Llywodraeth Cymru
Welsh Government

Delivering Science for Wales 2015-16

Annual Report on our Strategy for Science in Wales

Digital ISBN 978 1 4734 6284 7

WG28083

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Foreword

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

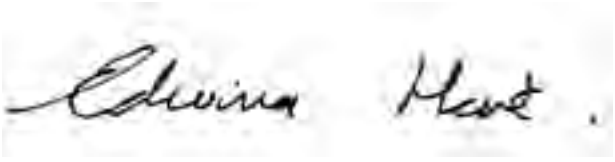
Four years ago, in March 2012, the First Minister launched *Science for Wales*. Setting out our ambitious agenda, it contained actions for both the Welsh Government and other stakeholders, to help science in Wales to thrive. The aim was and is to benefit the people of Wales through increasing research and innovation, which can lead to better jobs in a stronger economy, with enhanced health and an improved environment.

We have reported each year on progress and already seen most of the particular actions completed or underway, although any actions to boost research capacity or quality will take several years to show results. I said in an earlier foreword that it can take fifteen years to build up a successful research group in a university.

Innovation actions under *Science for Wales* were completed with the publication of Innovation Wales (using the European Union's 'Smart Specialisiation' approach) and the establishment of a Council to oversee it.

A strong theme in *Science for Wales* is the importance of engaging our young people's interest in science, technology, engineering and maths or STEM subjects, encouraging them through an interesting and relevant curriculum; qualifications which have credibility with employers; as well as a wide range of exciting extra-curricular science engagement. We now have new science GCSEs and A-Levels coming on stream and a new curriculum being developed over the coming years. Only this month, the independent report, commissioned by the Chief Scientific Adviser for Wales, on how we should make more and better use of women's talents in science has been published. It includes getting more girls to study sciences to a higher level.

The main content of this annual report (published earlier than usual because of the forthcoming election) covers recent developments for the Sêr Cymru programme – the most significant of Welsh Government actions in *Science for Wales*. I am pleased at the considerable progress we have made, both with developing the original elements of Sêr Cymru and also with the logical next steps developed to complement the original strategic agenda, which make up Sêr Cymru II. I hope for great things for this programme in further boosting our research capacity.



Introduction by the Chief Scientific Adviser for Wales

Professor Julie Williams CBE FLSW FMedSci
Chief Scientific Adviser for Wales (CSAW)

As we come to the end of the present Assembly term, it is a good time to look back at achievements and progress. Taking stock, we know that Wales science often punches above its weight and has genuine impact on the wider world. Our problem is that Wales lacks over 600 science researchers. While the researchers we have include many that are excellent; nationally and internationally collaborative and highly-cited, valuable work by Professor Peter Halligan and Dr Louise Bright has shown we just do not have enough people working on research in the STEM subjects.

So what do we do about it? First, we need to build on the excellence that we have – creating a critical mass around our successful teams. To achieve this, we applied for COFUND funding from the EU Horizon 2020 Marie Sklodowska-Curie Actions. The Welsh Government and its partners were fortunate enough to gain one of the largest awards of Horizon 2020 money made, so far – giving some £17 million, which will provide for 90 fellowships.

Next, we seek to attract 'rising stars' under this programme, both to expand existing teams and to develop in new areas. Here we successfully applied for EU Structural funds, which, with our partner Universities, has delivered a £39 million programme.

Another major issue we sought to tackle was the lack of women in STEM-related employment. The Royal Academy of Engineering and the Royal Society have said repeatedly that we will need another million scientists and engineers within the next decade – and without women's strong participation we will not reach this figure. I commissioned a task and finish group on 'Women in Science' to look at the issue. It is important that we change our mind-set about the role that women can play throughout a full career-span in STEM-related activities. Girls do better than boys in all science GCSEs, save Maths, yet only some 20 per cent of A-Level Physics candidates are female. Not taking Physics denies a whole range of exciting and fulfilling careers to many girls, since it is the gateway to Engineering and more. Early career researchers are roughly split 50/50 male and female but less than 20 per cent of female researchers become University Professors. The 'Women in Science' group's report *Talented Women for a Successful Wales* was published on International Women's Day – 8 March 2016. It seeks to make practical recommendations to reduce the barriers at all levels from education to recruitment, retention and promotion, including:

- Teachers with more science skills to enthuse both boys and girls
- Stronger links around STEM, between schools, colleges and the business community

- Regular access to female role models already working in STEM careers
- Challenge gender stereotypes at home, school and in the workplace
- Improve the relevance and focus of career information
- 'Keeping in touch' strategies, mentoring and agile working for returning mothers
- Confronting unconscious bias affecting selection and career progression
- Removing the gender pay gap
- Increasing female representation at all levels of academia, industry and commerce – 50:50 by 2020

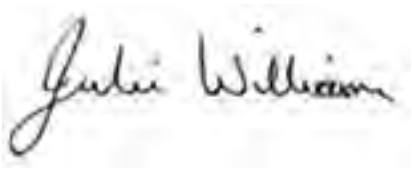
I will be delighted to take these recommendations forward in the near future.

I was pleased to see that our Sêr Cymru investment, in the appointment of Professor Diana Huffaker at Cardiff University, proved to be a key underpinning for the recent success in gaining the Compound Semiconductor Catapult Centre, the first to be led from Wales. It will join our Wales-based Precision Medicine Catapult centre, which will now be developing as a centre of excellence, bringing new research ideas into improving health, NHS and health company performance.

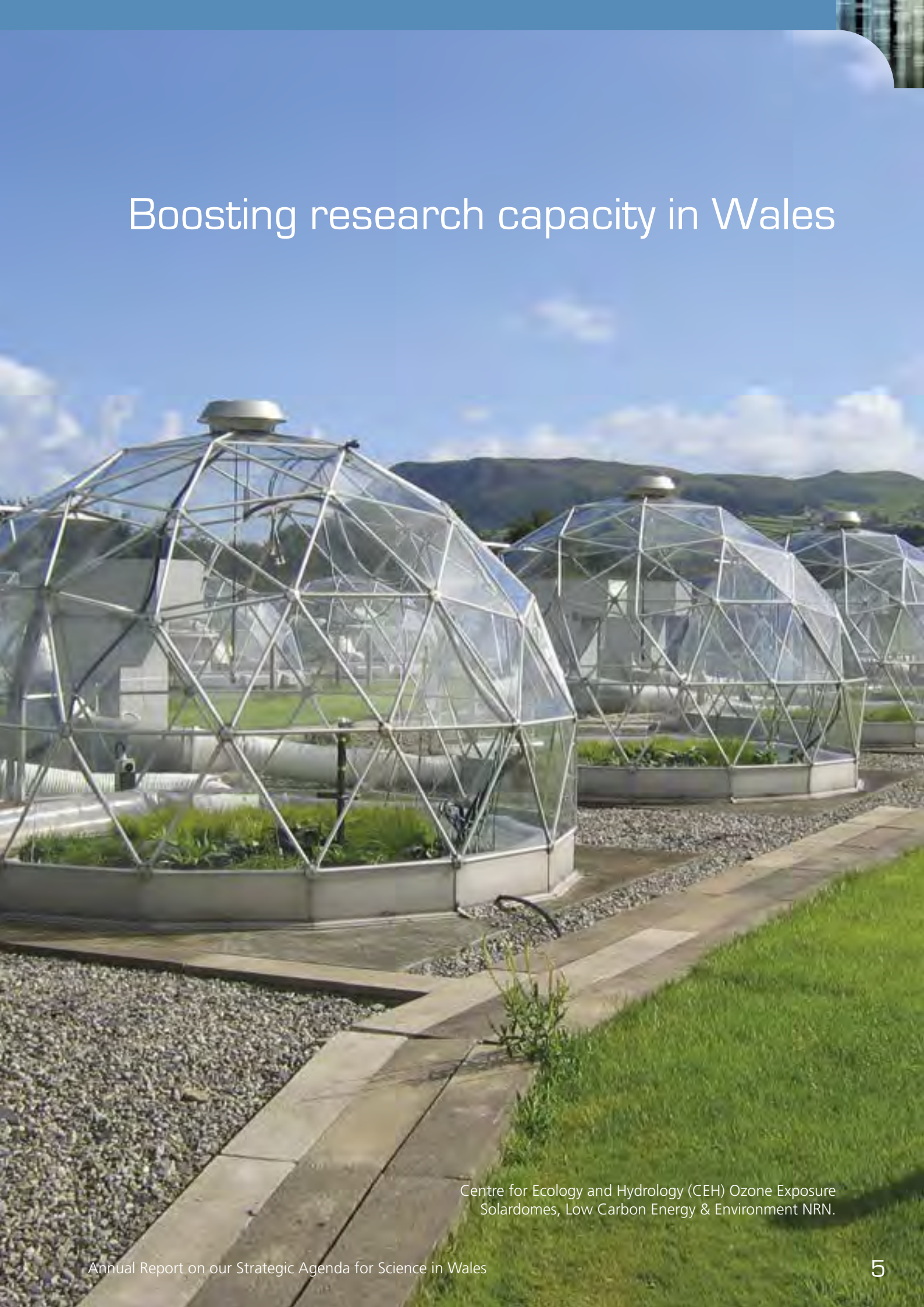
Developments in STEM education have been incremental, with new science GCSEs due for later in the year. A new Curriculum is forming, based on Professor Donaldson's recommendations. It will take shape over the next few years but science and technology will be one of six 'areas of learning and experience'. The STEM in Education Action Plan is just being published and will be a useful tool for teachers across Wales.

