

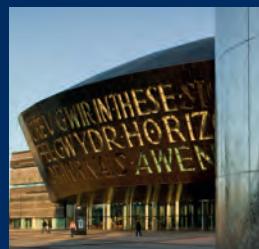


Llywodraeth Cymru  
Welsh Government

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# WELSH ACHIEVEMENTS

[ IN SCIENCE, TECHNOLOGY AND ENGINEERING ]



'Our vision in Wales is of a learning country, where highly-skilled and highly-qualified people are employed in high-technology, high added-value companies.'

**Professor John Harries**, first chief scientific adviser for Wales, speaking in 2011 at the Welsh universities collaboration, research knowledge and expertise programme – Welsh Crucible.



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On a global scale Wales is a small, but smart country, in which every opportunity has been taken to optimise resources, designs and processes. Shaped by landscape and culture it made its mark on the world through the maximisation of the great natural mineral wealth found here. Wales continues to make its mark through in-depth scientific and technical understanding and commercial innovation. From the past to the present an impressive list of achievements, many of which are the first of their kind in the world, have given Wales a great momentum for the future.

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The modern world is increasingly made up of the products of the application of science, technology and engineering.

Wales and the contribution of the Welsh people in the field of discovery and invention has underpinned many such applications – the theory of natural selection, the early development of crystallography, the discovery of free radicals and meson decay through to inventions of world-wide significance – the steam railway locomotive, the fuel cell and the microphone. More recently ground-breaking research into embryonic stem cells is underway and the work undertaken by Welsh computer scientists ranged from the technology necessary to underpin the World Wide Web to developments in the operating systems for touchscreen smartphones and tablet computers.

Wales may not have hosted any of the 'big science' projects of modern times, from the wartime Manhattan Project to the CERN Large Hadron Collider but it has played a significant part in both. The top secret Valley Works at Rhydymwyn in Clwyd, originally established to produce mustard gas, began conducting research for Britain's atomic bomb project in 1941. Scientists working there before work was assigned to the Manhattan Project in the USA included Rudolf Peierls and Klaus Fuchs. Fast forward some sixty years and we find Aberdare born Dr Lyn Evans project leading the commissioning work for the Large Hadron Collider and a team under Professor Mike Charlton of Swansea University working on the ALPHA experiment at CERN. To foster and continue this scientific tradition the Welsh Government has invested

# FOREWORD

£50 million in the Ser Cymru (Stars Wales) programme. This will build on Wales's established track record in the 'Grand Challenges' of:

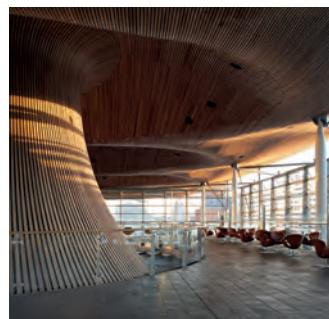
- Life sciences and health;
- Low carbon, energy and environment and
- Advanced engineering and materials

From 'big science' to everyday science the role of innovation is crucial.

Innovation knows no boundaries. The thought processes which lead to 'new' ideas can come from anyone and whilst research and development is structured to progress logically towards innovative processes and products, the 'Eureka' moment does not necessarily come about as the result

of such order. Inspiration and innovation often travel together and environments that stimulate, encourage and recognise good ideas, can only bring economic benefits.

The Welsh Government lays great stress on the value of innovation in maintaining and improving the prospects of Welsh companies for growth, as recognized in the Innovation Wales Strategy. In Wales a range of initiatives, competitions and activities are in place to encourage innovation from primary to tertiary education and industry. Outputs have already been translated into viable economic projects. Welsh universities form part of the world-leading science base of Britain, which is second only to the USA in its share of global citations.



Most innovations bring about incremental changes to an existing process or product. It is comparatively rare for the major step changes to occur but when they do, they can truly bring about a revolution in our standards of living and quality of life. We cannot all recognise the double helix of DNA for the first time nor bring microwave technology into the home but we can all come up with ideas for improving everyday life.

In an international study, Thomson Reuters ranked Wales among the world's top 20 countries in terms of citations per scientific paper, whilst other research shows the number of articles authored by Wales based researchers has grown at a rate outpacing the UK and world averages.

As this publication demonstrates, Wales has an enviable track record for incremental and step changes resulting from the application of innovative ideas. Initiatives are in place at all levels to encourage individuals and organisations to engage in lateral thinking to develop and commercialise their ideas. Humans are naturally curious and by creating an environment that encourages that curiosity, Wales is already feeling the economic benefits.

The following pages include past and current accomplishments and also some that could be said to be 'just on the horizon' in terms of realisation.

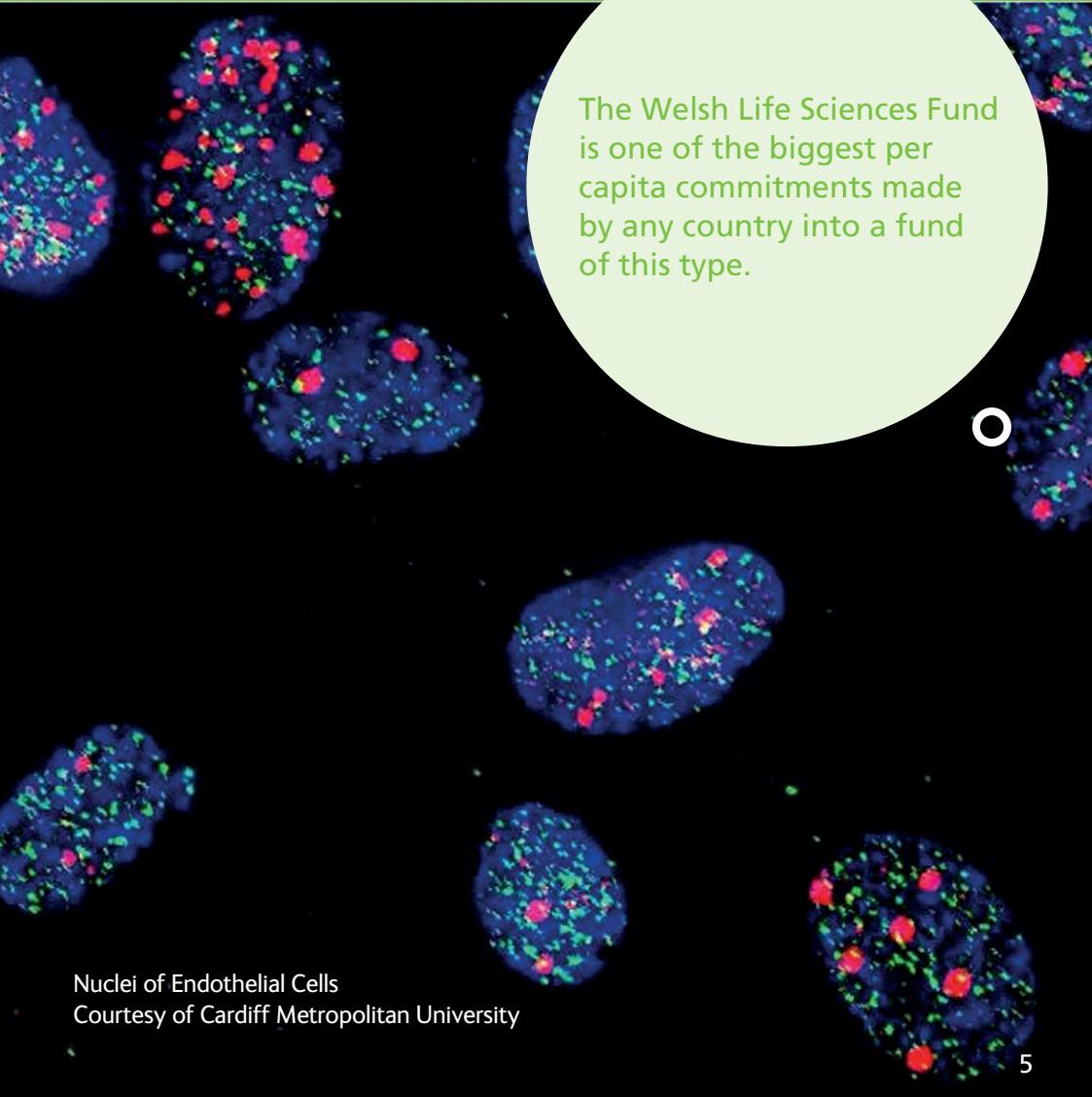
## Watch this space...



Wales has an enviable track record.



# BIOSCIENCES AND HEALTH



The Welsh Life Sciences Fund is one of the biggest per capita commitments made by any country into a fund of this type.

Nuclei of Endothelial Cells  
Courtesy of Cardiff Metropolitan University

Morvus Technology, established in 2007 to develop anti-cancer drugs, has embarked on collaborative ventures with Cardiff University School of Medicine in the development of diagnostic tests.



The Bioscience and Health sector is an important one in Wales. It is home to one of the UK's most well established bioscience clusters with its longstanding reputation for scientific and academic excellence, over 250 companies choosing Wales as their base.

With increasing demands and expectations for further improvements in healthcare, market opportunities have encouraged numerous spin-outs to emerge from the university sector where closer links between the various disciplines such as medicine, biosciences, electronics, chemistry and computer science are producing world-class developments.

Led by Professor Jorge D. Erusalimsky, the Cellular Senescence and Vascular Biology Group at Cardiff Metropolitan University

are engaged in work that may lead to life-style and pharmacological interventions to slow down the development of aging-related vascular pathologies. The group has discovered that one of the mammalian proteins called Sirtuins protects cells that form the inner lining of blood vessels.

The team led by Professor Ole Petersen at Cardiff University's School of Biosciences has discovered a protein that could lead to new treatments to reduce the risk of pancreatic cancer.

Powys based Alzeim Ltd are extracting a natural chemical called galantamine from daffodils which slows the progress of Alzheimer's disease.

Telemedicine diagnosis programmes for ophthalmology, such as retinopathy screening, have been pioneered in rural Wales as a pilot along with parts of Canada, Australia and India.

The diagnosis of adverse health conditions has benefited greatly from the convergence of different scientific disciplines. Increasing miniaturisation of test equipment now enables self-testing kits and telemetric systems to convey results to the surgery and hospital without the patient having to attend in person.

Many diagnostic tests are being developed and manufactured in Wales to detect, for example, diabetes, osteoporosis, thyroid disorders, anaemia and infectious diseases. The continued success of the sector has been built upon the links between renowned academic institutes such as Cardiff University (including

the University of Wales College of Medicine – UWCM) and indigenous companies in the sector. In addition, Wales also boasts a strong and stable skills base, purpose built infrastructure and a firm commitment to the sector by the Welsh Government.

The development of new drugs, the way in which they can be delivered to the active sites in the body and their mode of action are major research areas at the Welsh School of Pharmacy. Small molecules and much larger polymer-based molecules are being devised and evaluated to combat diseases such as cancer, viral and bacterial infections and tropical diseases.

The Wound Healing Research Unit at Cardiff University was the first in the world to specialise in this subject and five Schools in the University are also combining in the Cardiff Institute of Tissue Engineering and Repair (CITER) for the early application of research results into clinical practice.

