shared Apprenticeship project that will train young people for potential new jobs within the Nuclear and Engineering sector – aimed at the new Wylfa Power station on Anglesey. In 2011/12, 3,223 people were undertaking Modern Apprenticeship programmes at level 3.

There are also 40 people undertaking Higher Apprenticeships in STEM subjects. These exist in six areas, overseen by the relevant Sector Skills Councils. Examples include Engineering Environmental Technologies, Mineral Products Technology and Creative and Digital Media.

In 2013/14 eleven Foundation Degree routes in STEM subjects were available, such as Computer Science; Automotive Engineering and Creative Technology and Digital Media. Enrolments continued to rise from some 2,700 enrolments for 2011/12 to 3,175 for 2012/13 but the

popularity of different areas of science varies. A Review of Foundation Degrees in 2012/13 showed that, while there was a 21 per cent increase in Engineering and Technology enrolments and 36 per cent in enrolments in subjects allied to medicine, those enrolling in the physical science courses declined by 78 per cent (2010/11 figures compared with 2011/12).

Strategic Aim: To set the direction for and coordinate outreach STEM activities through the National Science Academy (NSA), to engage more young people in science.

We intend to review the operation and role of the National Science Academy, engaging expertise and those with an interest in its operation. This review will look to focus the future funding available to NSA on projects with a wider remit, which can broaden science opportunities for the greatest number of pupils. The review will include looking at the potential usefulness of a STEM Co-ordinator role. The review will be completed by the end of 2014.

The NSA now has an established grant scheme, which selects a portfolio of projects against clear criteria. The Autumn 2012 round funded 21 projects. These ran through into the period of this report, resulting in the delivery of 589 STEM engagement events, attracting over 25,000 attendees. The student participants ranged from those in the Foundation Phase through GCSE to A-level and other students over 16. NSA is always keen to fund projects which attract or target under-represented groups. In this round, these included the Institute of Physics (IOP) programme 'Lab in a Lorry' (attracting over 1,500 female students), the Swansea University-led, widening access initiative, 'S4 Summer School' (targeting Communities First Wards and female participants) and the Engineering Education Scheme Wales (EESW) Ltd. (including a range of activities targeting gender imbalance, under 'Girls into Engineering').

A further grant scheme, run in Autumn 2013, has awarded over £1.3 million in grant awards for 27 projects, to deliver a wide range of STEM enrichment and engagement. These projects are expected to reach in excess of 62,000 students, again covering all of the above groups, over the following eighteen months.

NSA 2012-13 Financial Year Achievements

NSA grant funded projects resulted in 295 STEM Engagements attracting 8,261 student participants. When fully considered in the context of the NSA 2012 Autumn Grant Scheme (covering a 9 month period from October 2012 up to 30 June 2013), the following project-related outputs were achieved:

491 STEM Engagements attracting over 35,000 student participants, accompanied by 38 CPD events attracting 193 CPD STEM teacher participants. These were complemented by over 2,000 British Science Association CREST Awards being awarded to students in Wales.

NSA 2013 Autumn Grant Scheme

The NSA 2013 Autumn Grant Scheme, launched in September 2013, is forecast, over an 18 month period, to achieve the following project-related outputs, namely funding over 600 STEM Engagements attracting over 65,000 student participants together with hosting over 200 CPD events for over 1000 teachers. In addition, NSA funding is expected to facilitate the awarding of over 2,500 British Science Association CREST Awards to students in Wales over a 12 month delivery period ending 31 March 2015.

Strategic Aim: Improvement of labour market intelligence (LMI) to help shape informed career choices for young people, including market needs for STEM skills.

Planned strands of activity to improve the quality and accessibility of labour market intelligence have now been largely completed. Survey data from employers is available to key audiences. We have a dedicated website for the Learning and Skills Observatory Wales www.learningobservatory.com providing key statistics, survey data and a wide range of articles and information on all aspects of LMI and careers implications of that intelligence. This includes articles and news items on STEM issues, such as the low numbers of women going into engineering in the UK or the markedly higher average salaries available to STEM graduates in recent months. The audience for this ranges widely from sector skills councils to schools, employers and interested academics.