The National Science Academy published its own STEM Enrichment Strategic Plan 2015-18 in July 2015, in time to inform the latest grant-funding round by the NSA, to support informal science learning with a range of activities, which enthuse and engage children in the fun and fascination of science.

Also, it is great to be able to celebrate and highlight some of the scientific achievements from academics in Wales recently, such as the strong part played in the discovery of gravitational waves and the award of two prestigious Queen's Anniversary prizes for excellent and impactful work. We have much to be proud of in Wales.



Boosting research capacity in Wales



Centre for Ecology and Hydrology (CEH) Ozone Exposure Solardomes, Low Carbon Energy & Environment NRN.

The Rationale for Sêr Cymru

The high-level aim of *Science for Wales* was to **build a strong and dynamic science base that supports the economic and national development of Wales**. Whilst Government can support some actions and lead the way, success ultimately depends on the research, business and education communities working together to bring about the desired changes.

Science for Wales stated that some building blocks were in place but improvement was needed across a range of areas. Investment in the science base in Wales was needed to strengthen it, so that it was more competitive, while retaining a focus on Wales' existing strengths in academia, business and industry.

To increase research capacity, while maintaining and increasing quality in areas where Wales has real strengths in research, Sêr Cymru ('Stars Wales' in English) was proposed by the Welsh Government to contribute to these aims and to enable a greater future capture of competitively awarded grant funding.

This programme has two strands of activity – securing truly world-class academics as Sêr Cymru Research Chairs, based within Welsh universities, to build and lead prestigious research groups, coupled with National Research Networks (NRNs) to bring together academic teams working in the three broad 'grand challenge areas'. These were identified both for their strength in academic departments in Wales and for their potential for commercial exploitation of research outcomes by businesses in and for Wales.

The Sêr Cymru programme, which started in late 2013, is already producing significant results for Wales. Combined, the NRNs and Research Chairs have brought £31 million of competitive research funding into Wales and have also been successful at winning Welsh research funding. Their research outputs have demonstrated Welsh excellence on the international scientific stage and their expertise and evidence on issues closer to home have informed Welsh Government policy. For example, researchers at Swansea University provided local expertise on research relevant to cockle fisheries in the Burry Inlet, Carmarthenshire.

Sêr Cymru Research Chairs

Wales now has four of these prestigious research chairs in place. They are at different stages of development with their research programmes and their research teams – but all are demonstrating truly world-class research.

Professor Yves Barde – Sêr Cymru Research Chair in Life Sciences and Health at Cardiff University, has recently assembled his talented team and these researchers are already winning Wellcome Trust grant funding, for research looking at cortical development.

Professor Yves Barde
Cardiff University

Professor Andrew Barron
Swansea University

Professor Barde continues with his research in the new laboratories in Cardiff University, looking at his discovery – the BDNF neutrophic factor, which may regulate not only the function, but also the growth of the adult brain. He is also contributing to the understanding of the operation of Fingolimod (a clinically approved drug), which may have potential for the treatment of Multiple Sclerosis and other nervous system development disorders. He has established multiple links with the pharmaceutical industry, including a $70,000 research agreement with Novartis and this year was a key partner in a successful bid for £1,200,000 HCRW funding.

Professor Andrew Barron – Sêr Cymru Research Chair in Low Carbon, Energy and Environment at Swansea University is installed in the new Science and Innovation Campus research facilities at Swansea University, working on energy systems resilience.

Professor Andrew Barron's research involves the application of nanotechnology to fundamental problems in energy research. At Swansea, Professor Barron is facilitating the creation and growth of the Energy Safety Research Institute (ESRI), on the new Science and Innovation Campus which will concentrate elements of the University's energy research with a unique focus on safety.

Professor Barron's research focuses on nanotechnology in energy research and has attracted a large number of industrial and academic partners. His current research is in the field of increasing the efficiency and safety of unconventional-gas exploration and extraction, In this area he is facilitating a large-scale international collaboration on hydrophobic materials.

Collaborative activities are rapidly expanding with interactions within Wales and UK as well as internationally. Industrial funding has been brought in and several MoUs have been signed with companies to create a project on alternative methods for gas production. Two additional agreements have been signed with Universiti Brunei Darussalam and Universiti Malaysia Pahang, expanding his team's international connections. They have, to date, won £1.8 million of grant funding for this research in Wales.

Professor James Durrant – Sêr Cymru Research Chair in Advanced Engineering and Materials at Swansea University, is a photo-chemist, who also leads a group at Imperial College, London, undertaking fundamental work on photochemistry and physical chemistry, much of it interdisciplinary in nature. The aim of the research is towards novel chemical approaches to solar energy conversion. He leads the Sêr Solar Initiative which is based at SPECIFIC IKC (Innovation & Knowledge Centre), where Professor Durrant is driving forward research and development of printed photovoltaic devices. Professor Durrant and his team have now brought in some £17 million of grant funding for their research around the Sêr Solar project into Wales

(over £13 million of which is highly competitive UK Research Council grant funding).

Left: Professor James Durrant, Swansea University, with Mrs Edwina Hart, Minister for Economy Science and Transport inspecting a Solar Panel at SPECIFIC.

Professor Diana Huffaker – Sêr Cymru Research Chair in Advanced Engineering and Materials at Cardiff University, since autumn 2015, has a world-class reputation in research on compound semiconductors. She is working on plans for spin-out commercial activity in Wales, using research outcomes from her time at UCLA, California. Her arrival at Cardiff University is also a crucial component of the Compound Semiconductor Catapult.

Professor Diana Huffaker
Cardiff University

We look forward to reporting on her future successes and on the exciting research she has started in Wales, in future reports.

National Research Networks

All three NRNs are now well-established and the majority of their funding has been deployed to their research programmes. Collectively, even though their programmes are less than halfway through, the networks have brought approximately £12 million of competitively won research grant funding into Wales.

The **Low Carbon, Energy and Environment Research Network Wales** (LCEE) has researchers from the Universities of Aberystwyth, Bangor, Cardiff, South Wales and Swansea, as well as the Centre for Ecology and Hydrology, the British Geological Survey and the Met. Office all involved. Research is being pursued under four themes:

1. Sustainable intensification of agriculture and aquaculture (to improve food security within environmental and spatial constraints, while maintaining other ecosystem services.

2. Low carbon energy pathways – looking at the boundaries of viability, spatial-specificity, socio-economic and environmental impacts of low carbon energy pathways from biomass, waste streams, wind and marine technology in an interdisciplinary context.

3. Developing the bio economy through social, economic and technological modelling.

4. The impacts and mitigation of climate change and human activity.

There are then a number of research clusters: Aqua Wales; Cleaner Cows; Climate-Smart Grass Geo-Carb Cymru Multi-Land; Plants and Architecture, Quotient, which are further explained on the LCEE web link above.

Right: Dr Katrien van Landeghem.

One innovative approach taken by this NRN is their Returning Fellowship Scheme. This facilitates a return to research from maternity/ paternity/ adoption/ health-related/ caring leave, with bursaries up to £20,000 to allow this, provided the Fellow agrees to produce a minimum of one peer reviewed publication and a minimum of one research bid over £250,000 as a Principal Investigator (PI) to RCUK or EU funding sources, before 30 June 2018. Benefiting from one of the first six of these Fellowship awards is marine geologist Dr Katrien van Landeghem at Bangor University.

She has been a lecturer there since 2012 and is modelling shipwreck erosion as an analogy for environmental impacts on marine renewables. She aims to predict the preservation potential of shipwreck sites by replicating erosion models. This can then, by analogy, predict damage to seabed structures for harvesting offshore renewable energy or for flood prevention.

The **Life Sciences Research Network Wales** (LSRNW) supports world class science within Wales and develop new therapeutic treatments in areas of unmet medical and veterinary need. The network brings together academics at Cardiff, Swansea, Aberystwyth and Bangor Universities and aims to further develop long term research capacity within the Life Sciences.

The Network previously identified AMR (Anti-Microbial Resistance) research as an area of considerable strength within Wales. In response to a call from the MRC ('Tackling AMR'), the Network organised a series of events aimed at bring together academics from across Wales with an interest in AMR. This resulted in the submission of a pan-Wales EOI to the MRC which highlighted areas of strength across Wales. The Network is particularly pleased that these activities have resulted in a number of new proposals, many of which have now been invited to full application stage. In particular, the Network provided support for the following projects:

- Computational identification of the routes of AMR acquisition between Environmental and host associated microbial communities – Dr Chris Creevey, IBERS, Aberystwyth University.
- Combating antimicrobial resistance using biomaterial fabrication and treatment to inhibit biofilms – Professor David Williams, School of Dentistry, Cardiff University.
- Assessing the risks of antimicrobial resistance dissemination in animal manure management: evaluating selection in situ and in vivo – Professor Duncan Wingham, Natural Environment Research Council.
- Forming an MRC centre in Immunomics – Professor Valerie O'Donnell, School of Medicine, Cardiff University.
- Compounds designed and prepared in the McGuigan laboratory at the School of Pharmacy, Cardiff University, with Public Health Wales laboratories, as part of the Network's Welsh Anti-Microbial platform, have shown early promise. These novel agents have significant activity against *E. faecalis* and *S.aureus* in particular, including against drug-resistant strains and research is on-going.