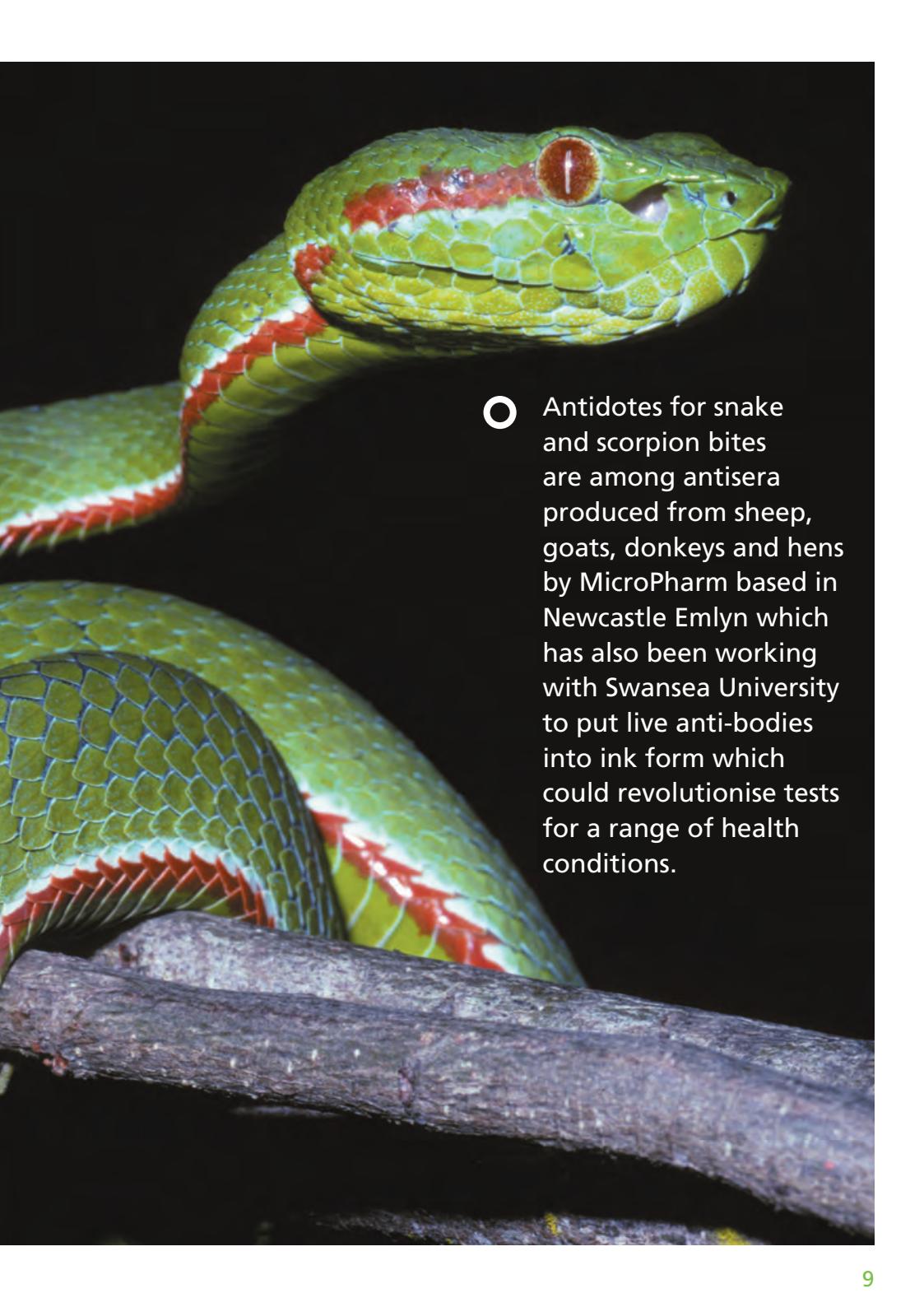


At the more fundamental level, the Institute of Medical Genetics has contributed to the maintenance of the Human Gene Mutation Database at Cardiff Wales Gene Park, putting Wales at the forefront of genetics research.

○ Hair samples are being used to identify historical exposure to drugs in humans in an analytical service developed by Concateno Tricho Tech of Cardiff, the longest established laboratory providing hair strand testing in the UK.

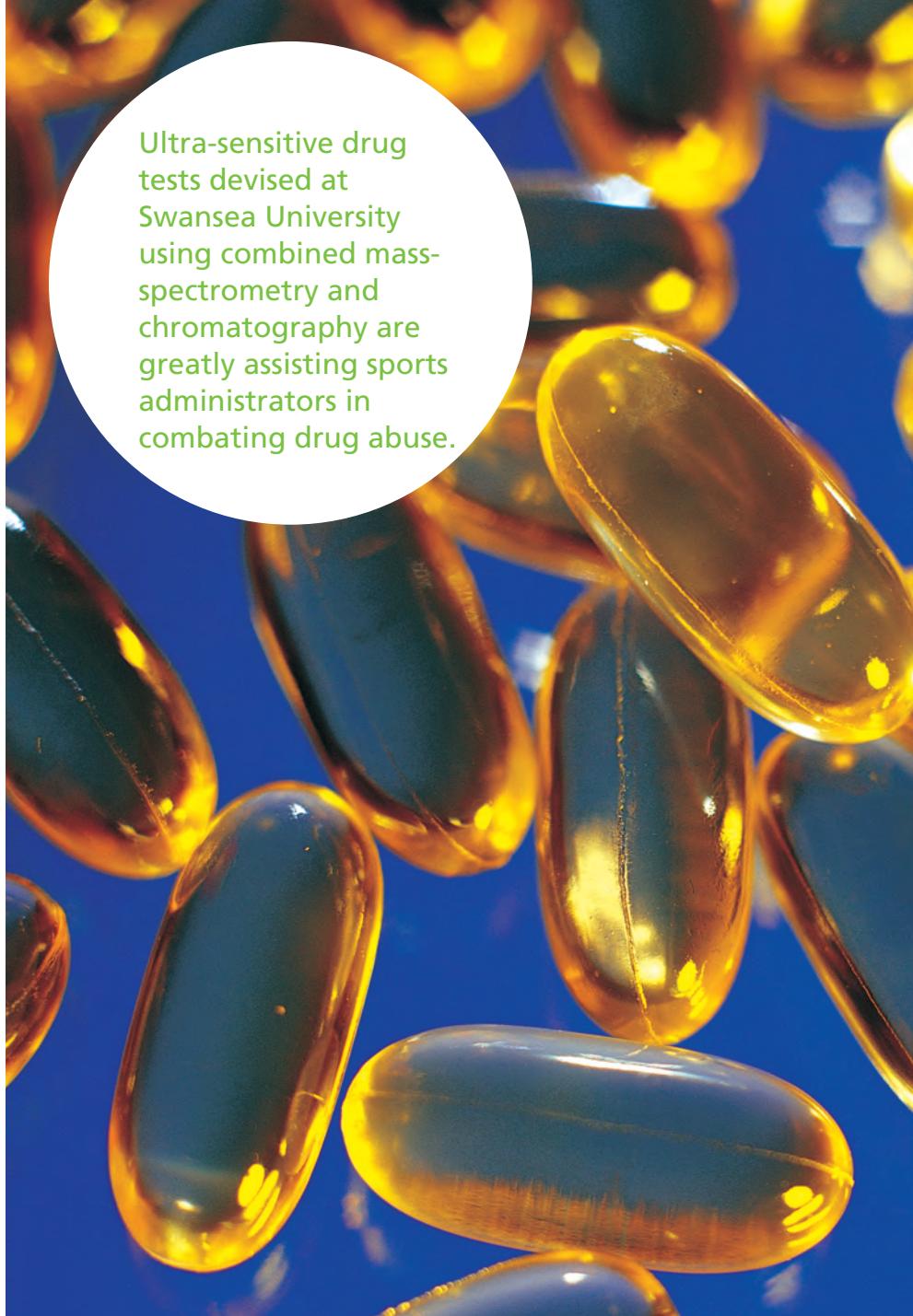
Greenbottle house fly maggots bred by BioMonde of Bridgend, are being used very successfully in the UK and Europe to treat ulcers. An application that offers much promise in the treatment of wounds infected by MRSA.





○ Antidotes for snake and scorpion bites are among antisera produced from sheep, goats, donkeys and hens by MicroPharm based in Newcastle Emlyn which has also been working with Swansea University to put live anti-bodies into ink form which could revolutionise tests for a range of health conditions.

- Scientists based at the NanoHealth Centre part of the Institute of Life Science (ILS), at Swansea University have made significant steps forward in osteoarthritis research.
- Cardiff University's chancellor, the Nobel laureate, Professor Sir Martin Evans, has been joined by the German Nobel laureate, Professor Robert Huber, who leads the development of structural biology at the university.
- Researchers at Cardiff University have developed an analytical tool using chemiluminescence and revolutionising biomedical research and clinical diagnosis.
- The protocol for the controlled trials of drugs devised by Professor Archie Cochrane at Cardiff was to become the world-wide standard procedure in drug evaluation.
- Cardiff University's Brain Research Imaging Centre (CUBRIC) combines the latest brain scanning technologies in order to pioneer advanced techniques capable of mapping the structure and function of the healthy and impaired brain and is leading the way forward in research on the brain's white matter – as opposed to grey matter.
- Bangor University was the first in the world to study the timing of chemical changes in the brain related to its function by combining electroencephalography (EEG) and mass resonance spectroscopy (MRS).
- Rapid and reliable detection of food-poisoning bacteria has been achieved using Picosorb's magnetic bead technology developed in their north Wales laboratories.
- Over 25,000 postmortem examinations were carried out by Gower born Sir Bernard Knight, one of the world's leading forensic pathologists.



Ultra-sensitive drug tests devised at Swansea University using combined mass-spectrometry and chromatography are greatly assisting sports administrators in combating drug abuse.

- Life science is a fertile area for academic interaction and technology transfer with a world class research hub being established at Swansea University. A unique collaboration here with IBM at the Institute of Life Sciences (ILS) provides a platform for computational biology dedicated to life science research using the supercomputer – Blue C.
- Professor Mark Baird's research team in Bangor are the first to prepare in the laboratory a set of key molecules present in TB cells, work which will open up new methods for detecting the disease and enhance worldwide efforts to improve the management of tuberculosis in populations high in HIV/AIDS and TB.
- Facial structure rebuilding following extensive surgery has greatly benefited from the use of rapid prototyping techniques by Cardiff Metropolitan University to construct a 3D model based on CT and MR scan information.

The assessment of cardiovascular disease and foetal heart monitoring has been greatly improved using Doppler ultrasound equipment developed and manufactured in Cardiff by world leaders Huntleigh Diagnostics (now part of ArjoHuntleigh).





# THE BUILT ENVIRONMENT

A wide-angle photograph of the National Botanic Garden of Wales at Llanarthne. In the foreground, numerous yellow daffodils are scattered across a grassy field. A large, translucent glass dome, designed by Lord Norman Foster, stretches across the middle ground. Bare trees stand in front of the dome, and the sky is clear and blue.

The largest single span glasshouse in the world was designed by Lord Norman Foster and partners for the National Botanic Garden of Wales at Llanarthne.



Superimpose centuries of human activity on a country bounded on three sides by the sea, on a topography laden with mountains, hills and river valleys all receiving high rainfall and you have a recipe for the need to build many bridges and aqueducts for roads, railways and canals. Combine this with a complex geology, host to a wide variety of rock types suitable for building stone and there is a recipe for a fascinating mix of structures in the built environment.

Taking the Newtown and Machynlleth Railway across the Cambrian mountains and through the rugged outcrop of Talerddig resulted in the deepest railway cutting in the world with a depth of 37 metres. Opened in 1862 it carried the line over the highest part of its route some 211 metres above sea level.

The task of crossing rivers and estuaries has preoccupied engineers in Wales for centuries and some of the major innovations in design and the use of materials have been incorporated in bridges.

The highest dam in the UK is Llyn Brianne, completed in 1973 to supply water to Swansea.

From the early use of stone and cast-iron to the fine lines of cable stayed structures, Wales has been at the forefront of bridge construction. In particular the severe weather conditions encountered in the Severn Estuary presented challenges for both design and materials of construction, challenges successfully overcome by the two graceful road crossings so essential to the economic well-being of Wales.