Strategic Aim: Examination of ways to raise the standard of science and mathematics teaching from primary through to secondary education.

Strategic Aim (longer term): Provision of Continuous Professional Development (CPD) for all STEM teachers and work with partners in developing standards.

The quality of teaching is widely acknowledged as the single most important factor in helping learners achieve their potential. We are committed to ensuring that all practitioners have access to career-long professional development that is effective, sustainable and linked to school improvement priorities. To that end, we are developing a national professional learning model that is characterised by practitioners working collaboratively to develop their practice through their own learning. The model sets out the most effective approaches to professional development, which are informed by the latest academic research and have been proven to positively impact on classroom practice.

Regulations now being implemented will govern school development plans (SDPs), requiring schools to set out their improvement priorities and targets. The SDPs will also show how they intend to deploy resources and develop the workforce to achieve their targets. This approach is supported by the performance management process, which requires schools to identify professional development needs with reference to school improvement priorities and professional standards.

Over the period of this report the Welsh Government has developed guidance on professional development for science teachers. It is improving the co-ordination and communication of CPD events to schools and is working closely with the Institute of Physics (IoP) and others to develop activities, aimed at narrowing the gender differential in the take up of girls at 'A' level physics. The development of a more focused programme of science teacher support is currently being considered.

Funding will not always be required for CPD but in those cases where it is, schools may access funding through the School Effectiveness Grant and the Pupil Deprivation Grant.

The Welsh Government has recently highlighted the opportunities that exist for CPD for physics teachers at the CERN Nuclear Research facility, near Geneva, through its Dysg e-Newsletter.

Strategic Aim (longer term): Continuing to target the supply of high quality STEM graduates.

Priority recruitment subjects, including some STEM related subjects have been the primary focus of financial incentives for Initial teacher training (ITT) for several years, although the value of the incentives and target subjects are notified annually and are subject to change. Top graduates in Physics and Chemistry can now receive incentives of up to £20,000, to undertake initial teacher training leading to qualified teacher status (QTS).

Strategic Aim (longer term): Developing and responding to research into progression in science education, including research on study of two and three sciences at GCSE.

The Tracking delivery section below includes data showing increases in the number of schools providing three sciences at GCSE and of pupils studying these subjects at page 45. There has recently been a sharp increase in the study of BTEC, at the expense of two sciences at GCSE. The proposed restriction of future science performance measures to GCSE qualifications is expected to address this trend.

Strategic Aim (longer term): Ensuring that our curricula for STEM subjects are in the vanguard of modern, challenging curricula for the students of Wales.

Professor Donaldson's review recommendations will be focused on this aim. Relevant actions will be developed as part of the Welsh Government's implementation of the review.

Improving Delivery in Government

Image courtesy of GE Healthcare. Cell composition image.

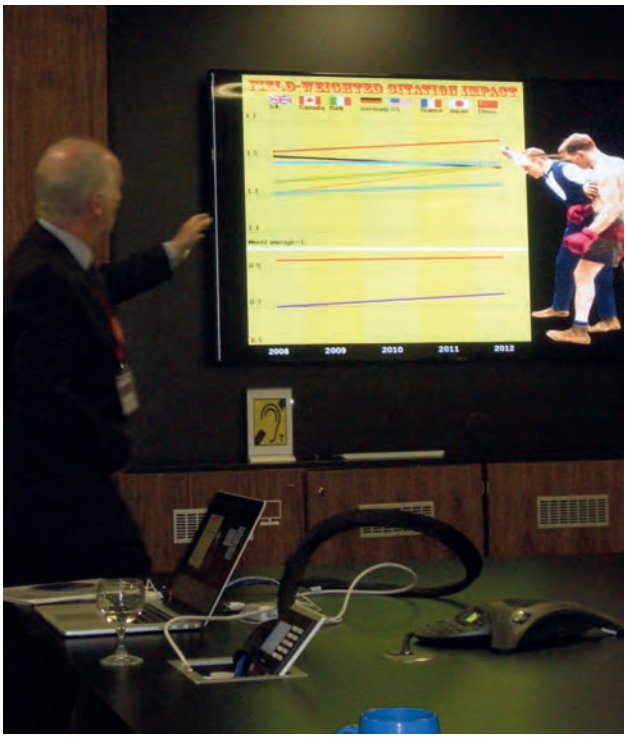
Strategic Aim: Establishing a new Chief Scientist's Department to lead science and research work across our government.