Scientists at Swansea University (Professor Paul Dyson and Dr Claire Morgan) were recently awarded a major award by Cancer Research UK to develop novel therapies for the treatment of prostate cancer. This £180, 000 award will support collaboration with Cardiff

University in developing a new therapy to target any solid tumour. This patented technology delegates production and delivery of therapeutic molecules to tumour-targeting bacteria that are otherwise harmless to healthy tissue. It has the potential to be developed into a new treatment for a wide range of cancers.

Right: Life Sciences Research Network Wales researchers.

Novel strategies for treatment of triple-negative breast cancer (TNBC) are being examined at Cardiff University. This is one of the most serious forms of breast cancer for younger-age patients (under 40 years) and currently lacks any effective therapy. Following collaboration between Cardiff University's Schools of Medicine and Pharmacy, scientists have now identified two lead compounds, which have the potential to become new therapeutic drugs. Further tests are ongoing but initial results are very promising.

The Advanced Engineering and Materials Network, which operates as **Engineering Research Network Wales** (ERNW), is a transformative alliance that will enhance fundamental and applied research in Wales, seeking to address the challenges articulated in *Science for Wales* and resulting in an increased critical mass of world class researchers through strategic collaboration, greater grant capture and improved industrial engagement.

The Network's activities cover three research areas, providing broad coverage of strategic research themes aligned to EPSRC and EU priorities and relevant to a range of industrial sectors:

- Materials and innovative manufacturing processes;
- Novel modelling techniques;
- Advanced sensors and devices;
- Recently the researchers within the network have secured 2 interesting funding streams focused on the development of the

world's first microchip combining Complementary-Metal-Oxide-Semiconductor (CMOS) and microfluidic techniques for electrical sensing and simulation of dielectric samples;

- Microwave liposuction using probes developed by Bangor researchers in a previous network project;
- Micro-scale energy harvester that can be attached to insects in order to monitor them through telemetry with no need to replace batteries.

Within a separate research stream, the network is undertaking collaborative work, funded through the Newton Exchange Project with the Vietnam Academy of Science and Technology (VAST) on 3D high-resolution high-speed printing of photonic and wider meta-materials.

The Rationale for Sêr Cymru II

Professor Peter Halligan and Dr Louise Bright's *The Case for Growing STEMM Research Capacity in Wales* (Leadership Foundation for Higher Education, February 2015) gave evidential backing for thinking more was needed to complete the original Sêr Cymru actions. Their research showed Welsh universities had not secured their expected percentage of competitively-awarded research funding and that this was largely explicable by a long-standing shortfall of 646 researchers – 621 of them in STEMM subjects, with large deficits in clinical medicine; biosciences; physics; electrical and computer engineering; mechanical, aero and production engineering, and maths – the fields gaining funding from the high-spending MRC and EPSRC.

Responding to this evidence of the need for yet more effort to boost research capacity, the Welsh Government designed a series of Fellowship schemes, collectively called Sêr Cymru II, to deliver its contribution to bridging this gap.

Sêr Cymru II

The Welsh Government, working with business and Higher education partners, applied for funding from the EU's Horizon 2020 Marie Skłodowska-Curie Actions programme – COFUND. We were very fortunate to secure one of the largest grants yet made from this fund – some €9.5 m. With match-funding this will approach €24.1 million, allowing for the provision of:

- **COFUND Research Fellowships**. Around 90 of such fellowships are aimed at candidates of truly exceptional quality, who will typically be some three to five years on from their PhD. They can come from anywhere, provided it is from outside the UK, to work in Wales, funded for three years. This element was launched officially in September 2015. The first call for applications went live on 7 October and has just closed – on Saint David's Day, with 63 applications received.

Right: Guests at the Brussels launch of the Sêr Cymru II scheme, held at Welsh Higher Education Brussels' office.

Sêr Cymru II Fellowships

In parallel with the COFUND application and again working with higher education and business, the Welsh Government applied to WEFO for Structural Funds support, which, with match-funding, would provide for the rest of the Sêr Cymru II fellowship programme. In granting this funding under the European Regional Development Fund or ERDF, WEFO described it as a 'backbone' project for them. Sêr Cymru II benefits to some £23 million from Structural funds, going towards a total value of £39 million. A launch event was held in Brussels on 17 November 2015.

- **Rising Star Fellowships** will be prestigious and highly competitive positions, to attract the very best 'rising stars' of academic research, with some 26 five-year fellowship packages, each funded at £0.2 million per year.
- **Welsh Fellowships** will be aimed, like COFUND, at stellar candidates, typically three to five years on from their PhD coming from anywhere in the world – including the UK – to work in Wales. We aim to support about 30 such research fellowships lasting up to three years. in duration.
- **Recapturing Research Talent** is a strand designed to provide support for some 12 researchers returning to work following a career break. The aim is to start to address the 'brain-drain' of researchers, many of them women, who take career breaks for childcare or otherwise and find it difficult to break back into active research careers. We need that talent.

There is one additional and different element, which joined these fellowship schemes:

- **Welsh Strategic Awards for Capital Equipment**. These have been directly funded by £1.7 million from the Welsh Government.

In April 2015, Universities in Wales were invited to bid for capital funding, providing a coherent plan for use of the equipment for use in research in any part of the academic disciplines encompassed by STEMM – a single piece or and/or many smaller pieces. The total request for funding was to be between £50K and £500K. 42 applications were reviewed by our newly appointed Independent Evaluation Panel (see below). After assessment, these proposals were funded:

- **Cardiff University MRC Centre for Neuropsychiatric Genetics and Genomics (CNGG)** HiSeq 400 sequencing system supported by Biomek robot allowing sequencing of whole genomes more than 36 times faster at more than 2.5 times reduction in cost. (Professor Sir Michael Owen)
- **Cardiff University, Cardiff Catalysis Institute** X-ray photoelectron spectroscopy for surface analysis (Professor Graham Hutchings)
- **Swansea University, College of Engineering** Prototyping and lifetime testing of low cost, durable solar cells made by printing and coating (Profesor James Durrant)
- **Cardiff University The Wales Gene Park** Genomic Big Data Hub – one petabyte optimised for storage and processing of human genomic data (Professor Julian Sampson)
- **Cardiff University MRC CNGG** MassARRAY system: nucleic acid detection and quantification platform (Dr Rebecca Sims)
- **Cardiff University, Neuroscience and Mental Health Research Institute** A set of miniature microscopes to image neuronal ensembles in rodent models of neuropsychiatric disorders (Dr Riccardo Brambilla)
- **Cardiff University, Systems Immunity Research Institute** Imagestream: high resolution microscope embedded in a fluidic system suitable for the analysis of suspended cells (Professors Philip Taylor, Paul Morgan and Valerie O'Donnell)
- **Swansea University, College of Medicine** Equipment to build depth and breadth in cell analysis capabilities (Professor Cathy Thornton)

Independent Evaluation Panel for Sêr Cymru II

The governance for Sêr Cymru II has been set up to ensure effective scrutiny of bids, so that the best are chosen. This panel will function similarly to the research board of a UK Research Council, with its governance protocols. All scientific decisions will be made on the basis of merit, assessed by peer review. There is no ministerial or civil service input. Members of the scientific and business community will be asked to consider fellowship applications annually for the first three years of the five year programme This panel, recruited through

an open and transparent competition, with robust arrangements for addressing any conflict of interest, is made up as follows:

Dr Wendy Ewart, **Chair**	Independent Biomedicine Consultant, former Deputy CEO, Medical Research Council
Mr Andris Bankovskis	Independent Energy Consultant
Professor Robert Beynon	Head of Dept. of Biochemistry, University of Liverpool
Professor Nigel Brown	Emeritus Professor, University of Edinburgh
Professor Graham Davies	Emeritus Professor, Univ. of New South Wales, Australia
Prof. Sir John Enderby	Emeritus Professor, Bristol University
Professor Nigel John	Professor, Computer Science Dept., University of Chester
Professor Peter McGuffin	Emeritus Professor, King's College London
Professor Alan Palmer	Entrepreneur & Visiting Professor (UCL & Reading)
Professor Wayne Powell	Chief Science Officer, CGIAR Consortium, France
Professor Marlene Sinclair	Professor of Midwifery, Ulster University
Professor David Toll	Professor, Engineering & Computer Sciences, Durham
Professor Christina Victor	Prof. of Public Health/Vice-Dean of Research, Brunel Univ'y.
Professor Xiao Yun Xu	Professor, Chemical Engineering, Imperial College London

Right: Members of the Sêr Cymru Independent Evaluation Panel, with the Chief Scientific Adviser for Wales, at the Pier Head in Cardiff Bay.

Programme Beneficiary Board: chaired by Professor Julie Williams, Chief Scientific Adviser for Wales, this Board will have very senior representation from stakeholder universities and other interested bodies, such as HEFCW and will sign off awards, based on the Independent Evaluation Panel's recommendation.

Finally, there is to be a group of three people, the **Responsible Research and Innovation (RRI) Oversight Group**. Members must have experience of sitting on ethical review panels and/or expertise in equality and diversity issues and will oversee the management of these matters, receiving annual reports on the way RRI has been addressed at both programme and individual fellowship level. Appointment is due soon, again through an open and transparent competition.