With an abundance of natural building stone, the man-made landscape in Wales has great variety. The use of dressed local stone has given many terraced-house communities in the mining valleys a unique character and the abundance of high quality slate extracted from the north-west quarries graces not only local buildings but also many world-wide. The use of indigenous materials is a tradition continued with the Wales Millennium Centre in Cardiff and many of the Tourist Information Centre buildings. The regeneration of Cardiff Bay and the Swansea dock areas is providing architects

with many opportunities to express new concepts for the built environment, reflected in examples such as the Senedd building in Cardiff Bay and the National Waterfront Museum at Swansea.

The increasing use of tensile fabric clad buildings has been led by Architen Landrell, of Chepstow. Associated with the Millennium Dome the company developed an acoustic liner for the Skyscape building as part of the Millennium celebrations. More recently the company provided the tensile fabric cladding for the London 2012 Aquatics Centre, using some 20,000 square metres of fabric.

Architen Landrell's technology in this field has been called upon to provide the explorers, scientists and scientific equipment of Sir Ranulph Fiennes Antarctic Expedition with a 'lifesaving' insulated zone for their attempt to be the first to cross Antarctica and reach the South Pole during winter.

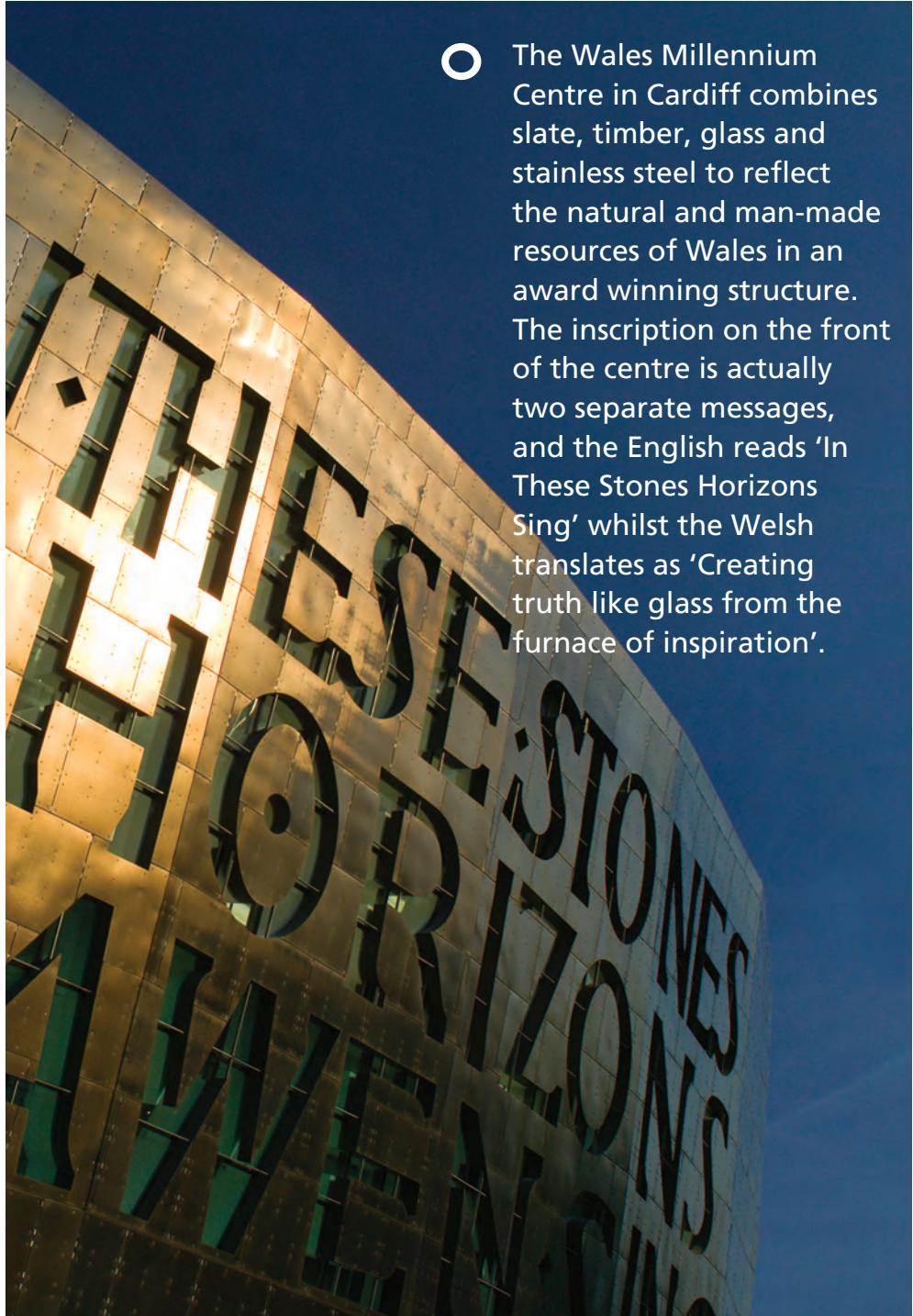
George Street Bridge across the Usk at Newport was one of the first cable-stayed bridges built in the UK.

Thomas Telford's Menai Suspension Bridge of 1826 was the world's first large scale road crossing by an iron suspension bridge.



The highly innovative streamlined box-girder units for the deck of the first Severn Crossing suspension bridge were fabricated at Fairfield Shipbuilding and Engineering Ltd, now Mabey Bridge Ltd, in Chepstow.





The Wales Millennium Centre in Cardiff combines slate, timber, glass and stainless steel to reflect the natural and man-made resources of Wales in an award winning structure. The inscription on the front of the centre is actually two separate messages, and the English reads 'In These Stones Horizons Sing' whilst the Welsh translates as 'Creating truth like glass from the furnace of inspiration'.

The first building to exploit the technique of reinforced concrete in Britain was the multi-storey Weaver's Mill of 1897 in Swansea.

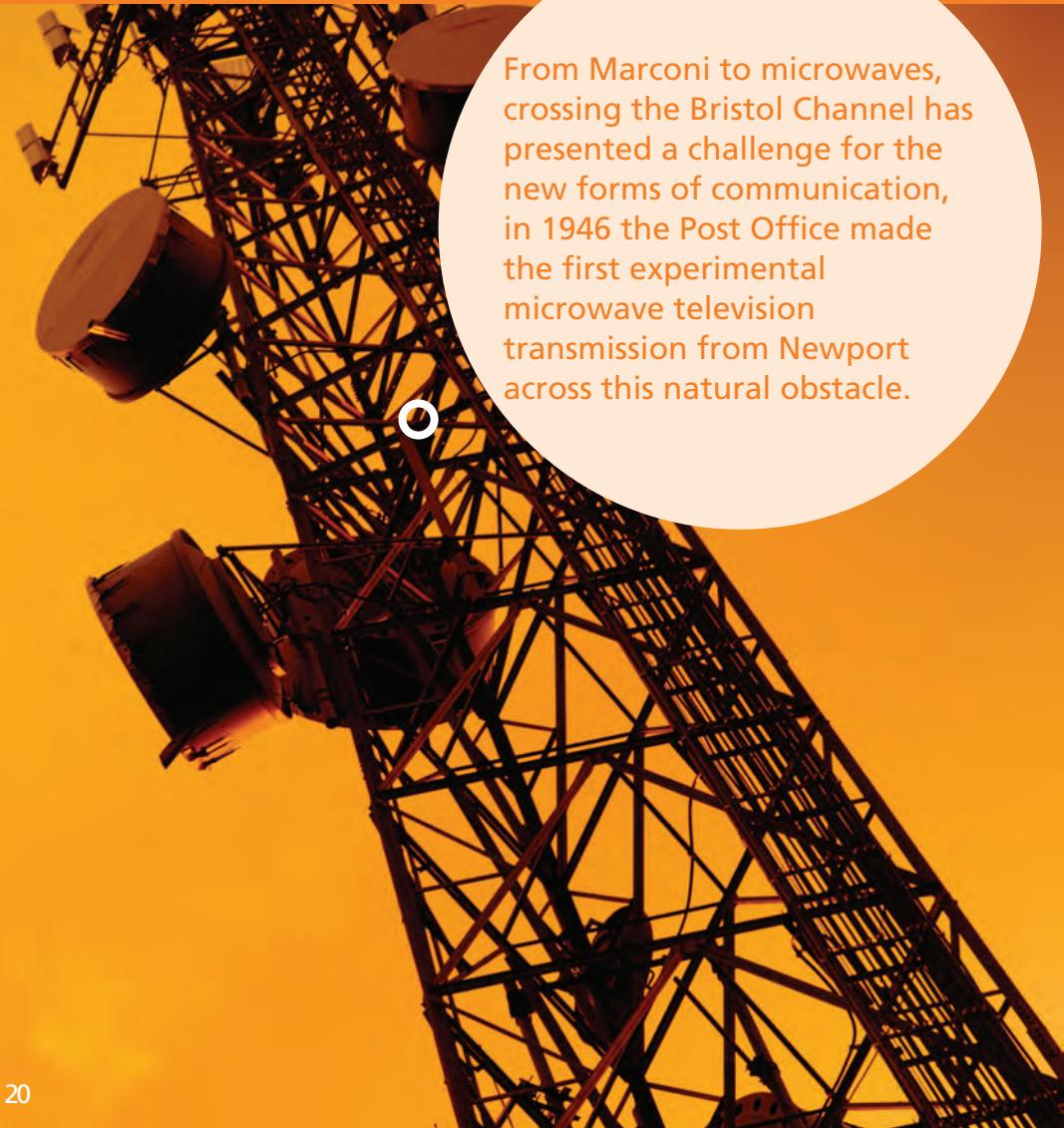
- The pioneering design by Richard Rogers for the Inmos factory at Newport in 1982 exposes the services and structural members on the outside leaving the inner space free of detail.
- The canal age's greatest monument to iron is Thomas Telford's Pontcysyllte Aqueduct which carries a cast-iron trough, 300 metres long, across the Dee Valley on stone piers 40 metres above the river in 1805. It is now the centrepiece of a World Heritage Site.
- The Severn Tunnel was the longest railway tunnel in the UK for over 100 years, being completed under the Severn Estuary in 1885. At 7.2km long it represented 'the ultimate in the engineer's fight against adversity'.
- The oldest surviving iron railway bridge, dating back to 1793, can be found at Pontycrafnau in Merthyr Tydfil.
- Robert Stephenson developed, in conjunction with others, the box-girder bridge in order to cross the Menai Straits. The first wrought-iron tubular bridge to this design was built at Conwy in 1848 and still stands today.

- One of the largest maritime civil engineering projects in Europe was the Cardiff Bay Barrage built to create a permanent fresh water lagoon and flood relief provision. Constructed from 1994 to 2000 it has received a number of awards including the Concrete Society Awards 2001-2002 winner for 'Outstanding Structures'.





# TELECOMMUNICATIONS AND ICT



From Marconi to microwaves, crossing the Bristol Channel has presented a challenge for the new forms of communication, in 1946 the Post Office made the first experimental microwave television transmission from Newport across this natural obstacle.

Since the early days of the primary inventions of the microphone and printing telegraph by David Hughes, Wales has been closely involved with the communications revolution. From the initial transfer of signals along a copper wire, through the ability to send a signal over the air to the onset of the electronics age and the evolution of fibre optics and digital communication, Wales has made major contributions to man's ability to communicate.

Researchers at Welsh universities can access High Performance Computing (HPC) Wales, a £40million five-year project and Fujitsu's largest supercomputing project with 190 teraflops of reliable and secure processing power available.

Computer scientist Alan Cox of Swansea University was responsible for one of the first Linux installations on a busy computer network and contributed to the development of the whole kernel, which led to developments such as the Android operating system.



The internet search engines Google and Yahoo! were developed with funding from Welsh born Michael Moritz.

Wales has been instrumental in a number of basic communications technologies including the microphone, the telegraph, radio transmission, airborne radar, microwave television transmission and packet-switched data communication as the precursor of the Internet. Industrial and academic investments are maintaining Wales' presence at the forefront of communications technology.