With the appointment of Professor Julie Williams as our new Chief Scientific Adviser for Wales, in September 2013, we have refreshed the structure of support for the Chief Scientific Adviser. The Chief Scientific Adviser's Division now provides more direct support and helps deliver programme activity such as Sêr Cymru and the NSA. Scientific staff and staff in technical policy areas across the wider Welsh Government work with the CSAW, as required. She meets senior staff often. A Science Co-ordination Group with scientific staff and members of other analytical professions has been established and meets regularly to discuss common issues. A Senior Science Strategy Group is also being set up to provide for the senior leaders in scientific and analytical fields to have an overview of their field of work within the Welsh Government, discuss matters of mutual concern and implement best practice. The CSAW is currently working with scientific institutes, the Royal Society and other learned societies, and the Institute for Engineering and Technology, to build policy groups and networks in relevant areas to fully exploit expertise within and outside government.

NISCHR is a part of our Health and Social Services Department. The CSAW holds an overarching brief across all scientific areas to advise and challenge. Given the strategic importance of NISCHR to the research agenda, links have been made strong by dedicated staff in the Chief Scientific Adviser's Division collaborating with NISCHR colleagues on appropriate health research projects. There is regular liaison between the CSAW, the Chief Medical Officer, and the Head of NISCHR.

Strategic Aim: Continuing to support the Chief Scientific Adviser for Wales' role in providing independent advice across government, drawing on advice from the Science Advisory Council for Wales (SACW), on science issues and from the new innovation leadership that emerges from the innovation strategy, on innovation issues.

Chief Scientific Advisers, while distinguished in their own field of study, cannot hope, however, to acquire or retain expertise in all the fields on which they might be required to advise. Mechanisms are now in place to give prompt access to other experts who can assist and advise in their turn. The Science Advisory Council for Wales was established in December 2010. A group of well-respected experts, it provides advice, as required, on a variety of topics and on wider science policy questions.



Above: Professor Peter Halligan briefing Welsh Government science staff on the Elsevier report.

During the year a task and finish group from SACW produced a report on Science, technology, engineering and maths (STEM) engagement activity, which is now being used, with other information sources, to look at how we can promote more and better coordinated science activities, especially for children and young people in Wales. Professor Julie Williams is reviewing the overall processes by which she and other technical advisors obtain the best science and technology advice, as well as making effective links with a wide range of external advisors and sources of advice. Access to expertise, when required, for the Chief Scientific Adviser for Wales is being expanded, both through Welsh Government arrangements and making appropriate use of UK science advice mechanisms, facilitated by the Government Office for Science (GO-Science) in Whitehall and close links with Sir Mark Walport, the UK Government Chief Scientific Adviser and Professor Anne Glover, Chief Scientific Adviser to the EU Commission and its President.

Tracking and overseeing delivery

Image courtesy of Techniquest. Secondary school pupils 'Balancing Broomsticks' at Mathamagic.

When *Science for Wales* was published, we indicated that a variety of relevant measures would feature in our strategy monitoring arrangements. As pointed out last year, some are not yet relevant, as their 'lag' means they are measuring activity in years before the strategy came into force. As measures become more recent they can provide useful baselines for future monitoring. As far as possible, results have been included under the appropriate section of the report, while the remainder are set out below.

Numbers of Wales-based Academics serving on United Kingdom Research Councils, their Boards and Committees:

Research Council	Council Members from Welsh Universities (Council membership shown in Brackets)	Members from Welsh Uni.s on Boards and Committees
Arts and Humanities	0 (16)	0
Biotechnology and Biological Sciences	0 (17)	7
Engineering and Physical Sciences	0 (18)	11
Economic and Social	0 (13)	5
Medical	1 (15)	5
Natural Environment	0 (16)	8
Science and Technology Facilities	0 (11)	7

Achievement of agreed metrics in EU-funded projects

Priority 1 of both the European Social Fund and European Regional Development Fund (ESF and ERDF) programme areas cover research and innovation. Progress is currently variable across targets in this area. Some remain a challenge, but the ERDF Programmes had enabled 940 collaborative R&D projects by the end April 2014 and this is expected to reach over 1,250 by the end of these programmes. WEFO publishes annual implementation reports which contain further detail and can be found on their website here.