The 'Women in Science' Group Report

Professor Julie Williams, as Chief Scientific Adviser for Wales, had been concerned to investigate the reasons behind and remedies for the lack of women taking up science, technology, engineering, maths and medicine (STEMM) study or careers or reaching senior positions in those STEMM-related careers in research or industry. In *Science for Wales*, within its theme of 'increasing the science and engineering talent pool', action to increase the number of girls and women in STEM is a key focus. In striving to boost our capacity in research and in technical industries in a competitive world, we cannot afford not to make use of the skills and abilities of all of our population.

Left: Professor Hilary Lappin-Scott and Professor Karen Holford with a copy of the report, at the launch of 'Talented Women for a Successful Wales'.

To undertake this work, Professor Williams established an independent task and finish 'Women in Science' Group, chaired by two of the most senior female academics in Wales, Professors Karen Holford of Cardiff University and Hilary Lappin-Scott of Swansea University, both of them Pro-Vice Chancellors at their respective institutions. Over the last year, the Group has been looking widely at the role of women in STEM based education and careers in Wales. On

March 8 – International Women's Day – their report Talented Women for a Successful Wales was published. It has made a wide series of recommendations to improve the position in the fields of STEMM education, recruitment, retention and promotion for women.

The Welsh Government has welcomed the report and thanked the Independent group for their work but it will be for the incoming Welsh Government to respond in more detail and consider adoption of those recommendations made by the Group.

The report points to overwhelming evidence that women are under-represented in such subjects, coupled with a recognition of skills shortages in many science-based occupations, has led many governments and employers around the world to acknowledge the need to increase the number of women working in the field, with clusters of best practice and successful policy initiatives emerging. Unconscious bias within employment systems and structures has been and often remains a significant barrier to women's progression. The report is wide-ranging but just a few of the points made are set out here:

STEM Education and Engagement

Girls and women are under-represented in engineering, physics and computer science, from the uptake of these subjects to A-level and on to university. Only 12 per cent of engineering and technology students at Welsh Universities are women, while they make up 84 per cent of students in medicine-related subjects. Children generally enjoy STEM lessons in school yet few aspire to STEM professions. Factors such as perceptions of ability; gender stereotyping, lack of awareness of job opportunities in STEM and assumptions by children, their parents and teachers put them off. There are, fortunately, many useful initiatives to increase the numbers of girls taking certain STEM-related subjects but there has been a lack of longitudinal tracking to determine their impact.

Right: Pupils enjoy a bridge-building exercise with ICE Wales Cymru. Credit: Institution of Civil Engineers (ICE) Wales Cymru.

Recruitment, Retention and Promotion

One estimate is that there is an annual shortfall of 40,000 STEM workers in the UK. The Royal Academy of Engineering have assessed the need for engineering graduates as meaning their numbers must double by 2020, to meet demand. The shortfall of circa 600 STEM academics in Wales has been raised earlier – realistically, this shortfall can only be met by increasing the number of women already educated in STEM being brought into STEM careers. The WISE campaign has estimated that increasing the number of women in STEM could be worth £2bn to the UK economy.

Women are more likely than men to take a career break and are therefore disadvantaged when applying for promotions due to interrupted career histories. The greatest loss of women from STEM careers occurs when they have children. Employment structures still often operate on a full-time, inflexible norm, which makes it difficult for care-givers, typically women, to manage work-life balance and achieve career progression. A coordinated strategy and structural change in organisational management are essential to maximise impact.

The report also notes that women are under-represented in leadership positions, including secondary school head teachers, STEM professors, fellows of learned societies, FE and HE governors, business leaders and members of STEM-related Welsh Government sector panels.

Recommendations include:

- Teachers with more science skills to enthuse both boys and girls
- Stronger links around STEM, between schools, colleges and the business community
- Regular access to female role models already working in STEM careers
- Challenge gender stereotypes at home, school and in the workplace
- Improve the relevance and focus of career information
- 'Keeping in touch' strategies, mentoring and agile working for returning mothers
- Confronting unconscious bias affecting selection and career progression
- Removing the gender pay gap
- Increasing female representation at all levels of academia, industry and commerce – 50:50 by 2020

Catapults

Another significant development in the research landscape in Wales has been the start of Wales' contribution to the UK-wide network of Catapult Centres, overseen by Innovate UK, the UK Government's innovation agency.

Firstly, the Wales centre of the **Precision Medicine Catapult** (PMC) will be sited in Cardiff, as one of six centres across the UK, co-ordinated by a £50 million PMC headquarters in Cambridge, which will itself provide another centre of excellence for its region. Wales' contribution is being delivered by a consortium, headed by the Welsh Government, NHS Wales and Cardiff University and will work on local programmes – building expert teams across the city and seeking to research and develop innovative technologies for the UK healthcare sector. Swansea University are to play a part too, as well as Cardiff University. The centre of excellence will collaborate with local, national and global partners to drive development and innovation in personalised medicine, new diagnostics and e-health systems and to identify and resolve barriers to building a leading UK precision medicine industry.

Secondly, announced only in January 2016, Wales will host the headquarters of a **UK Catapult Semiconductor Applications Centre** – the eleventh such Catapult. The August 2015 establishment of the Compound Semiconductor Centre – a collaboration between IQE, the world-leading supplier of advanced compound semiconductor wafer products, with manufacturing bases in South Wales and Pennsylvania USA, and Cardiff University, as a hub of expertise in CS and CS applications makes Cardiff a natural choice, particularly when coupled with the arrival of Professor Diana Huffaker, an acknowledged CS expert on a global scale, at this university. It is, nevertheless, a tremendous achievement for the partners and for Wales to be heading this cutting-edge research and development offering for the wider UK, benefitting from £10 million of investment each year until 2020-21. The worldwide market for CS is estimated to stand at around £125 billion by 2025. They lie at the heart of much of the technology we use daily – mobile phones, satellite communication systems, new high-efficiency lighting, novel imaging techniques for a variety of uses in important areas such as security and medical diagnostics and future electronic vehicles.

STEM engagement and education

Airbus Industrial Cadets launch event – an exercise to build a loadbearing chair with only balloons and sticky-tape.

The National Science Academy

The National Science Academy (NSA) has been the Welsh Government's main vehicle for encouraging greater participation in STEM since before 2010. The Welsh Government wants children and their parents and carers to experience what science is all about, before decisions are made on the subjects they will study and particularly encouraging girls that STEM subjects are for them. The NSA principally supports STEM outreach or informal learning activities, by giving grants for activities targeting children, young people, teachers, parents and guardians, to engage and increase the future workforce of scientists and engineers. After a strategic review in July 2015 the NSA published The National Science Academy STEM enrichment Strategic Plan 2015-18. This set out the NSA's priorities and informed the grant call launched at that time, for funding through to 2018. The **priorities** are:

- supporting projects which target children aged 7-14 and their parents/guardians;
- supporting projects that seek to break down barriers to studying STEM subjects, especially subjects where girls are underrepresented; and
- providing long-term stability for programmes seen to be performing well.

NSA has reduced the number of programmes supported but sharpened their focus, while maintaining investment. NSA's Summer 2015 open competitive grant call produced nine proposals which satisfied independent expert assessment. They amount to approximately £873,000 of grant funding. In addition, a previous identified group of nine existing projects that had demonstrated added value, were funded with £1.38 million, on to a maximum 3 year delivery period. This £2.2m total of NSA grant funding has enabled a range of targeted STEM enrichment outreach activities – mostly pan Wales and free at the point of delivery. They represent a spectrum of approaches to engagement but all aim to stimulate and enthuse children and expose them to the fascinating world of science which they can explore and study further. A **full list** of the programmes supported is at **Appendix A** below.

NSA will be holding another of the well-received STEM Engagement Stakeholder Events, first set up in March 2014, later in the year.

The popular F1 in Schools programme – open to teams of 11-19 year olds from all secondary schools in Wales, saw a success for Wales this year. The Welsh winning team, Team 'Tachyon' – four girls in Year 9 at Denbigh High School, went all the way to Singapore to compete in the international final, where they won in the 'Best Sponsorship and Marketing' section. Amy Martin, Holly Roberts, Katie Rowlands

Williams and Jessica Briody-Hughes won '1st Place Overall'; 'Best Engineered Car'; and 'Fastest Car Overall' (sponsored by Jaguar) – four of the six awards, at their North Wales heats. It is unusual to see a team composed of such relatively young girls doing so well in a closely-fought and high-profile competition. A great result for them and an inspiration to other pupils across Wales. Support for F1 in Schools is enabled by the funding to EESW from the NSA and from the Social Fund support.

Left: Team 'Tachyon' showcasing their winning entry.

STEM in Education and Training: A Delivery Plan for Wales'

March 2016 sees the publication of *Science, Technology, Engineering and Mathematics (STEM) in Education and Training: A delivery plan for Wales*. It will be on the Learning Wales website and outlines current and proposed initiatives to enhance young people's experience of STEM. The importance of increasing the number of girls in STEM is highlighted throughout the plan.

The background leading up to this important plan goes back to the publication in 2014, by the Minister for Education and Skills, of *Qualified for Life: an education improvement plan*. This stated that 'learners in Wales will enjoy teaching and learning that inspires them to succeed, in an education community that works cooperatively and aspires to be great, where the potential of every child and young person is actively developed.' Last October, *A Curriculum for Wales, a curriculum for life* set out Welsh Government plans for taking forward all of Professor Graham Donaldson's recommendations set out in his *Successful Futures* report, including the four purposes for the curriculum in Wales to ensure all children and young people develop as: **(i.)** ambitious, capable learners, ready to learn throughout their lives **(ii.)** enterprising, creative contributors, ready to play a full part in life and work **(iii.)** ethical, informed citizens of Wales and the world **(iv.)** healthy, confident individuals, ready to lead fulfilling lives as valued members of society.