OpTIC Glyndŵr, a subsidiary of Glyndŵr University, is playing a major role in the European Extremely Large Telescope (E-ELT) project set to revolutionise optical astronomy.

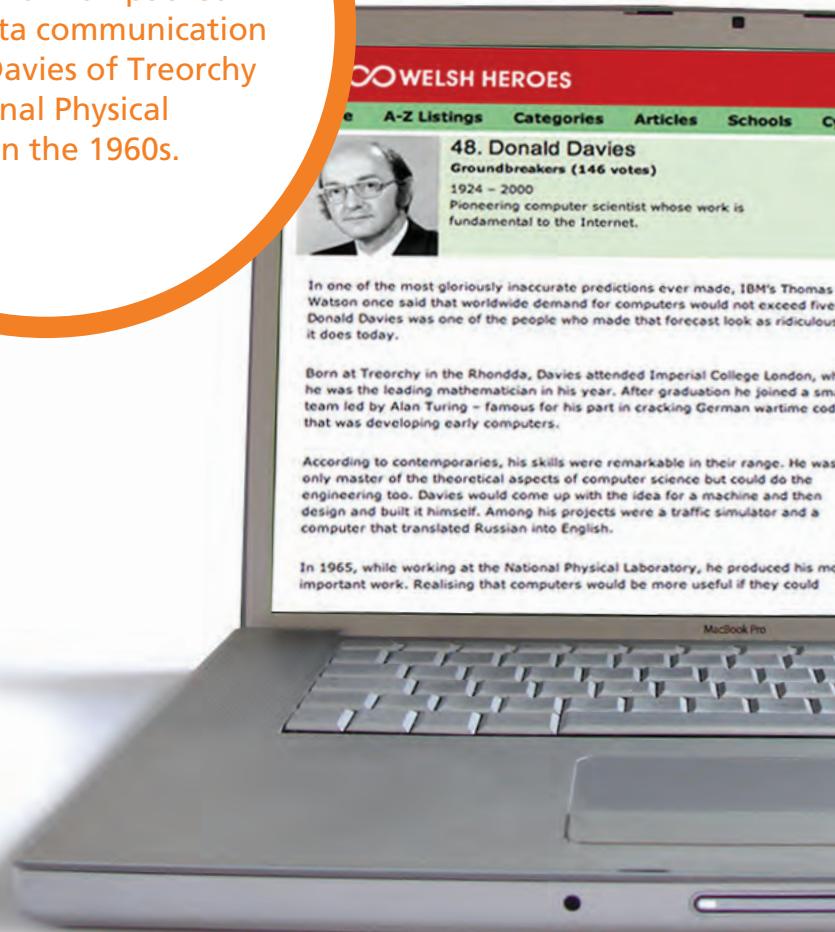
In the second world war a reliable system of airborne radar was developed in 1940 by Edward Bowen from Swansea.

The 'Superfast Cymru' programme is being rolled-out to deliver high speed fibre broadband to 96% of homes and businesses in Wales by the end of 2015 and represents one of the largest partnerships of its kind currently in the UK.



Web design company S8080 based in Swansea have had several high profile commissions including the design of Number10.gov.uk.

The development of the Internet followed on the pioneering work on packet-switched data communication by Donald Davies of Treorchy at the National Physical Laboratory in the 1960s.



One of Europe's most advanced data centre environments is underpinned by BT in Cardiff Bay which has fostered the growth of digital commerce companies. Comparison websites such as the UK's first car insurance comparison site,

Confused.com, based in Cardiff, Gocompare.com in Newport and Moneysupermarket.com in Ewloe, Flintshire, are also well represented.

When it opened in 1982, the HTV television studio complex at Culverhouse Cross, Cardiff was the world's largest purpose facility of its kind.

- The first airborne radio telephone transmission was made in 1911 by Harry Grindell Matthews, using his 'Aerophone', with pilot B.C. Hucks flying from Ely Racecourse in Cardiff.
- 2012 marked the official opening of the BBC Cymru Wales' Roath Lock studio complex in Cardiff Bay, one of the largest investments in new drama facilities in Europe and the first industrial building in the UK to obtain the prestigious BREEAM Outstanding certificate.
- Next Generation Data have secured contracts from BT and Logica for the provision of space and infrastructure at their data centre in Newport, which at 75,000 sq metres is one of the world's largest.
- In 1844 the telegraph pioneer Charles Wheatstone first demonstrated submarine telegraphy with the help of experimental scientist and industrialist, John Dillwyn Llewelyn, in Swansea Bay.
- Swansea's Morfa works supplied the copper for the first transatlantic cable in 1857 and this ideal conductor would be in great demand for both overland telegraph wires and undersea telegraph cables.

- The type-printing telegraph was invented by David Hughes from Bala in 1855 and used throughout the expanding USA. He also invented the carbon granule microphone and transmitted electromagnetic waves in 1879, although he didn't realise it at the time.



The first over-water transmission of radio waves was made by Gugliemo Marconi between Lavernock and the island of Flat Holm in the Bristol Channel in 1897.

- Sir Terry Matthews founded the Mitel Corporation in 1972 to manufacture and supply private exchanges (PABXs) for organisations worldwide.



# CREATIVE INDUSTRIES



Wales is becoming a centre of creative excellence for UK-produced drama following productions like Dr Who and Sherlock starring Benedict Cumberbatch.

Sherlock, filmed in Wales  
Courtesy of Hartswood Films



The creative industries sector in Wales employ over 26,000 people in over 2,500 active businesses, generating a turnover of about £1 billion annually.

Wales offers real opportunities as a place for creative business to establish and grow. The diverse sector comprises a wide range of companies ranging from software development, games and animation, to high-end film and television production, music, Journalism and fashion design.

With its world renowned centres of excellence and university system, Wales produces nearly 5,000 graduates every year with specialist qualifications in subjects such as computer science, games development, animation, visual effects, digital and mobile technology development and journalism.

Wales' devolved government offers unique opportunities through public sector procurement, with public service broadcasting (BBC and S4C) spending more than £100 million annually in the creative industries sector.

The arts and particularly music have been a feature of Welsh culture for centuries. Whilst the application of new electronics-based technologies to creating sound and images is creating a rapidly growing aspect of the economy, the more traditional forms typified by the talents of Katherine Jenkins, Bryn Terfel and the Welsh National Opera Company are also thriving.

The Royal College of Music and Drama is the National Conservatoire of Wales, and was the first All-Steinway Conservatoire in the UK. It competes alongside an international peer group of conservatoires and specialist arts colleges for the best students globally, enabling students to enter and influence the world of music, theatre and related professions.

The creation of solid objects remains a strong feature in the Welsh economy where long experience in design and the manipulation of materials maintains thriving operations in the jewellery, garment, furniture, pottery and painting sectors.

Wales's animation heritage is long established, in 1987 the BAFTA Best Animation award was given to Siriol Productions of Cardiff for their animated cartoon series Superted.

The National Museum & Galleries of Wales hosts the international contemporary

visual art show, Artes Mundi, one of the most significant in the world and which offers the largest cash prize awarded for the arts in the UK.

One of the finest collections of impressionist and post-impressionist paintings outside France, including Renoir's 'La Parisienne', can be found in the National Museum & Galleries of Wales.

Moving Image Wales (MIW) is part of the Creative Industries Research and Innovation Centre (CIRIC), at Swansea Metropolitan University, it aims to support the development of

new IP project proposals from Welsh media companies (TV, film and digital media) that are aiming to attract a portion of final production funding from outside Wales.

MediaLab is based at the Cardiff School of Creative and Cultural Industries, at the University of South Wales, and is the centre for digital media innovation and enterprise.

Cardiff School of Journalism, Media and Cultural Studies has teaching programmes designed to be relevant to

a rapidly changing media environment, and keeps abreast with the most recent academic thinking. Staff include some of the world's leading writers and thinkers on media and culture, working alongside other teachers who have had outstanding careers in journalism, the media industries and public relations. The School is regularly commissioned by the media industry, government, research councils, foundations and non-government organisations to conduct research.



The National Screen and Sound Archive of Wales houses a comprehensive collection of films, television programmes, videos, sound recordings and music.

Cardiff School of Arts and Design (CSAD) is part of Cardiff Metropolitan University. CSAD's strengths are in art, design and technology. The School is interested in the relationship between arts and sciences, and in situating the student in the real world.

- Two of the largest Schools of Music in the UK are located at Bangor University and Cardiff University.

- A documentary photography diploma course was established by David Hurn of Magnum fame at the Newport College of Art in 1973.
- Alfred Sisley (1839–1899), one of the greatest landscape painters of the 19th century, and a leading figure behind the Impressionist movement, choose to come to south Wales in 1897, taking up lodgings at Penarth and later Langland Bay near Swansea. The Welsh land and seascape inspired Sisley and gave rise to some of his most free and improvisatory paintings.

Image courtesy of Iconicles Ltd and Dinamo Productions Ltd.

The animation scene remains strong in Wales building upon the work of companies such as Siriol and Dinamo.





- Internationally significant creative content production companies include Tinopolis, the largest UK production company outside of London at Llanelli.
- Boomerang, which produces extreme sports and children's content for clients including Disney, Playstation3 and Red Bull.
- Welsh gold, mined for Celtic chieftains over 2,000 years ago, is still sought after as jewellery items for the Royal family. When Prince William placed a wedding band on Kate Middleton's finger in 2011, it was made by family jewellers from Wales from a nugget of Welsh gold. The Llandudno jewellers, Wartski, also

made wedding rings for the Prince of Wales and the Duchess of Cornwall for their wedding in 2005.

- Specific Media is a global interactive media company and owner of MySpace, with a presence across the US and Europe. It has a base in Wales in the shape of Xumo, a provider of online video products and solutions.

**Merthyr-born Laura Ashley established her first shop in 1968 with the company headquarters set up in Carno, near Newtown.**



Doctor Who, filmed in Wales  
Courtesy of BBC Worldwide

Da Vinci's Demons is a multi million pound fantasy drama series filmed in Wales. It follows the untold story of the world's greatest genius during his turbulent youth.



Courtesy of 2013 Tonto Films and Television Limited

- Major TV productions include Doctor Who, produced by BBC Wales.
- Sherlock produced by Hartswood films – their dedicated nations and regions office operating from Cardiff city centre has led to a significant proportion of the first series being produced in Wales, using Welsh locations, cast and crew.
- Being Human – produced by Touchpaper Television for BBC3 which is streamed online via Netflix to USA and Canadian audiences.
- Recent high-end TV drama productions filmed in Wales include Hinterland, a contemporary television detective drama series, shot back-to-back with English and Welsh language versions of the programme being produced simultaneously.
- The Machine a modern day re-imagining of Mary Shelly's Frankenstein, set in the near future, was produced in south east Wales by Cardiff based Red and Black Films and has already sold to over 20 countries worldwide.



Courtesy of Cranc Cyf

- Ironclad, a major feature film, was shot entirely in Wales and produced in Dragon Studios near Bridgend and using locations throughout south Wales.
- Wales has a number of excellent facilities for video and audio post production such as Gorilla, Crash Editing, Bang, Cranc Cyf and Mercury FX. Some of the services offered include: online and offline grading and finishing; Audio editing and mixing; VFX, motion graphics and Design Post production; video editing; dubbing for documentaries, commercials animation and drama; and HD digital effects.
- Although Cardigan in west Wales gave its name, via the Earl of Cardigan, to a type of woollen sweater that buttons down the front, it was the home of Britain's biggest jeans factory. The jean tradition here is being carried on by the Huit Denim Company based in Cardigan Bay.
- William Haggar gave his first public performance of a 'Bioscope' show in 1898 at Aberavon Fair, he went on to film, in 1901, what was probably the first fictional film produced in Britain, and up to 1909 it is estimated that he made up to sixty narrative films.