Research Income of Higher Education Institutions in Wales 2012/13 – by Institution:

	Total Research Income	Recurrent Research Funding	Research Councils	UK-based charitable bodies	UK central government bodies	UK industry, commerce and public corporations	EU sources	Non-EU sources	Other sources
University	£k	£k %	£k %	£k %	£k %	£k %	£k %	£k %	£k %
Glamorgan	8,135	2,647	582	208	1,907	1,011	1,739	0	41
Aberystwyth	26,137	7,669	8,011	763	4,620	1,065	3,826	96	41
Bangor	28,018	7,645	4,291	1,111	5,314	361	8,222	693	357
Cardiff	130,891	42,680	22,865	18,382	26,810	4,955	9,808	5,163	228
University of Wales, Trinity St David	1,178	845	108	103	112	5	0	0	5
Swansea	49,784	12,590	9,819	1,761	8,886	2,138	12,528	608	1,454
Cardiff Metropolitan	3,709	1,232	39	23	1,545	491	343	0	36
University of Wales, Newport	595	469	19	22	54	0	31	0	0
Glyndŵr	1,943	0	374	15	1,054	365	112	23	0
Swansea Metropolitan	1,008	400	457	105	0	30	16	0	0
University of Wales CAWCS‡	891	397	354	50	0	61	26	0	3
WALES TOTALS	251,398	76,247 30.33%	46,565 18.52%	22,493 8.95%	50,302 20.01%	10,421 4.15%	36,625 14.57%	6,583 2.62%	2,162 0.86%

‡Centre for Advanced Welsh and Celtic Studies

Sources:

Higher Education Statistics Agency – Resources for Institutions of Higher Education 2012/13 (all figs. except recurrent research funding). All figures subject to rounding. HEFCE, HEFCW and SFC Recurrent Grant Circulars, 2012/13 (Recurrent research funding – consists of QR and PGR, or equivalent.

Research Income of Higher Education Institutions 2012/13 Wales compared to England, Scotland, Northern Ireland and UK Totals:

	Total Research Income	Recurrent Research Funding	Research Councils	UK-based charitable bodies	UK central government bodies	UK industry, commerce and public corporations	EU sources	Non-EU sources	Other sources
	£k	£k %	£k %	£k %	£k %	£k %	£k %	£k %	£k %
WALES	251,398	76,247 30.33%	46,565 18.52%	22,493 8.95%	50,302 20.01%	10,421 4.15%	36,625 14.57	6,583 2.62%	2,162 0.86%
Wales as per cent of UK (%)	3.7	3.9	3.0	2.3	5.9	3.6	5.3	1.7	4.7
ENGLAND	5,431,100	1,558,249 28.69%	1,231,195 22.67%	815,712 15.02%	667,233 12.29%	236,071 4.35%	558,390 10.28%	333,485 6.14%	30,765 0.57%
England as per cent of UK (%)	81.0	80.4	79.9	83.6	78.8	80.8	80.9	88.4	66.4%
SCOTLAND	895,418	256,193 28.61%	241,519 26.97%	127,189 14.20%	102,256 11.42%	41,435 4.63%	81,412 9.09%	33,391 3.73%	12,023 1.34%
Scotland as per cent of UK (%)	13.4	13.2	15.7	13.0	12.1	14.2	11.8%	8.8%	25.9
NORTHERN IRELAND	127,583	46,261 36.26%	20,777 16.29%	10,623 8.3%	26,504 20.77%	4,317 3.38%	13,858 10.86%	3,856 3.02%	1,387 1.09%
N. Ireland as (%) per cent of UK	1.9	2.4	1.3	1.1	3.1	1.5	2.0	1.0	3.0
TOTAL UK	6,705,499	1,936,950 28.89%	1,540,056 22.97%	976,017 14.56%	846,295 12.62%	292,244 4.36%	690,285 10.29%	377,315 5.63%	46,337 0.69%

Sources:

Higher Education Statistics Agency – Resources for Institutions of Higher Education 2011/12 (all figs. except recurrent research funding). All figures subject to rounding. HEFCE, HEFCW and SFC Recurrent Grant Circulars, 2011/12 (recurrent research funding – consists of QR and PGR, or equivalent).