To achieve our purposes, STEM skills and knowledge are vital components. This vision for the curriculum covers early years through to the end of compulsory education and beyond to further and higher education and the world of work. A fundamental for *Science for Wales* was the need to use STEM skills and research to promote a sustainably prosperous Wales and annual reports on *Science for Wales* have highlighted the range of interesting and well-paid careers that can come from having STEM qualifications and skills, especially at a higher level. An outline understanding of scientific issues is increasingly necessary to everyone, in any event, given our science and technology-driven world.

STEM subjects, along with other quantitative disciplines, are highly valued across a range of occupations, offering students varied and highly rewarding career opportunities. These subjects also support the Welsh Government's commitment to jobs, growth and developing a highly skilled workforce for the future. Our ambition, set out in the *Policy Statement on Skills* and in the subsequent *Skills Implementation Plan*, is to develop a skills system in Wales that supports our future competitiveness, helps us evolve into a highly skilled society as well as tackle poverty, and is sustainable against the backdrop of ever scarcer resources. Our focus is on raising productivity, reducing barriers into work and supporting people into sustainable employment.

The National Assembly for Wales' Enterprise and Business Committee (EBC), in an enquiry and follow-up into this important field had called for a coherent plan for the promotion, monitoring and evaluation of STEM enrichment activity through the National Science Academy (NSA) and across the Welsh Government. The NSA published its short plan in July 2015. This complementary and longer plan now covers the wider field of formal education, setting out how some further EBC recommendations are being developed and developments in curriculum and qualifications change, practitioner professional learning and support programmes – all as applied to the STEM subjects. It makes the important point that a good standard of both literacy and numeracy underpin any successful study of STEM subjects and acquisition of STEM skills.

Professor Julie Williams already chairs an internal group, the STEM in Education Group. This is a vehicle for collaboration and information-sharing with Education and Economy, Science and Transport officials, on curriculum; qualifications; teacher professional development; careers; schools marketing and the NSA, meeting quarterly. It will now take on formal oversight of the STEM Education Delivery Plan. It already receives updates on the ongoing *Qualified for Life: Focus on Science* engagement campaign for teachers, pupils and their parents/guardians, which is Education-led.

During the year we have seen an extension of the Institute of Physics (IoP) and Techniquest's pilot programme from 12 to up to 50 schools. For the academic year 2015-16, secondary schools across Wales are benefitting from teacher mentoring through the IoP's successful Stimulating Physics Network programme, alongside girls in those schools accessing specific enrichment activity to encourage their progression to A-level physics. Initial signs are positive from this pilot.

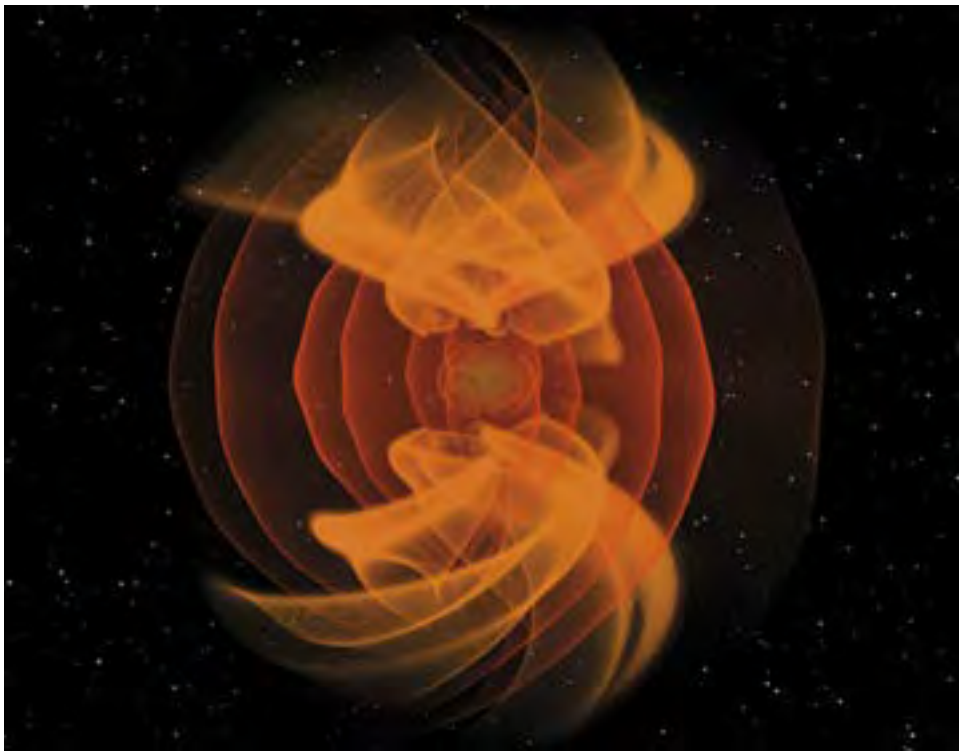
The STEM in education plan sets out the rationale for what it is undertaking; explains how it will demonstrate progress using key indicators, before detailing the actions to deliver increased uptake and development of STEM skills through evolution of teaching and learning. This is often through the major curriculum and qualifications reforms already in train, making them comparable with the best in the UK and beyond but also a revised strategic approach to supporting curriculum enrichment activity. Underlying support to develop teachers' and support staff's skills and knowledge, through the New Deal for the Education Workforce, and access to fit-for-purpose bilingual teaching resources, are also covered and are equally important. The plan goes on to note that these structural changes are being put in place, but their efficacy will be limited, unless and until there is also a notable shift in the perception of STEM; shaking up and challenging often deep-rooted societal stereotypes. There are actions to meet this challenge and seek to change attitudes.

We have already seen the announcement of the Pioneer Schools for the New Deal, curriculum design and development, including those working on the Digital Competence Framework, which will be made available to schools from September 2016. STEM enrichment activities are essential in helping bring STEM alive for young people. The strength of the curriculum and teacher support arrangements, however, is fundamental to ensuring the flow of future STEM skills increases.

Some Welsh scientific highlights 2015-16

False-colour representation of two merging black holes and the gravitational radiation emitted Credit: Max-Planck Institute for Gravitational Physics, Potsdam, Germany

Vital work by researchers at all levels from the **Gravitational Physics Group** at **Cardiff University** helped in the first detection of Gravitational Waves – at 9:51am GMT on 14 September 2015 – by the Laser Interferometer Gravitational-wave Observatory's (LIGO) interferometers, one in Louisiana and one in Washington State, USA. The Cardiff Group form part of 950 scientists, from universities all over the world, who make up the LIGO Scientific Collaboration or LSC.



Left: False-colour representation of a gravitational wave pattern from binary rotating masses. Picture credit: Numerical – relativistic Simulation: S. Ossokine, A. Buonanno (Max Planck Institute for Gravitational Physics). Scientific Visualization: W. Benger (Airborne Hydro Mapping GmbH).

For years the Cardiff Group have worked on means to detect gravitational waves, designing new algorithms and software. These have grown into standard search tools for these waves – first predicted by Albert Einstein in 1916 but only now found.

Gravitational waves are tiny ripples in space-time resulting from some of the largest and most violent events across the cosmos – such as supernovae (exploding stars) and 'black holes' colliding and merging. The waves uniquely tell physicists about the events which gave birth to them and the very nature of gravity. The Cardiff Group has also provided considerable computing power to aid LIGO in seeking the elusive signals from a vast body of data and their world-class expertise and modelling of black hole collision – the event where these detected waves originated, some 1.3 billion light years away from Earth.

Ending a 50-year search for Gravitational Waves, their observation will provide a foundation for huge new developments in astronomy, as Einstein's predictions and explanations of the nature of space, time and matter are tested further.

Two of Wales' best research teams were honoured in 2015 by winning a prestigious **Queen's Anniversary Prize for Higher and Further Education**. This 2014-16 round is the eleventh biennial round, since the scheme started in 1994 to commemorate the 40th anniversary of the Queen's accession to the throne. Their prizes (formally part of the UK honours system) were won after rigorous independent assessment, for work submitted for review that shows excellence, innovation and impact that benefits both the University or College and people and society more widely.

Cardiff Metropolitan University were recognised for their continuously innovative application of advanced manufacturing technologies to maxillofacial surgery. Over the past fifteen years the **PDR (The National Centre for Product Design and Development Research)** Surgical & Prosthetic Design team's use of design and related 3D digital scanning technologies to improve the processes in maxillofacial reconstructive surgery, either for disease or traumatic injury, has been a leader in the field. Their technology and approach is used in complex cases across most of the world. They have pioneered rapid production of prosthetics for individual patients to use in surgical procedures. Not only has this benefitted patients hugely, by limiting the amount of invasive surgery needed, since the required prosthesis can be pre-manufactured to a bespoke fit before any surgery but it has also helped bring about major advances in surgical training through improved accuracy when using simulations for surgical training and wider educational applications.