# ENERGY



The SPECIFIC Innovation and Knowledge Centre (IKC) is a collaboration led by Swansea University with Tata Steel and a consortium of industrial and academic partners. The project aims to commercialise technologies which will allow buildings to become power stations and generate their own energy.

In terms of natural and renewable forms of energy Wales is well placed. It has been blessed with large quantities of fossil fuels including a wide range of coal ranks and off-shore gas and is well positioned for wind and tidal power options. Facing the SW prevailing winds off the Atlantic it is on the 'energetic' side of the UK, receiving relatively high rainfall on to hilly topography.

The Bristol Channel and Severn Estuary concentrate the tides to give the second highest tidal rise and fall in the world of about 15 metres. Severn tidal power schemes are constantly under discussion and if implemented could generate some 5% of the UK's electricity. Wales is moving towards becoming the UK's leader in the field of renewable energy with the go ahead given for the Gwynt y Môr 750MW wind

farm off the north coast which, when finished in 2014, will be the second largest in the world. Wales currently has 28 on shore wind farms comprising of 495 turbines.

Traditionally Wales has been renowned for its coal, the quality of which made trans-Atlantic steam navigation viable, and the preferred choice for steaming the Royal Navy. The climate allows for good cultivation and encourages timber and other plants to grow well here and produce high yields.

Projected to come on line in 2015, the Skerries Tidal Stream Array will be Wales' first commercial tidal energy farm and the largest of its kind in

- A tidal mill for grinding corn was built during the 16th century adjoining the 13th century castle at Carew in Pembrokeshire.



Lord Walter Marshall of Rhymney was director of the Atomic Energy Research establishment, Harwell and later Chairman of the Central Electricity Generating Board.

the UK. It will be developed by Siemens-owned Marine Current Turbines (MCT) and will supply up to 10,000 homes.

Wales has an association with the steam engine that goes back almost three hundred years to 1715. In that year a Newcomen atmospheric steam engine was installed on the Hawarden coalfield at Woods Mine, Ewloe, with another engine being installed at the Talargoch lead mines at Dyerth. These were the first in Wales and amongst the very first to be built following the first successful operation of a Newcomen engine in 1712.

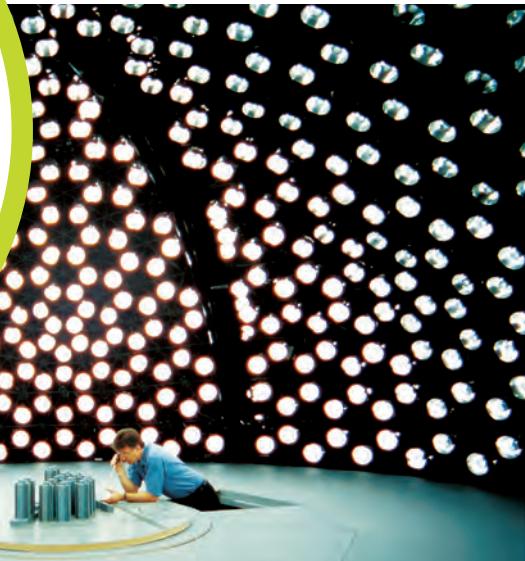
Welsh coal has provided energy for ships, trains, industry, power stations and homes. It has kept the home fires



burning and set the standard for steam coal.

Now the concentration is on examining renewable and more sustainable sources of energy. Lord Nelson considered Milford Haven to be one of the finest natural harbours in the world and today it is one of the few in Europe capable of accommodating super-tankers to supply the refinery industry and has now become the receiving terminal for imported LNG (liquefied natural gas), as the cleanest of the fossil fuels. A number of valleys in Wales have been dammed for water storage and supply whilst others provide hydroelectric power.

Sharp Solar, the largest photovoltaic manufacturer in the world, has one of its most technically advanced facilities in Wrexham where it assembles monocrystalline and polycrystalline solar modules for use in both residential and commercial installations.



The Centre for Alternative Technology in Machynlleth has for thirty years provided expertise and working examples in the field of energy generation and usage. A number of industrial initiatives has resulted directly from their activities and are being applied world-wide.

Expertise in the academic sector is yielding more efficient photovoltaic materials and thermoelectric devices and a number of companies are

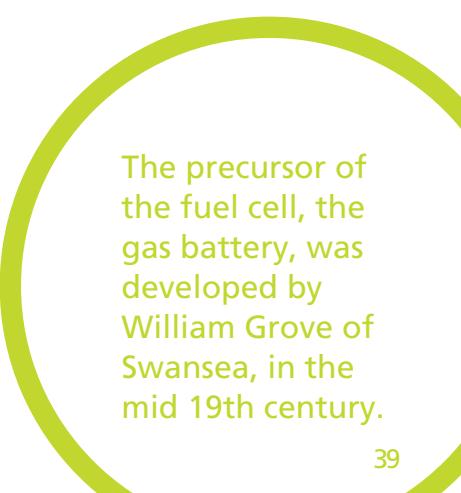
producing photovoltaics and finished systems using this technology. Coming over the horizon is the generation and use of hydrogen as an energy source and Wales is investing in the generation of the gas from wind and solar sources as well as from bacteria.

Energy generation in Wales encompasses most of the available technologies including nuclear, coal, gas, hydro, biomass and wind.

What will this list look like in ten years time?

- Swansea based company Enfis develop light engines and arrays that emit extremely high-power light – including the world's brightest LED package.

- The import and regasification of LNG (Liquefied Natural Gas) at Milford Haven is one of the largest hydrocarbon projects of its kind in Europe. The project involved the construction of a 300km pipeline from Milford Haven to Gloucestershire which is capable of carrying a fifth of the natural gas required by the UK.
- The Baglan Energy Park hosts the hydrogen energy research centre, developed by the University of South Wales in partnership with Neath Port Talbot Council.
- The basis for the classification of fossil foraminifera, an essential feature in oil exploration, was laid by Professor Alan Wood at Aberystwyth University.
- Western Wood Energy biomass power plant, in Port Talbot, produces clean electricity from sustainable fuel (wood chips) and was the first commercial-scale plant of its kind in the UK.
- Britain's first major oil refinery was opened at Llandarcy in 1921.
- Dinorwig power station at Llanberis is the largest pumped storage scheme of its kind in Europe, housed in the largest man-made cavern in Europe.
- Clarence Arthur Seyler, working in Swansea, devised the original classification of coal ranks.
- The first carbon dioxide capture and storage pilot plant in the UK at Aberthaw power station will be providing a crucial test ground for the potential of CO<sub>2</sub> capture and storage technology to generate low-carbon energy.



The precursor of the fuel cell, the gas battery, was developed by William Grove of Swansea, in the mid 19th century.

- The Institutes of Rural Sciences and Biological Sciences, and the Institute of Grassland and Environmental Research (IGER) have come together in the Institute of Biological, Environmental and Rural Sciences (IBERS) at Aberystwyth University. This is a world class research and education facility with the greatest access to expertise of its kind in the UK.
- Cardiff based G24 Innovations are pioneering a new range of dye-sensitised thin film solar panels that produce more electricity than the most highly efficient conventional solar cells.
- As part of the SPECIFIC programme Tata Steel's Corus Colors subsidiary aims to produce sheet steel used in roofing for warehouses, offices and other buildings treated with a sensitive coating, to generate electricity.



The National Plant Phenomics Centre at IBERS uses one of the most sophisticated research greenhouses and a unique facility in the UK.



# ENGINEERING



Rapid prototyping is revolutionising product design, and here industry is supported by a unique university partnership, the Advanced Sustainable Manufacturing Technologies (ASTUTE) network led by Swansea University, in collaboration with the Universities of Aberystwyth, Bangor, Cardiff, Cardiff Metropolitan, Glyndŵr, Swansea Metropolitan, University of Wales Trinity St David, and the University of South Wales.

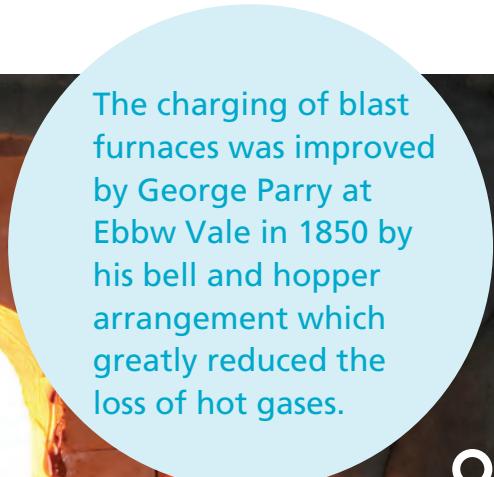
Image supplied by Stephen K. Jones

**With the basic production of metals, particularly iron and steel, extending back over centuries it was natural for Wales to become a major supplier to the engineering sector.**

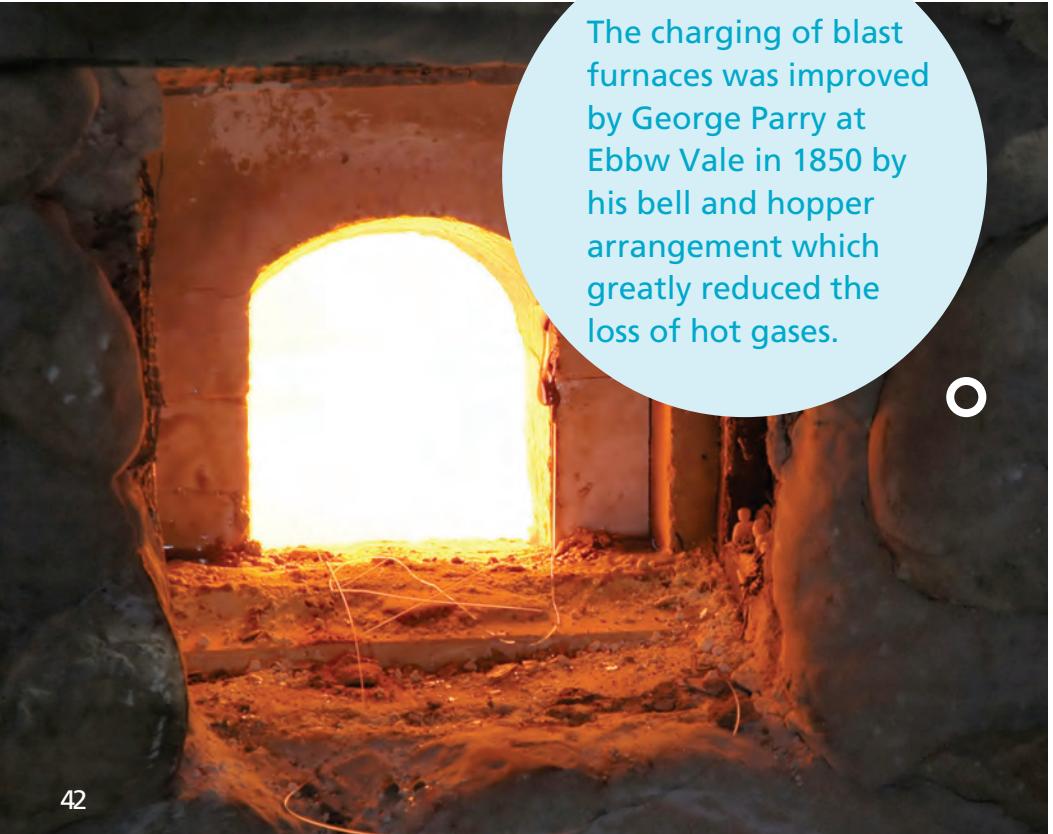
Metal production and finishing has traditionally ranged from large castings and forged items, the rolling of rails for the railways, tinplate and other specialised coatings and alloys to structural steelwork and steel for the automotive industry. The trend is now towards the manufacture of smaller and more complex

items and components with, ultimately, the arrival of technology suitable for manufacturing machines on a nano-scale.