Wales level Key Stage 4 Science Data for 15 year olds, 2009-2013

	2009	2010	2011	2012	2013
Total number of schools:	222	222	221	220	219
Total number of pupils aged 15:	35,936	35,348	34,316	33,684	34,874
Number of pupils achieving equivalent of A*-C in Science GCSE	22,482	22,782	23,008	24,351	26,856
Percentage (%) of pupils achieving equivalent of A*-C in Science GCSE	62.6	64.5	67.0	72.3	77.0
Number of schools with pupils entering:					
	2009	**2010**	**2011**	**2012**	**2013**
Single Science GCSE	205	198	201	205	207
Double Science GCSE	220	219	216	215	214
Triple Science GCSE	104	110	119	128	133
BTEC Science	9	21	45	96	158
Percentage (%) of schools with pupils entering:					
	2009	**2010**	**2011**	**2012**	**2013**
Single Science GCSE	92.3	89.2	91.0	93.2	94.5
Double Science GCSE	99.1	98.6	97.7	97.7	97.7
Triple Science GCSE	46.8	49.5	53.8	58.2	60.7
BTEC Science	4.1	9.5	20.4	43.6	72.1
Number of pupils entering:					
	2009	**2010**	**2011**	**2012**	**2013**
Single Science GCSE	6,020	6,266	6,137	5,862	6,553
Double Science GCSE	23,706	22,725	20,693	18,597	14,965
Triple Science GCSE	3,553	3,690	4,179	4,855	5,071
BTEC Science	229	845	1,863	4,126	9,029
Percentage (%) of pupils entering:					
	2009	**2010**	**2011**	**2012**	**2013**
Single Science GCSE	16.8	17.7	17.9	17.4	18.8
Double Science GCSE	66.0	64.3	60.3	55.2	42.9
Triple Science GCSE	9.9	10.4	12.2	14.4	14.5
BTEC Science	0.6	2.4	5.4	12.2	25.9

Source: Welsh Government/Welsh Examinations Database. Note: Only includes maintained mainstream secondary schools – excludes independent schools; pupil referral units; special schools and NEWBES (Pupils not from an English or Welsh based education system). The total number of 15 year olds will differ from published figures as those figures include all schools.

Numbers of Pupils in Wales Studying Science-related Subjects at GCE Advanced Level:

Group	Subject name	2005	2006	2007	2008	2009	2010	2011	2012	2013
Science	Biology	2000	1887	1822	1832	1785	1862	1916	1849	1789
	Biology: Human	21	15	23	22	16	32	0	0	0
	Chemistry	1414	1411	1332	1467	1476	1448	1514	1420	1470
	Physics	956	972	942	889	982	1013	974	919	946
	Science: Environmental	8	6	8	0	5	*	0	*	6
	Science (VQ)	13	7	22	41	32	85	130	132	200
Design and Technology	D & T Food Technology	33	47	40	50	44	7	52	44	39
	D & T Product Design	706	864	792	764	797	792	805	679	600
	D & T Systems Cont.	*	*	8	*	0	0	*	*	6
	D & T Textiles Technology	0	0	0	0	0	36	25	24	15
	Design and Technology	0	0	0	0	0	19	0	0	0
	Home Economics	51	56	46	48	32	0	0	0	0
	Home Economics:food	0	0	0	0	0	16	24	19	16
Mathematics	Additional Mathematics	0	0	0	0	0	0	0	*	0
	Mathematics	1724	1690	1826	1967	2058	2171	2130	2133	2243
	Further Mathematics	104	91	85	81	130	107	144	183	183

Source: Welsh Government/Welsh Examinations Database.

a) Pupils aged 17 on 31 August of that academic year. Only includes schools with pupils aged 17 on the register.

b) Includes maintained secondary schools, excludes FE colleges –data for this is collected separately.

c) Excludes discounted qualifications e.g. if a pupil has re-taken an exam it will only count as one entry.

d) Excludes NEWBES (Pupils not from an English or Welsh-based education system).