An outstanding example of their innovation is the use of haptic or touch-sensitive technology from the computer gaming industry – 'digital sculpting' – to create fine-tuned, naturally shaped skull plates by CAD (Computer Aided Design). This cuts the time, cost and patient discomfort involved. Greater dignity and quality of life for over 2000 people has resulted from the close partnership and multi-disciplinary approach between design technologists at the University and surgeons and other clinicians in many hospitals in the UK and beyond.

Cardiff University's MRC Centre for Neuropsychiatric Genetics and Genomics, led by Professor Sir Michael Owen, was recognised for their ground-breaking insights into the causes, diagnosis and treatment of mental illness, discovered by its various research teams. These leading researchers are investigating causes of major psychiatric and neurodegenerative disorders –how they arise; how to design new diagnostic approaches and how to identify new targets for treatment. Since the MRC Centre was launched in 2009, they have pioneered understanding of the genetic underpinnings of diseases including Alzheimer's, ADHD (Attention Deficit Hyperactivity Disorder), bipolar disorder and schizophrenia, including the first specific genetic risk factors for them. They have also discovered over 27 Alzheimer's

disease risk genes. Their work has implicated a number of newly-found disease mechanisms.

MRC Centre researchers are already translating these vital recent findings into new approaches to treatment and prevention, using a range of cutting-edge techniques and planning to become a leading centre of translational neuroscience, over the next decade. They are also applying genetic findings to epidemiology – studying the impact of genes at a population level. This will improve prediction and diagnosis. They are also examining how environmental and social factors interact with genetic predisposition to cause mental illness. Such cutting-edge work has been highly influential in policy terms too. MRC Research has shown strong evidence for cannabis being only of only a modifiable risk factors in preventing schizophrenia, for example and led fundamental transformed how homeless young people in Wales are assessed for mental health conditions. The MRC Centre is responsible for creating 182 high-quality jobs and attracted over £90M of investment. It has placed Cardiff University and Wales at the forefront of neuroscience and mental health research and practice globally.

The disruptive technology pioneered by **SPECIFIC**, a National Innovation and Knowledge Centre stands to **make fuel poverty a thing of the past** in if successfully scaled-up and rolled-out. Jointly funded by industry, academia and Government and hosted at **Swansea University**, SPECIFIC's founding partners are Tata Steel, NSG Pilkington Glass and BASF, EPSRC, Innovate UK and the Welsh Government. Now in its fifth year, SPECIFIC carries out translational innovation and up-scaling activities with some 50 industrial and construction supply chain partners and 14 academic partners. They are covering the innovation spectrum from concept to commercialisation. SPECIFIC's vision is to transform the world of energy, by turning 'buildings into power stations' so that they generate, store and release electrical and heat energy at the point of use. The Centre is now targeting the construction of a Demonstrator Building Programme, using this 'buildings as power stations' approach, with houses also capable of time shifting energy, through storage. This builds on the early success of a demonstrator house at Stormy Down, Bridgend (built by the Welsh School of Architecture at Cardiff University). This House was designed and built as 'fit for market' – a social styled house, using existing local supply chains and existing 'available now' technology. Cost was approaching a market price. It formed part of SPECIFIC's demonstrator programme of some 25 buildings of all types and sizes, built over the past five years, both new build and retrofit.

Modelling, using the Government's targets for new-build homes, showed that the equivalent of one large central Power Station (1 to 3 GigaWatts) of central electricity generating capacity could be saved

within 10 years and possibly more. SPECIFIC's novel approach reduces electrical central generation needs and consequent cost; removes the stress on the grid; decarbonises heat generation for homes, by generating low carbon energy at a competitive price; allows the private sector to deliver this solution and, finally, has clear potential greatly to reduce fuel poverty.

Such adoption of energy saving, storage and generating devices onto new-build social housing and retrofitting onto existing housing promises to make homes virtually energy neutral, if not energy producing. Over the next 20 years, this presents the opportunity to alleviate much of the fuel poverty experienced by families and homes across Wales and the UK. It may even provide an income stream to families in these properties, as excess energy is sold to the grid for use by others. If there is no fuel to be paid for – there is no fuel poverty.

This is a major opportunity, generating employment across many sectors in the supply chain, from researchers and innovators; manufacturers; to the distributors, retailers and installers and will demonstrate the validity of the Welsh Government's drive for energy efficiency and delivering sustainability for future generations. With further research and innovation, costs will be driven down continuously, until such technology becomes the standard for all housing and buildings.

Right: SPECIFIC's demonstrator Solcer House.

The strategy now focuses on developing firstly, a national roll-out programme to deliver the social, economic and supply chain wealth-creation benefits from a fuller deployment of this innovative approach, working region by region and secondly, an indigenous UK supply-chain capability able to deploy this approach on a much larger scale. The UK has some 26 million homes which need upgrade and a forward new-build programme of over 2 million homes in the next 10

years. To enable this to happen, a £26 million EU-backed investment, to drive forward the solar energy and related storage technologies being taken forward by SPECIFIC, was announced in early 2016 by the Welsh Government. It is made up of £15 million of EU funds, £4 million from the Engineering and Physical Sciences Research Council (EPSRC) and Innovate UK, with a £7 million investment from Swansea and Cardiff Universities, coupled with crucial investment from industry partners.

Bangor University launched its new **Bangor Institute of Health and Medical Research (BIHMR)** in February 2016. It is drawing together existing excellent groups, to provide a focus for their interdisciplinary research and growth and striving to win additional research funding. Their research will extend from bench to bedside but always with the aim of tackling real world health problems to the benefit of local health and healthcare, as well as more widely in Wales, the UK and beyond.

Bangor's health researchers already have a track record for such practice-changing work. Now, through BIHMR, a critical mass of academics from across different scientific and professional disciplines can form new collaborations, providing more opportunities for interdisciplinary work in clinical and applied research. By working closely with Betsi Cadwaladr University Health Board, BIHMR will be part of a strong NHS research environment for north Wales, focusing particularly on its existing excellence in such areas as dementia, cancer diagnostics and rehabilitation, and using new methods for doing top quality research. REF 2014 results saw 95 per cent of Bangor's health research recognised as world-leading and internationally excellent. Their results put them in the top 3 out of 94 Universities in this field. The research it covered important global health challenges relating to the organisation and delivery of healthcare for patients of all ages.

Appendices

Credit: Life Science Research Network Wales

Appendix A National Science Academy Grant Awards 2015

Project and organisation	Brief description of project / activity	Start / end dates
GCSE & AS Science Revision – Bangor University	Further developing their GCSE revision app., to establish a smartphone/tablet app. to aid Year 11 GCSE Additional and Triple Science (Chemistry, Biology, Physics) revision bilingually throughout Wales. Establish AS Biology, AS Physics and AS Chemistry to support and enthuse Year 12 students. Produce new and updated resources for the GCSE courses to bring in line with new syllabus from 2016.	9/4/15 – 31/3/18
CREST for Wales, for all – British Science Association	Develop 2 new tailor-made CREST resources for Wales, gathering partners and broadening reach across the STEM sector, particularly in supporting 'Qualified for Life' & 'Curriculum Cymraig'. To maintain & improve the accessibility to CREST Awards for Welsh students.	9/4/15 – 31/3/18
Universe in the Classroom 2.0: Robotic Telescope for Wales and innovation in the primary classroom – Cardiff University	Project aims to inspire children by developing enquiry based activities that utilise the Robotic telescope, due to the success of the previously funded project. The project will continue to provide more opportunities for pupils to pursue their own scientific interests. Provide more professional development, support and advice to schools on science teaching and learning.	9/4/15 – 31/3/18
Lab in a Lorry Cymru 2015-2017 – Institute of Physics	Lab in a Lorry is a mobile science laboratory that takes hands-on physics expriments to secondary schools. The aim of the project is to enable students aged 11-14 the opportunity to experience science as it is really done as opposed to simply repeating demonstrations where the outcome is already know.	9/4/15 – 31/3/17
Sustainable expansion of Spectroscopy in a Suitcase (SIAS) in Wales – Royal Society of Chemistry	Purpose of funding is to increase the number of Welsh pupils studying chemistry at university, supporting teachers in inspiring their pupils to follow a science based career. SIAS will expand across Wales including Swansea University and Techniquest Glyndŵr science centre bringing spectroscopy workshops to previously unreached areas of Wrexham. Also development of a Spectroscopy Day event held at Aberstwyth University.	9/4/15 – 31/3/18
STEM Activities – National Eisteddfod of Wales	To increase motivation and inspirations of pupils through the following activities: Invention-Innovation competition, IP Challenge, CREST Award Science Workshops, Live Science shows. Provide opportunities for individuals within the STEM community to develop public engagement skills, becoming positive role models (STEM Ambassadors) and support STEM clubs.	9/4/15 – 31/3/18
Astrocymru – Science Made Simple	The project will continue to contribute towards STEM activity and coordination in Wales. AstroCymru will deliver 3D shows, lectures and workshops. Engage the general public with STEM. Promote Careers in STEM by highlighting current research and technology. Develop new STEM educational resources and 3D shows.	9/4/15 – 31/3/18
Technocamps:Playground Computing, Technoteach – Swansea University	There are 2 elements to this project: Technoteach – is a structured programme of free training opportunities in which teachers enrol on a 6 week, 20 hr training programmes focussed around the newly – emerging Computer Curriculum. Playground Computing – is a primary school outreach programme delivering full day in – school Workshops focusing on teaching children and their teachers.	9/4/15 – 31/3/18
EESW 2015-2017 – EESW	Project aims to increase attainment levels in STEM subjects amongst 11 – 19 year olds through 4 strands: Girls into STEM (GIS), F1 in Schools, Introduction to Engineering (i2E) and EESW 6th Form Activity.	1/9/15 – 28/2/17