Forging, casting and stamping were the traditional engineering activities during the industrial revolution and these have undergone



The charging of blast furnaces was improved by George Parry at Ebbw Vale in 1850 by his bell and hopper arrangement which greatly reduced the loss of hot gases.



their own revolution with the advent of new materials, control systems and finite element techniques. Numerous companies produce aluminium alloy and magnesium alloy castings and the latest laser and high pressure water jet cutting techniques are now much in evidence. The automotive component is still a major employer but an increasing number of companies produce engineered items for the biomedical, electronics and environmental sectors to very high tolerances.

Eureka UK lists the use of the 'world-changing' Finite Element Method outside the area of solid mechanics, as pioneered by Olgierd (Olek) Cecil Zienkiewicz of Swansea

University, one of the top 100 discoveries made in a British university.

Drawing on their experience in semiconductor development, the academic sector in Wales is pioneering lab-on-a-chip technology as well as the development of micro and nano-technology devices. Very small can be very rewarding!

- The first excavator to be operated solely by hydraulic power was produced by Hymac Ltd at Rhymney in 1962.

Chain cable for every Royal Navy ship from the 1820s to WWI was supplied by Brown Lenox of Pontypridd. The chainworks also supplied Brunel's Great Eastern steamship and the Cunarder QE2.



- A system for maintaining constant pressure on rolling mills was devised and patented by Statimeter Ltd of Rhydymwyn in 1948 which became widely adopted.
- The Welding Institute Technology (TWI) Centre provides a wide range of support to Welsh companies including non-destructive testing (NDT). In July 2013 the Institute moved to a new research facility built to BREEAM Excellent standard at the R&D campus in Harbourside Park, Port Talbot.
- The boring of cylinders to a high accuracy, for cannon and steam engine applications, was perfected by John Wilkinson at Bersham from 1774.
- The first universal speed control drive compatible with all types of electric motor was designed and manufactured by Control Techniques Ltd of Newtown.

A novel method of fastening sheet materials together was developed by High Torque Fastener Systems Ltd of Swansea – eliminating the need for external fasteners which fashions a unique threadform helix in the farthest sheet to act as the nut.





# ENVIRONMENTAL SCIENCES

O

A polar explorer and authority on the study of temperate glaciers and their modelled response to climate change, Professor Tavi Murray of Swansea University is only the eighth woman to be honoured with the Polar Medal, an award for both her Arctic and Antarctic research, which makes it doubly unusual.



Image supplied by Swansea University

With its long history of mining for coal and metal ores, of metal and non-ferrous metal smelting and slate quarrying, it was not surprising that Wales faced many environmental challenges in dealing with contaminated land. Through a combination of academic research, enlightened civil engineering and central government funding these challenges have been met and overcome to regenerate safe and beautiful landscapes throughout Wales. The spin-out has resulted in growing expertise in the development of sensors and treatment methods for waste materials.

- The application of gas chromatography to chemical analysis was pioneered by Professor Howard Purnell at Swansea University.
- Live willow support systems were developed as a sustainable alternative for slope stabilisation by Richards, Moorehead and Laing of Ruthin.

The wealth of growing expertise in Wales in the environmental sciences is assisting organisations throughout the world to deal with their own environmental issues. Experience gained in dealing with the legacies of coal, steel, non-ferrous metal and slate extraction and processing at home has seen many challenges abroad

successfully overcome by Welsh-based groups.

There is an increasing move towards on-site monitoring where the equipment is brought to the sample and not the sample to the equipment. A number of sensors and analytical devices are now available from Welsh manufacturers where the benefits of miniaturisation in electronics have given portability with increased speed of analysis and improved accuracy. Devices are available to monitor micro-organisms in soil, trace levels of toxic and strong-smelling compounds in air, bacterial contamination of surfaces and methane generation from waste sites.

In Wales we have changed 'How green was my valley' into 'How green is my valley' through our own skills and dedication.

- Lion Laboratories of Barry developed the world's first electronic breathalyser in 1974 and sold the product to police forces around the world to measure the evidential alcohol levels of motorists.

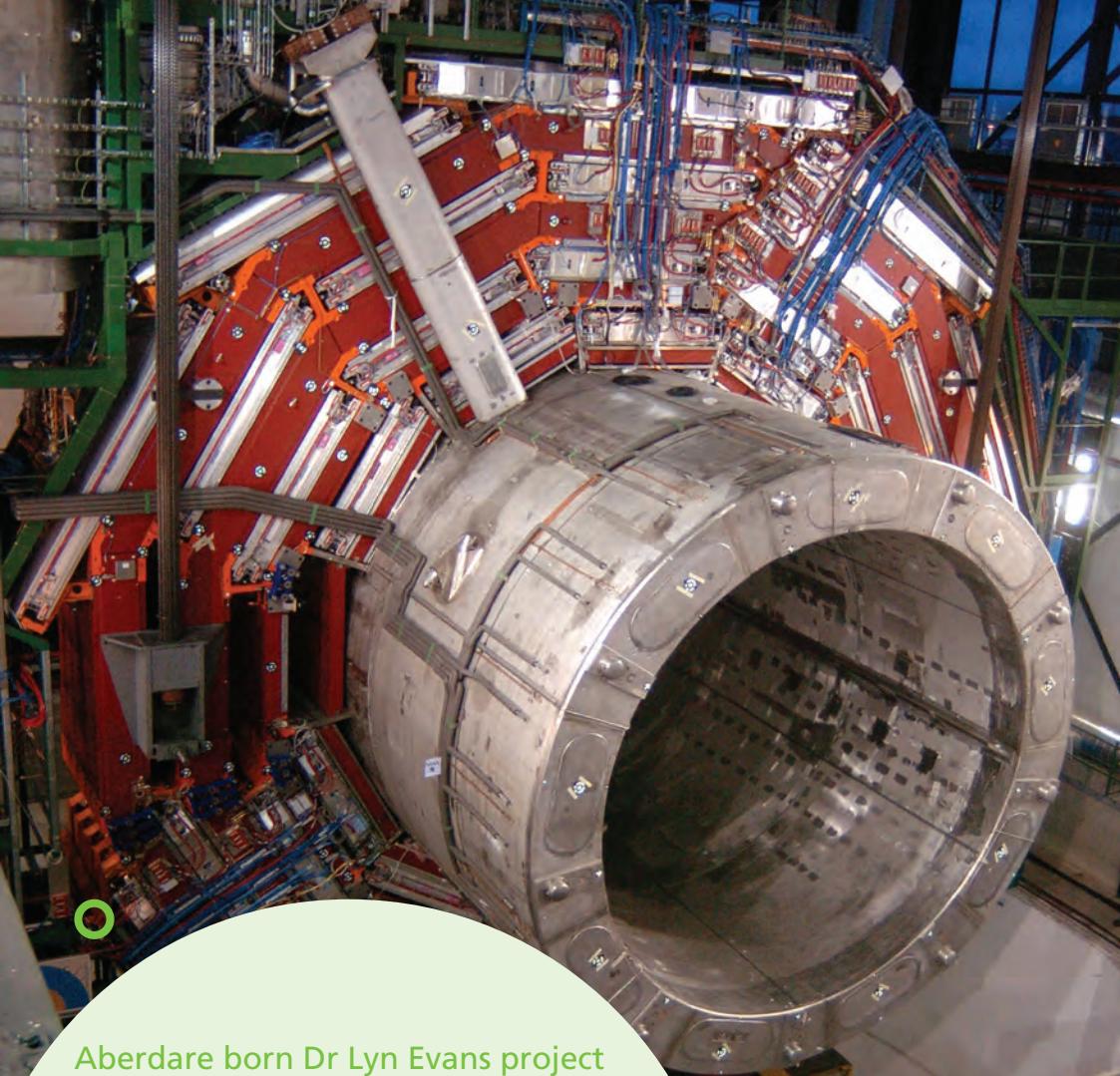
- Waste slate from north Wales has been spun into fibres to make insulation material.
- Formaldehyde arising from insulation materials and other sources can be measured in seconds using a handheld monitor developed by PPM at Bangor.

Research into the effects of lightning strikes on aircraft composite materials and structures will be the objective of Cardiff University's Morgan-Botti Lightning Laboratory, the most advanced University based lightning test facility in the UK.



DNA-based technology for detecting and identifying pollution affecting our waterways and beaches was pioneered by Ystrad Mynach based EnviroGene Ltd.

- Welsh physician, physicist and statistician, William Morgan FRS, is considered the father of modern actuarial science and is credited with being the first to record the 'invisible light' produced when a current is passed through a partly evacuated glass tube – the first x-ray tube.
- Welsh scientists are making a major contribution to the fight against climate change including Sir John Houghton who was jointly awarded the Nobel Peace Prize in 2007.
- The application of computers to weather forecasting was introduced by Sir Oliver Sutton of Cwmcarn during his term as Director of the Meteorological Office from 1953 – 1965.
- Standards for contaminated land reclamation were set by the 1966 Lower Swansea Valley Report that followed the successful programme that reclaimed 450 hectares of land.
- Major aircraft manufacturers and airlines use a portable monitor developed by ECHA Microbiology of Cardiff to measure microbial fouling in aviation fuels.



Aberdare born Dr Lyn Evans project led the most significant attempt being made so far to unravel the mysteries of the universe, by the European Nuclear Research Organisation (CERN) in Geneva using the Large Hadron Collider (LHC). His next role will be as project director of the LHC's planned big brother, the cataclysmic International Linear Collider (ILC) as well as the Compact Linear Collider (CLIC).





# MATERIALS

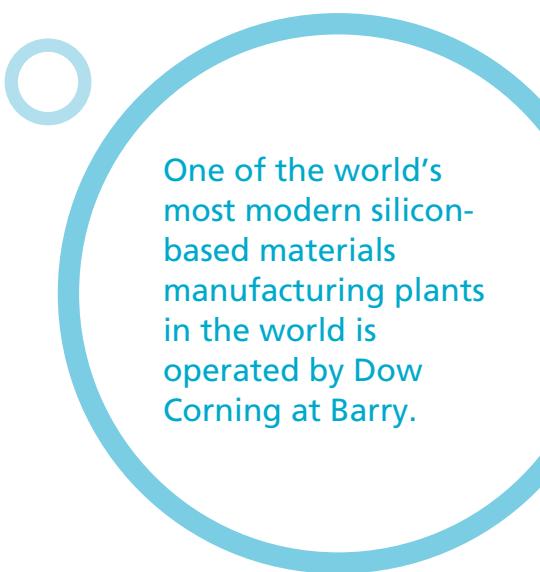


Fully customer-qualified  
6" semiconductor wafers  
were produced for the  
first time by IQE plc of  
St. Mellons, Cardiff.

With an abundance of iron ore, non-ferrous metal ores, timber and coal it was inevitable that metal smelting and manipulation in Wales would lead to the creation of major industries and discoveries.

Through the period of industrialisation Wales would set the world price of industrial commodities, coal at Cardiff, copper at Swansea and tin plate at Llanelli. Swansea became known as Copperopolis and was renowned for copper-smelting with some 90% of all the copper-smelting capacity of Britain being based within twenty miles of the town by 1820. Fuelling the demand was Anglesey's Parys Mountain mines, which became the world's main source of copper ore from 1768.

Materials research, development and manufacture have subsequently been a major feature of academic and industrial operation for many years. Applications have been based on the extraction and manipulation of indigenous materials, on the development of new materials, on the combination of materials in new arrangements and on the reuse of 'wastes'.



One of the world's most modern silicon-based materials manufacturing plants in the world is operated by Dow Corning at Barry.

For a small country, Wales has been a major contributor in the manufacture and processing of materials. From steel manufacture and rolling to primary aluminium smelting and pure nickel production, tin-plate manufacture and titanium processing, Wales supplies world-wide markets.