* data item has been suppressed as it is too low and may be disclosive.

Graduates in STEM Subjects in Wales by Level and Class – 2012/13

Subject area	Type of qualification	1st class honours	2.1 honours	2.2 honours	3rd hons./ Pass	Unclassified	Classification not applicable	All
Medicine and dentistry ‡ MB BS Medical degrees not classified, B Med Sci & some BDS (Dentistry) are.	Doctorate	*	*	*	*	*	75	75
	Other higher Degree	*	*	*	*	*	240	240
	Other postgraduate	*	*	*	*	*	505	505
	First degree	15	40	20	*	390‡	*	465
	HND/DipHE	*	*	*	*	*	15	15
	All	15	40	20	*	390	835	1,300
Subjects allied to medicine	Doctorate	*	*	*	*	10	60	70
	Other higher Degree	*	*	*	*	25	320	345
	Other postgraduate	*	*	*	*	20	525	545
	First degree	415	870	655	145	60	*	2,140
	Foundation degree	*	*	*	*	15	25	40
	HND/DipHE	*	*	*	*	*	160	165
	Other undergraduate	*	*	*	*	10	215	225
	All	415	870	655	145	135	1,310	3,525
Biological sciences	Doctorate	*	*	*	*	10	140	145
	Other higher Degree	*	*	*	*	95	460	560
	Other postgraduate	*	*	*	*	55	75	130
	First degree	480	1,325	730	100	35	*	2,670
	Foundation degree	*	*	*	*	*	70	70
	HND/DipHE	*	*	*	*	65	50	115
	Other undergraduate	*	*	*	*	120	145	265
	All	480	1,325	730	100	385	935	3,950

Subject area	Type of qualification	1st class honours	2.1 honours	2.2 honours	3rd hons./ Pass	Unclassified	Classification not applicable	All
Agriculture and related subjects	Doctorate	*	*	*	*	*	15	15
	Other higher Degree	*	*	*	*	10	55	70
	Other postgraduate	*	*	*	*	*	10	10
	First degree	25	70	70	20	*	*	185
	Foundation degree	*	*	*	*	*	55	55
	HND/DipHE	*	*	*	*	*	25	30
	Other undergraduate	*	*	*	*	*	10	10
	All	25	70	70	20	20	170	375
Physical sciences	Doctorate	*	*	*	*	*	100	100
	Other higher Degree	*	*	*	*	10	245	255
	Other postgraduate	*	*	*	*	*	10	10
	First degree	205	510	335	60	*	*	1,110
	Foundation degree	*	*	*	*	*	*	*
	HND/DipHE	*	*	*	*	*	45	45
	Other undergraduate	*	*	*	*	5	50	55
	All	205	510	335	60	15	450	1,580
Mathematical sciences	Doctorate	*	*	*	*	*	20	20
	Other higher Degree	*	*	*	*	*	55	55
	Other postgraduate	*	*	*	*	*	*	*
	First degree	110	90	65	25	10	*	295
	HND/DipHE	*	*	*	*	*	10	10
	Other undergraduate	*	*	*	*	*	15	15
	All	110	90	65	25	10	95	395

Subject area	Type of qualification	1st class honours	2.1 honours	2.2 honours	3rd hons./ Pass	Unclassified	Classification not applicable	All
Computer science	Doctorate	*	*	*	*	*	30	30
	Other higher Degree	*	*	*	*	80	185	265
	Other postgraduate	*	*	*	*	*	50	50
	First degree	135	300	290	70	35	*	830
	Foundation degree	*	*	*	*	*	35	35
	HND/DipHE	*	*	*	*	5	95	100
	Other undergraduate	*	*	*	*	5	125	130
	All	135	300	290	70	125	520	1,435
Engineering and technology	Doctorate	*	*	*	*	*	95	95
	Other higher Degree	*	*	*	*	20	505	525
	Other postgraduate	*	*	*	*	5	65	70
	First degree	385	600	355	80	75	*	1,495
	Foundation degree	*	*	*	*	*	70	70
	HND/DipHE	*	*	*	*	*	205	205
	Other undergraduate	*	*	*	*	*	385	385
	All	385	600	355	80	105	1,325	2,845
Architecture, building and planning	Doctorate	*	*	*	*	*	20	20
	Other higher Degree	*	*	*	*	*	200	200
	Other postgraduate	*	*	*	*	*	30	30
	First degree	45	170	105	35	65	*	425
	Foundation degree	*	*	*	*	10	45	55
	HND/DipHE	*	*	*	*	25	25	45
	Other undergraduate	*	*	*	*	25	85	110
	All	45	170	105	35	125	405	885