Project and organisation	Brief description of project / activity	Start / end dates
Science Enrichment Experience – See Science	The project aims to develop a suite of activities which will have specific links of Wales and the world of work for KS2 and KS3 pupils that could be used as a project, a transition day, a cross curricular day or as a club resource.	1/10/15 – 31/3/17
Total Funding for the above continuing programmes = £1,362,307		
All sySTEMs go – G2G Communications Community Interest Co. (CIC)	Enrichment activities held in schools, libraries and community venues for present Key Stage 2 & 3 pupils. All project resources are available free on the CIC's 'e-learning platform' (Lesson plans; curriculum resources; hand-outs; programmes; videos; multimedia learning resources; STEM games and other teaching and learning resources.	1/1/16 – 31/3/18
Raising Aspiration: Inspiring the next generation of STEM – STEMworks	Workshops to enthuse and engage students in STEM at present Key Stage 2 to 3 transition – challenging engineering stereotypes – particularly on gender. They aim to provide schools with different workshop options to support their Schemes of Learning – such as CSI/forensics, computer control LEGO and K'nex, renewable energy and maths workshops.	1/1/16 – 31/3/18
Science of How to Train your Dragons – Science2Life	An innovative and interactive 50-60 minute STEM with Literacy roadshow, based on Cressida Cowell's *How to Train Your Dragon* books. It targets present Key Stage 2 & 3 pupils. Pre-show resources allow teachers to prepare students and enhance classroom creativity through storytelling and a journal allowing students to describe being engaged in real science situations.	1/1/16 – 31/3/18
Science & Engineering Superheroes – role models in STEM – Science Made Simple	Who wants to be a superhero?' a 50-minute live show written for present Key Stage 2, featuring six young STEM role models (five of them women), working in various jobs in Wales. It addresses gender stereotypes in girls (and boys) at upper-primary-school levels.	1/1/16 – 31/3/18
S4: Swansea University Science for Schools – College of Science, Swansea University	Summer Camps for pupils from four feeder schools of Cymer Afan Comprehensive in Neath. Year 9-11 taster days and Year 12 summer schools address their transitions to A Level and Higher Education, with training in practical principles in bioscience; computer science; geosciences; maths and physics. They also foster awareness of the economic and cultural roles of STEM, with participation in hands-on science activities.	1/1/16 – 31/3/18
Online Continual Professional Development (CPD) for Gopher Science Labs – Royal Society of Biology	Gopher Science Labs (GSL) use simple hands-on science activities to facilitate learning by primary aged children and to ease pupils' transition to secondary education. Building on the success of GSL for Wales events for primary schools and twilight teacher training courses delivered in 2014, this project will develop further support for schools in Wales. Through the development of an online training module the project aims to offer all teachers in Wales the opportunity to access continuing professional development, developing confidence in the science behind the activities and supply participants with new activities to try out in their schools.	1/1/16 – 28/2/18
Techniquest Glyndŵr (TG)	This project delivers STEM activities to support students as they move from present Key Stage 2 to Key Stage 3. They will be for schools across North Wales, in particular the GwE lead schools for science. Activities were piloted by TG and well received. Activities include Lab Skills Days at TG for upper Key Stage 2 students, with lab. safety tranining and simple scientific tests using laboratory equipment. There are professional learning sessions for primary school teachers with support resources and equipment for use in school following a Lab. Skills Day.	1/1/16 – 31/3/18

Project and organisation	Brief description of project / activity	Start / end dates
School of Physics & Astronomy, Cardiff University	Enthusing secondary students in STEM activities through engagement in real astrophysics experiments – measuring cosmic rays (high-energy particles travelling through space), using detectors hosted in schools. A first in Wales – building on Birmingham University's successful QuarkNet STEM programme.	1/1/16 – 31/3/18
South West Wales Reaching Wider Partnership	Saturday STEM clubs for girls, taster workshops and a residential opportunity all target pupils form present Key Stage 2 to Key Stage 4. The programme is progressive, allowing participants to engage in multiple STEM engagements with both FE and HE providers to help them build 'science capital' through multiple intensive engagements.	1/1/16 – 31/3/18
Total funding for the above new programmes = £858,072		
Overall NSA funding total = £2,220,379		

Appendix B Research Income of Higher Education Institutions in Wales, 2014/15

Institutions	Total Research Income	Recurrent Research Funding		Research Councils		UK-based charitable bodies		UK central Government bodies		UK central government tax credits for R&D expenditure		UK industry, commerce & public corporations		EU sources		Non-EU sources		Other sources	
	£K	£K	%	£K	%	£K	%	£K	%	£K	%	£K	%	£K	%	£K	%	£K	%
WALES																			
South Wales	8,605	3,015	35	548	6	372	4	1,324	15	0	0	556	6	2,757	32	20	0	13	0
Aberystwyth	29,303	7,676	26	9,579	33	593	2	4,780	16	0	0	1,593	5	4,844	17	230	1	8	0
Bangor	30,981	7,485	24	4,464	14	1,370	4	5,549	18	1,162	4	826	3	8,812	28	501	2	812	3
Cardiff	150,992	43,210	29	25,876	17	19,427	13	31,589	21	9,773	6	4,322	3	10,963	7	4,154	3	1,678	1
UW Trinity St.Dvd.	1,171	819	70	26	2	39	3	10	1	0	0	0	0	197	17	41	4	39	3
Swansea	60,575	12,422	21	12,434	21	1,651	3	14,635	24	4,120	7	2,262	4	10,282	17	1,004	2	1,765	3
Cardiff Met.	5,236	1,223	23	132	3	96	2	2,661	51	0	0	358	7	746	14	0	0	20	0
Glyndŵr	1,974	0	0	352	18	8	0	1,048	53	0	0	283	14	283	14	0	0	0	0
UW Adv. Welsh/ Celtic Studies	1,116	398	36	680	61	38	3	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS																			
WALES	8,605	76,248	26.3	54,091	18.7	23,594	8.1	61,596	21.2	15,055	5.2	10,200	3.5	38,884	13.4	5,950	2.1	4,335	1.5
Wales as a % of UK	29,303	3.9		3.0		2.3		6.4		3.0		3.0		4.7		1.5		6.9	
ENGLAND	30,981	1,557,953	24.4	1,454,563	22.8	862,374	13.5	751,645	11.8	408,572	6.4	280,743	4.4	687,890	10.8	345,034	5.4	39,196	0.6
England as a % of UK	150,992	79.4		81.0		83.4		78.4		82.4		83.4		82.3		88.1		62.0	
SCOTLAND	1,171	278,979	26.6	263,742	25.2	135,459	12.9	113,351	10.8	64,333	6.1	41,937	4.0	94,112	9.0	37,178	3.5	19,101	1.8
Scotland as a % of UK	60,575	14.2		14.7		13.1		11.8		13.0		12.5		11.3		9.5		30.2	
N. IRELAND	5,236	49,261	33.2	22,371	15.1	13,046	8.8	32,685	22.0	8,040	5.4	3,648	2.5	15,246	10.3	3,466	2.3	579	0.4
N. Ireland as a % of UK	1,974	2.5		1.2		1.3		3.4		1.6		1.1		1.8		0.9		0.9	
TOTAL U.K	1,116	1,962,441	24.9	1,794,767	22.8	1,034,473	13.1	959,277	12.2	496,000	6.3	336,528	4.3	836,132	10.6	391,628	5.0	63,211	0.8

Sources: HESA Finance Record 2014/15 (for all figures except recurrent research funding), HEFCE, HEFCW and SFC Recurrent Grant Circulars, 2014/15 (for recurrent research funding only). Note: Recurrent Research Funding consists of QR and PGR (or equivalent). All figures subject to rounding.