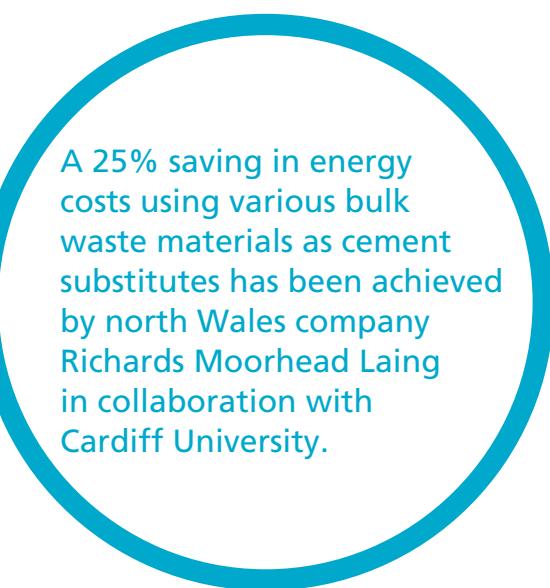
Successive investments have established one of the world's largest silicone polymer plants here as well as semiconductor manufacturers and their downstream processors.

University expertise is assisting in the synthesis and evaluation of novel semiconductor materials and the examination

of material surfaces which offers the promise of major advances in materials application.

With the increasing move towards sustainability, Wales is investing in the sourcing of materials from renewables, especially from plants. The properties of plant-derived polymers on their own and in conjunction with other materials are being studied at the BioComposites Centre in Bangor and novel applications for naturally occurring polysaccharides are being evaluated at Glyndŵr University in Wrexham.

- Blaenafon and its surrounding landscape were made a World Heritage Site in 2000. 'The area around Blaenafon bears eloquent and exceptional testimony to the pre-eminence of South Wales as the World's major producer of iron and coal in the 19th century.'



A 25% saving in energy costs using various bulk waste materials as cement substitutes has been achieved by north Wales company Richards Moorhead Laing in collaboration with Cardiff University.

- The Dowlais works took out the first licence to operate the Bessemer steelmaking process in 1856 and in 1869 William Siemens built the Landore Works near Swansea to promote the superiority of steelmaking by the Siemens-Martin open-hearth method.
- The application of powdered metals technology was pioneered by Osprey Metals of Neath following applied research at Swansea University.
- The Hafod Copperworks, established by Henry Hussey Vivian, in the lower Swansea valley grew into the largest works of its kind in the 19th century.

The packaging of beer in tin-plated steel cans was first introduced in Europe by the Felinfoel Brewery at Llanelli in 1935.

- Concrete Cloth, developed by a Pontypridd company, is being used for use as emergency accommodation in trouble spots throughout the world.



The identification of crystal faces using 'Miller's Indices' was devised by William Miller of Llandovery during the mid 19th century.

- William Weston Young (1776–1847), entrepreneur and inventor, would develop a high quality fire-brick for furnace lining that used Dinas silica rock quarried and manufactured in the Vale of Neath from 1822. It was exported world-wide and even today the Russian word for 'firebrick' is 'Dinas'.
- In today's society electronics based technology is becoming redundant at an increasing rate, bringing with it the problem of what to do with our Waste Electrical and Electronic Equipment (WEEE). Sims Recycling Solutions at Newport can process over 100,000 tonnes of e-waste annually and is part of the world's largest electronics recycling company.
- The Waterwall® blast isolation system by Newport based Cintec International Ltd uses water to reduce the potential for harm in explosive situations.

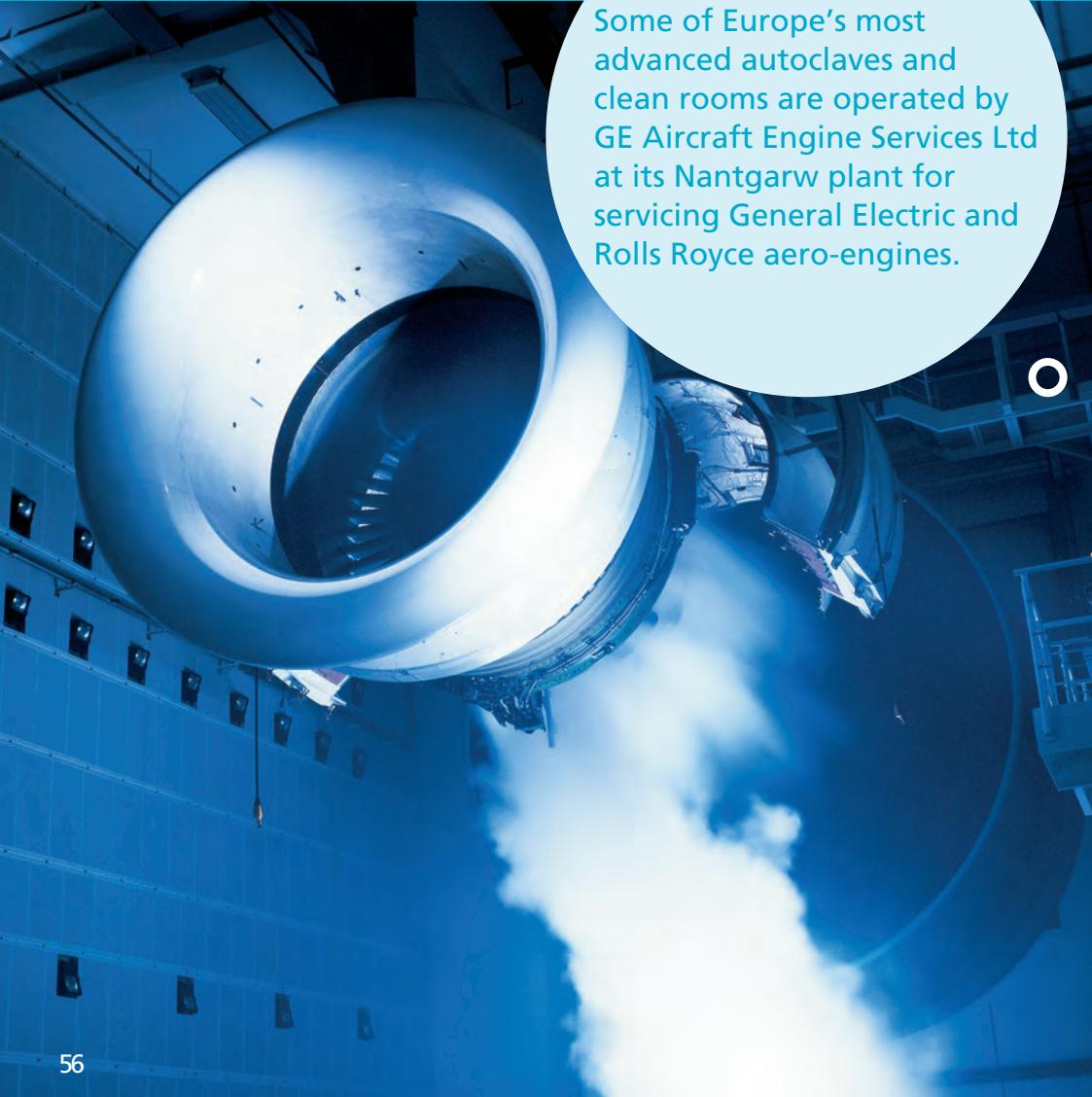
- Nickel is produced by INCO at Europe's largest nickel refinery at Clydach on the site founded by Ludwig Mond in 1902.
- The process that enabled iron to be smelted from phosphatic iron ores and then used in steel making was invented by Sidney Gilchrist Thomas and Percy Carlisle Gilchrist at Blaenafon in 1878.



John Hanbury was to pioneer the rolling of sheet iron at the end of the 17th century leading to the establishment of Pontypool as the foremost producer of tinplate and Japanware in the 1800s.



# TRANSPORT



Some of Europe's most advanced autoclaves and clean rooms are operated by GE Aircraft Engine Services Ltd at its Nantgarw plant for servicing General Electric and Rolls Royce aero-engines.

The onset of the Industrial Revolution put pressure on innovators to develop transport systems capable of carrying bulky and heavy loads. Wales was at the forefront of canal building and within a few decades saw the first journey in the world made by a railway locomotive built by Richard Trevithick.

The early days of aviation and road transport benefited greatly from the activities of the Hon C S Rolls of Monmouth and his visions are now reality through the many operations in Wales devoted to the aerospace and vehicle sectors. With two of the world's major vehicle engine plants and huge investments in aircraft construction, aero-engine and aircraft servicing, Wales is going places!

University of South Wales spin-out GeoVS Ltd has developed the world's first three-dimensional vessel traffic service system to help improve the safety of maritime navigation.



The world's first scheduled helicopter service opened between Cardiff, Wrexham and Liverpool in 1950.

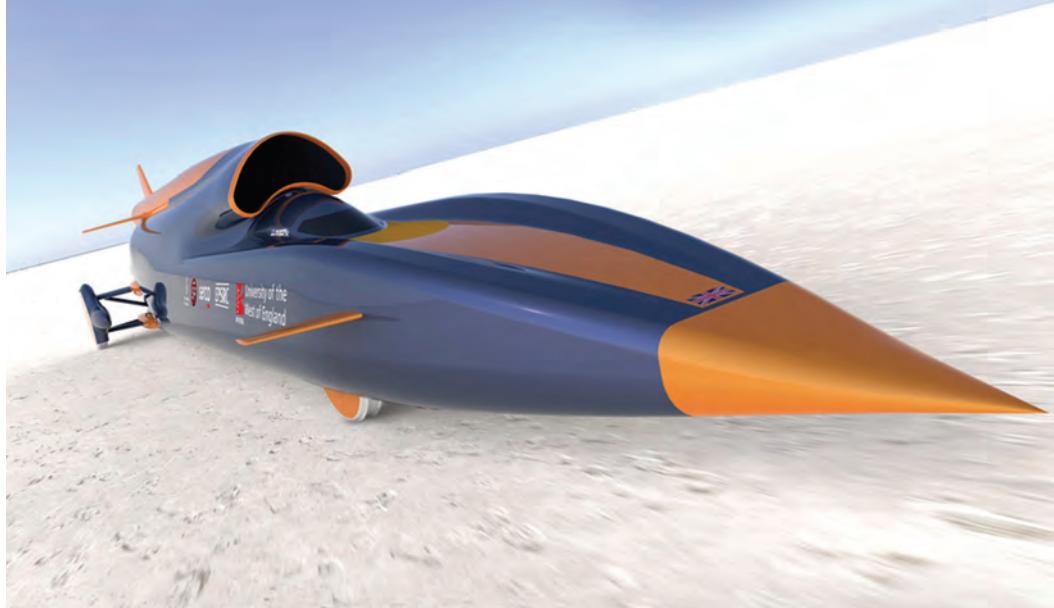
Aerospace has been a feature on the Welsh industrial scene for many years through the presence of Ministry of Defence Establishments in providing facilities for military aircraft and test ranges for unmanned aerial vehicles. Expansions in the private aerospace sector have placed Wales at the forefront of aircraft maintenance and aero-engine servicing for major carriers. With ever increasing demands for higher performance in components, Welsh Universities are devoting considerable resources to developing and testing new materials and designs for aerospace applications. In the automotive

sector, Wales is host to two major engine plants. Ford recently announced a £24m investment to produce the new 1.5 litre EcoBoost engine at its Bridgend facility which opened in 1980 and at Deeside Toyota celebrated 20 years of engine production in 2010. In addition a wide range of automotive component manufacturers can be found here; a sector complemented by academic expertise in vehicle production economics and the application and evaluation of new materials.

Literally at the leading edge, Welsh based academic expertise was instrumental in



Pleasure watercraft that can travel on the surface and under water is the potential of the Scubacraft currently being developed by Anglesey based company; Creative Worldwide Ltd.



developing the aerodynamic design for the Thrust supersonic car, expertise which has also been involved in aspects of the Airbus designs.