Subject area	Type of qualification	1st class honours	2.1 honours	2.2 honours	3rd hons./ Pass	Unclassified	Classification not applicable	All
All	Doctorate	*	*	*	*	20	555	575
	Other higher Degree	*	*	*	*	245	2,270	2,515
	Other postgraduate	*	*	*	*	80	1,270	1,350
	First degree	1,810	3,975	2,615	530	675	*	9,610
	Foundation degree	*	*	*	*	20	300	325
	HND/DipHE	*	*	*	*	95	630	725
	Other undergraduate	*	*	*	*	170	1,025	1,195
	All	1,810	3,975	2,615	530	1,305	6,050	16,290

Source:
Higher Education Statistics Agency
(a) Data are rounded to the nearest 5

List Of Acronyms

AAPBS	Advanced Anaerobic Processes and Biogas Systems
ABMU (Health Board)	Abertawe Bro Morgannwg University Health Board
ADRC	Administrative Data Research Centre Wales
AHRC	Arts and Humanities Research Council
AM & M	Advanced Material & Manufacturing Sector
BBSRC	Biology and Biological Sciences Research Council
BNDF	Brain-derived Neurotrophic Factor
BT	British Telecom
CaSE	Campaign for Science and Engineering
CIPHER	Centre for the Improvement of Population Health through e – Records Research
CPD	Continuous Professional Development
CSAW	Chief Scientific Adviser for Wales
CSER	Centre for Solar Research
DNA	Deoxyribonucleic acid
E & E	Energy & Environment Sector
EC	European Commission
EESI	Energy and Environmental Systems Institute
EPSRC	Engineering and Physical Sciences Research Council
EESW	Engineering Education Scheme Wales
ERDF	European Regional Development Fund
ESF	European Social Fund
ESRI	Energy Safety Research Institute
ESRC	Economic and Social Research Council
F & PS	Financial & Professional Services Sector
GW4	Great Western Four
HEFCE	Higher Education Funding Council for England
HEFCW	Higher Education Funding Council for Wales
HEW	Higher Education Wales
HPC	High Performance Computing
IBERS	Institute of Biological, Environmental and Rural Sciences
IKC	Innovation and Knowledge Centre
IOP	Institute of Physics
ITT	Initial Teacher Training
KTPs	Knowledge Transfer Partnerships
LCRI	Low Carbon Research Institute
LMS	Life Sciences Sector
MRC	Medical Research Council

MOD	Ministry of Defence
NEWBES	Not From an English or Welsh Based Education System
NERC	Natural Environment Research Council
NHS	National Health Service
NIHR	National Institute for Health Research
NISCHR	National Institute for Social Care and Health Research
NRNs	National Research Networks
NSA	National Science Academy
OECD	Organisation for Economic Co – Operation and Development
PISA	Programme for International Students Assessment
PGR	Postgraduate Research
PSI	Public Sector Investment
QR	Quality Research
QTS	Qualified Teacher Status
R & D	Research & Development
RD & I	Research Development & Innovation
RAE	Research Assessment Exercise
RCUK	Research Councils UK
REF	Research Excellence Framework
SACW	Science Advisory Council for Wales
SBRI	Small Business Research Initiative
SDPs	School Development Plans
STEM	Science, Technology, Engineering and Mathematics
SFC	Scottish Funding Council
SME	Small and Medium Enterprises
TSB	Technology Strategy Board
VCSEL	Vertical Cavity Surface Emitting Laser
WEFO	Wales European Funding Office
WISERD	Wales Institute of Social and Economic Research