Appendix C Number[1] of graduates[2] in STEM subjects from Welsh Higher Education Institutes by level of qualification and classification, 2014/15

Subject Area	Class of Degree	1st class Hons.	Upper 2nd class Hons.	Lower 2nd class Hons.	3rd class Hons./Pass	Unclassified	Classification not applicable	Total
Medicine & dentistry	Doctorate	.	.	.	.	.	70	**70**
	Other higher Degree	.	.	.	.	5	220	**225**
	Other postgraduate	.	.	.	.	55	370	**430**
	First degree	20	50	30	*	350	.	**450**
	HND/DipHE	.	.	.	.	*	10	**10**
	Other undergraduate	.	.	.	.	*	.	*
	Total	20	50	30	*	415	675	**1,190**
Subjects allied to medicine	Doctorate	.	.	.	.	*	65	**70**
	Other higher Degree	.	.	.	.	45	345	**390**
	Other postgraduate	.	.	.	.	60	515	**575**
	First degree	630	945	560	140	50	.	**2,330**
	Foundation degree	.	.	.	.	10	30	**40**
	HND/DipHE	.	.	.	.	15	140	**155**
	Other undergraduate	.	.	.	.	20	175	**190**
	Total	630	945	560	140	210	1,265	**3,750**
Biological sciences	Doctorate	.	.	.	.	*	175	**180**
	Other higher Degree	.	.	.	.	150	470	**625**
	Other postgraduate	.	.	.	.	35	85	**115**
	First degree	545	1,345	645	100	25	.	**2,655**
	Foundation degree	.	.	.	.	.	100	**100**
	HND/DipHE	.	.	.	.	10	60	**70**
	Other undergraduate	.	.	.	.	35	195	**230**
	Total	545	1,345	645	100	255	1,085	**3,970**

1 Figures rounded to nearest five. Figures withno data have been replaced with " . ", or less than five " * ".
2 Including Postgraduate and undergraduate students

Subject Area	Class of Degree	1st class Hons.	Upper 2nd class Hons.	Lower 2nd class Hons.	3rd class Hons./Pass	Unclassified	Classification not applicable	Total
Agriculture & related subjects	Doctorate	.	.	.	.	*	*	5
	Other higher Degree	.	.	.	.	10	50	60
	Other postgraduate	.	.	.	.	.	15	15
	First degree	30	65	60	15	*	.	170
	Foundation degree	.	.	.	.	.	110	110
	HND/DipHE	.	.	.	.	.	40	40
	Other undergraduate	.	.	.	.	*	35	40
	Total	30	65	60	15	10	255	435
Physical sciences	Doctorate	.	.	.	.	*	100	100
	Other higher Degree	.	.	.	.	15	190	205
	Other postgraduate	.	.	.	.	*	15	20
	First degree	230	535	285	65	10	.	1,125
	Foundation degree	.	.	.	.	.	15	15
	HND/DipHE	.	.	.	.	*	50	50
	Other undergraduate	.	.	.	.	*	80	85
	Total	230	535	285	65	30	450	1,600
Mathematical sciences	Doctorate	.	.	.	.	.	10	10
	Other higher Degree	.	.	.	.	5	35	40
	Other postgraduate	.	.	.	.	.	*	*
	First degree	115	95	70	25	*	.	310
	HND/DipHE	.	.	.	.	*	*	*
	Other undergraduate	.	.	.	.	*	20	25
	Total	115	95	70	25	10	70	385

Subject Area	Class of Degree	1st class Hons.	Upper 2nd class Hons.	Lower 2nd class Hons.	3rd class Hons./Pass	Unclassified	Classification not applicable	Total
Computer science	Doctorate	.	.	.	.	.	25	**25**
	Other higher Degree	.	.	.	.	120	225	**345**
	Other postgraduate	.	.	.	.	20	45	**65**
	First degree	195	290	225	105	15	.	**825**
	Foundation degree	.	.	.	.	40	50	**90**
	HND/DipHE	.	.	.	.	*	90	**95**
	Other undergraduate	.	.	.	.	10	135	**145**
	Total	195	290	225	105	205	570	**1,585**
Engineering & technology	Doctorate	.	.	.	.	*	125	**125**
	Other higher Degree	.	.	.	.	40	480	**520**
	Other postgraduate	.	.	.	.	*	45	**45**
	First degree	460	590	400	90	50	.	**1,580**
	Foundation degree	.	.	.	.	5	95	**100**
	HND/DipHE	.	.	.	.	*	170	**170**
	Other undergraduate	.	.	.	.	5	470	**475**
	Total	460	590	400	90	105	1,380	**3,015**
Architecture building & planning	Doctorate	.	.	.	.	*	25	**25**
	Other higher Degree	.	.	.	.	*	150	**150**
	Other postgraduate	.	.	.	.	*	30	**35**
	First degree	60	110	80	25	55	.	**330**
	Foundation degree	.	.	.	.	*	50	**50**
	HND/DipHE	.	.	.	.	10	20	**30**
	Other undergraduate	.	.	.	.	20	85	**105**
	Total	60	110	80	25	95	355	**725**

Subject Area	Class of Degree	1st class Hons.	Upper 2nd class Hons.	Lower 2nd class Hons.	3rd class Hons./Pass	Unclassified	Classification not applicable	Total
Total	Doctorate	.	.	.	.	10	600	**610**
	Other higher Degree	.	.	.	.	390	2,170	**2,560**
	Other postgraduate	.	.	.	.	180	1,120	**1,295**
	First degree	2,275	4,025	2,355	565	550	.	**9,775**
	Foundation degree	.	.	.	.	60	440	**500**
	HND/DipHE	.	.	.	.	50	575	**620**
	Other undergraduate	.	.	.	.	95	1,200	**1,295**
	Total	2,275	4,025	2,355	565	1,335	6,100	**16,660**

Appendix D Number of Pupils aged 17 studying selected science-related subjects at A-level (a) (b) (c)

Group	Subject	2005	2006	2007	2008	2009 (d)	2010	2011	2012	2013	2014	2015
Science	Biology	2,000	1,887	1,822	1,832	1,785	1,870	1,917	1,849	1,793	1,761	1,662
	Biology: Human	21	15	23	22	16	32	0	0	0	0	0
	Chemistry	1,414	1,411	1,332	1,467	1,480	1,455	1,514	1,420	1,472	1,569	1,303
	Physics	956	972	942	889	986	1,019	974	920	949	967	888
	Science: Environmental	8	6	8	0	5	*	0	*	6	*	*
Design Technology	Science (Vocational Qualification)	13	7	22	41	32	91	130	132	200	222	232
	D & T Food Technology	33	47	40	50	44	7	52	44	39	40	41
	D & T Product Design	706	864	792	764	797	796	805	679	601	550	541
	D & T Systems Cont.	*	*	8	*	0	0	*	*	6	*	6
	D & T Textiles Technology	0	0	0	0	0	36	25	24	15	11	17
	Design & Technology	0	0	0	0	0	19	0	0	0	0	0
	Home Economics	51	56	46	48	32	0	0	0	0	0	0
	Home Economics: Food	0	0	0	0	0	16	24	19	16	15	12
Mathematics	Additional Mathematics	0	0	0	0	0	0	0	*	0	0	0
	Mathematics	1,724	1,690	1,826	1,967	2,083	2,203	2,160	2,191	2,253	2,233	2,102
	Mathematics (Further)	104	91	85	81	131	107	144	184	183	186	222

a) Pupils aged 17 on 31 August of that academic year. Only includes schools with pupils aged 17 on register. Excludes FE colleges – data for this is collected separately.
b) Includes maintained mainstream secondary schools only.
c) Excludes discounted qualifications.
d) Note that from 2009 onwards, the definition of this table has changed. From 2009, the table includes entries taken in previous years.
*data item has been suppressed as it is too low and may be disclosive.

Entries and results of pupils aged 15 in Wales studying science-related Subjects at GCSE Level 2014-15:

Subject/Subject Group	Number of entries	Percentage achieving an A*	Percentage achieving an A	Percentage achieving a B	Percentage achieving a C	Percentage achieving A*-C
Biological Sciences	5622	15.6	26.9	28.1	21.4	91.9
Chemistry	5503	18.5	26.0	26.5	21.8	92.9
Physics	5497	18.7	24.3	27.6	21.5	92.2
Single Science	17527	1.7	7.6	17.7	37.7	64.7
Additional Science	11927	3.5	10.9	23.0	35.0	72.3
Other Sciences (1)	669	8.8	21.5	27.1	22.0	79.4
Craft, Design & Technology	8029	3.4	12.4	20.7	25.9	62.4
ICT	5946	4.6	21.1	27.2	21.3	74.3
Mathematics	34871	7.6	10.0	13.7	35.9	67.3
Additional Appl. Science	877	-	2.4	9.8	35.5	47.8
(VQ) Applied Science	0	0	0	0	0	0

1 'Other Sciences' include: Astronomy, Electronics, Environmental science, Geology, Public understanding of science, Science in society

List of acronyms

ADHD	Attention Deficit Hyperactivity Disorder
BDNF	Brain-derived neurotropic factor, generally known by its acronym
BIHM	Bangor Institute of Health and Medical Research
CS	Compound Semiconductors
CSAW	Chief Scientific Adviser for Wales
DipHE*	Diploma in Higher Education
EPSRC	Engineering and Physical Sciences Research Council
ERDF	European Regional Development Fund (WEFO administered)
ESRI	Energy Safety Research Institute (at Swansea University)
FTE	Full time equivalent (used for calculating job numbers)
GCSE	General Certificate of Secondary Education
HCRW	Health and Care Research Wales
HEFCE*	Higher Education Funding Council for England
HEFCW	Higher Education Funding Council for Wales
HEI	Higher Education Institution
HESA	Higher Education Statistical Agency
HND*	Higher National Diploma – a further education qualification
LIGO	Laser Interferometer Gravitational-wave Observatory
LSC	LIGO Scientific Collaboration
MoU	Memorandum of Understanding
MRC	Medical Research Council
NRN(s)	National Research Network(s)
NSA	National Science Academy
PDRA(s)	Post-Doctoral Research Associate
PGR*	Post Graduate Research
PhD	Doctor of Philosophy – a postgraduate research degree
QR*	Quality Research
R&D	Research and development
REF	Research Excellence Framework (2014)
RCUK	Research Councils UK
SACW	Science Advisory Council for Wales
SFC*	Scottish Funding Council
STEM	Science, Technology, Engineering and Mathematics
STEMM	Science, Technology, Engineering, Mathematics and Medicine

UCLA University of California, Los Angeles (known widely by its acronym)

WEFO Wales European Funding Office

*Only found in the Appendices