The BLOODHOUND SuperSonic Car (SSC) project aims to set a new land speed record of 1,000mph, breaking the 763mph set in 1997 by the

THRUST SSC. Engineers at Swansea University worked alongside Sir Richard Noble and his team in breaking the sound barrier and as BLOODHOUND founding members are part of the team designing and building its successor, drawing upon Swansea's expertise in computational fluid dynamics.

Every wing for every Airbus aircraft has been produced at the Airbus UK factory at Broughton in north east Wales. In 2002 it commenced production of the A380 wings.



Wales is going places and at some speed!

- Toyota produces diesel engines for the first time in the UK in 2003 at Deeside and became the first Toyota factory outside Japan to manufacture a hybrid vehicle engine in 2010.
- Europe's only civil licensed airport for routine unmanned aerial operations is ParcAberporth in west Wales.

- The electric vehicle Zecar (ze standing for zero emissions) is being produced in Port Talbot by a father and son partnership, Stevens Vehicles Ltd of Port

The world's first scheduled hovercraft service opened between Rhyl and Wallasey in 1962.



Talbot in conjunction with the Alternative Vehicle Research Centre of the University of South Wales.

- Britain's first motorway tunnel was opened on the M4 at Brynglas, Newport in 1967.
- John Dillwyn Llewelyn operated the world's first electrically powered boat using Grove cells for power on the lake at Penllergaer House in 1850.

The aerodynamic design of the Thrust Supersonic Car was developed by the Department of Civil Engineering at Swansea University with use of a Cray supercomputer and verified at the nearby Pendine rocket testing site. This set the new land speed record of 763 mph in 1997.

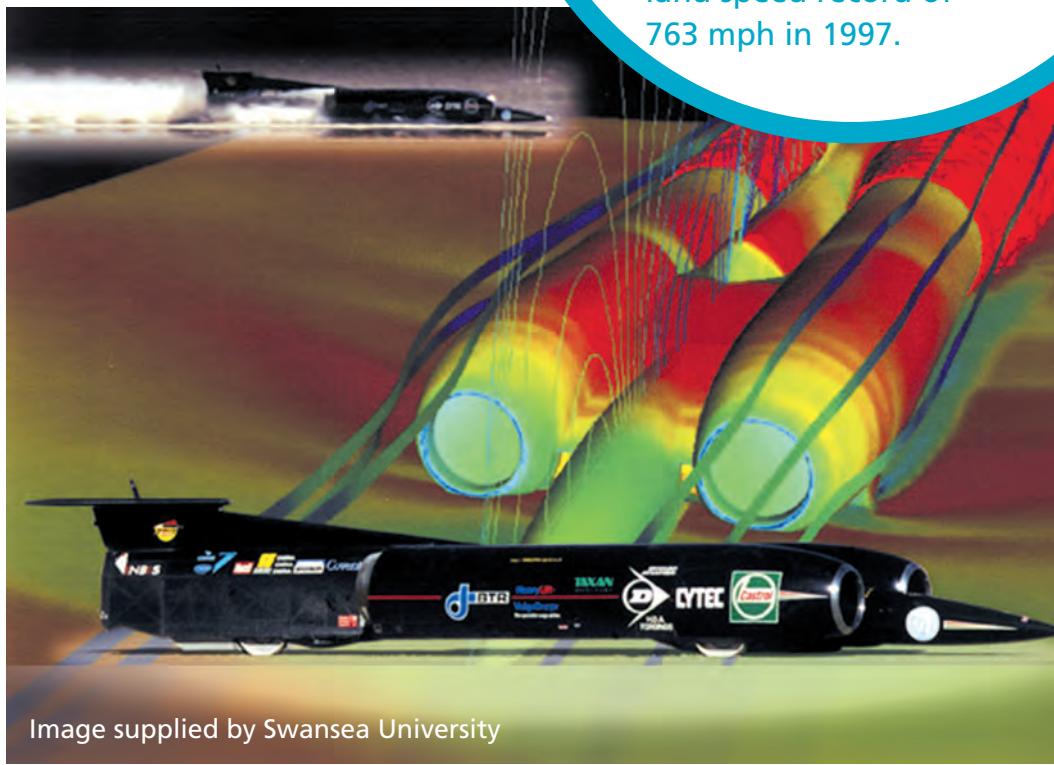


Image supplied by Swansea University

The world land speed record of 172.33 mph was made at Pendine Sands in 1926 by J G Parry Thomas in his car Babs.

- The emission-free tribrid bus, a carbon-free minibus powered by three different green technologies, using the fuel cell system for constant low-end power, lead acid battery for medium constant power and finally ultra-capacitors to deliver the instantaneous power needed for high load acceleration. It has been developed as the result of international collaboration led and co-ordinated in Wales by the University of South Wales.
- A railway locomotive built by Richard Trevithick made the first recorded journey at Merthyr Tydfil in 1804.
- New developments in using thermoelectric generators by car manufacturers are being pioneered at Cardiff University.
- The Comet, the world's first jet airliner, was manufactured at the Broughton factory of the De Havilland Aircraft Co from 1957.
- The Hon Charles Stewart Rolls was born in Monmouth in 1877 and developed his engineering skills as one of Britain's earliest aviators and joint founder of Rolls-Royce.
- Bangor born Richard Parry-Jones joined the Ford Motor Company and rose to become the Group Vice President and Chief Technical Officer, overseeing product development activities for all Ford vehicles worldwide until his retirement in 2007. In 2012 he changed modes of transport, going from road to rail, to become chairman of Network Rail.

A wide-angle photograph showing the interior of a massive hangar. A large white aircraft is positioned in the center-left, its fuselage and wings extending towards the background. The hangar's ceiling is a light blue color with a ribbed structure. Large windows along the left wall provide natural light. In the foreground and middle ground, several workers in white protective suits and caps are visible, some standing near the aircraft's engine compartment which is exposed, and others walking across the dark floor. Various pieces of maintenance equipment, including a red lift truck and yellow scaffolding, are scattered around the work area.

One of the world's largest hangars is home to British Airways Maintenance Cardiff who maintain and overhaul Boeing 747, 767 and 777s in four bays at Cardiff Airport.

# PEOPLE



Charles Rolls motorist,  
aviator and joint founder  
of Rolls-Royce.



Between the work of Robert Recorde in the 16th century, whose 'equals' sign was to be widely adopted as the symbol we use today, and the continuing expansion of the electronics revolution, Wales has played its part in fostering creativity and innovation as a way of fulfilling society's aspirations.

Both the hectic activities during the industrial revolution and the tranquil solitude of much of the rural environment have stimulated indigenous Welsh people and those choosing to live and work here to develop their ideas and talents.

The encouragement of curiosity and its progression into economic benefits is high on the list of priorities in Wales.

Yes, ideas come from....people!

**1957 –**

**Professor Julie Williams.**

b. Merthyr Tydfil.

A global leader in research into Alzheimer's disease at Cardiff University, work highlighted by Time magazine as one of the world's top 10 medical breakthroughs of 2009.

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**1957 –**

**Sir Chris Evans.**

b. Port Talbot.

Entrepreneur in the field of biotechnology and founder of companies in the fields of genes, enzymes and micro-organisms.

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**1955 –**

**Michael Moritz.**

b. Cardiff.

The internet search engines Google and Yahoo! were developed with funding from Welsh born Michael Moritz.

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**1952 –**

**Terry Morgan.**

b. Cwmbran.

Engineer and chairman of Crossrail, Europe's biggest construction project at £16bn that will see 13 miles of new tunnels built under London.

**1951 –**

**Sir Leszek Krzysztof Borysiewicz, FRS.**

b. Cardiff.

Polish British immunologist, scientific administrator and Vice-Chancellor of Cambridge University, Britain's only billion-pound university.

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**1951 –**

**Richard Parry-Jones.**

b. Bangor.

Group Vice-President, Global Product Development and Chief Technical Officer, Ford Motor Company up to 2007. In 2012 he became chairman of Network Rail.

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**1946 –**

**Professor John Harries.**

b. Aberavon.

The first chief scientific advisor to the Welsh Government. Professor of Earth Observation at the Blackett Laboratory in Imperial College, London, as a scientist he led the team providing the first direct observational evidence of an increase in the Earth's greenhouse effect. Awarded NASA's Distinguished Public Service Medal in 2011.

**1945 –**

**Professor Anthony Campbell.**

b. Bangor.

Professor in Medical Biochemistry at Cardiff University and authority on intracellular signalling and chemi- and bio-luminescence. Founded The Darwin Centre for Biology and Medicine in Pembrokeshire.

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**1943 –**

**Sir Terry Matthews.**

b. Newbridge.

Telecommunications entrepreneur and founder of Mitel, Newbridge Networks and the Wesley Clover Foundation.

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**1942 –**

**Howard Stringer.**

b. Cardiff.

Chairman and Chief Executive Officer Sony Corporation up to 2013 and 2012 respectively.

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**1939 –**

**Brian Josephson.**

b. Cardiff.

Nobel prize winner through his studies of the phenomena of low-temperature physics, especially superconductor and insulator combinations.

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**1935 – 2013**

**Dr Tom Parry Jones.**

b. Anglesey.

Inventor of the 'Breathalyser' and the later electronic version, the 'Alcolmeter'. Which was adopted world-wide.

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**1932 –**

**Sir John Meurig Thomas.**

b. Gwendraeth Valley.

Leading Welsh chemist and one of the most cited authors in the field of heterogeneous catalysis.

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**1932 – 1995**

**Lord Walter Marshall.**

b. Rhymney.

Director of Atomic Energy Research Establishment Harwell and later Chairman of Central Electricity Generating Board.

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**1931 –**

**Sir John Houghton.**

b. Dyserth.

Director of the Meteorological Office 1983 – 1991, and authority on global warming.

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**1931 –**

**Sir Bernard Knight.**

b. Gower.

Undertook more than 25,000 post-mortem examinations and became one of the world's leading forensic pathologists.

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**1926 – 2005**

**Professor John Vaughan.**

b. Merthyr Tydfil.

Professor of food microscopy, King's College London.

Pioneer in the properties of oilseeds and their industrial applications.

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**1925 – 1996**

**Professor Howard Purnell.**

b. Rhondda.

Professor of Chemistry, Swansea University.

Pioneering research into gas chromatography for chemical analysis.

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**1924 – 2000**

**Donald Davies.**

b. Treorchy.

Working at the National Physical Laboratory, he laid the foundation for the Internet through his work on packetswitched data communication.

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**1911 – 2002**

**Professor Ewart Jones.**

b. Wrexham.

Waynflete Chair of Chemistry at Oxford University. Research in natural product chemistry including steroids, terpenes and vitamins.

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**1910 – 1992**

**Professor Alan Wood.**

Chair of Geology at UW Aberystwyth. Laid the basis for the classification of fossil foraminifera, an essential feature of oil exploration.

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**1909 – 1988**

**Professor Archibald Cochrane.**

Chair of tuberculosis and chest diseases at Welsh National School of Medicine. Developed protocol for controlled trials of drugs which became worldwide standard procedures in drug evaluation.

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**1906 – 1994**

**Professor Gwendole Rees FRS.**

The first Welsh woman to be made a Fellow of the Royal Society. She devoted her life to helminthology, the study of parasitic worms.

**1904 – 1987**

**Donald Holroyde Hey.**

b. Swansea.

Organic chemist who observed that the decomposition of benzoyl peroxide gave rise to free phenyl radicals, important reactions in processes ranging from synthetic rubber to biochemical damage to DNA.

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**1904 – 1972**

**Emily Dix.**

b. Gower.

Revolutionised plant biostratigraphy, techniques critical in the story of tropical forests and climate change during Late Carboniferous (Pennsylvanian) times.

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**1903 – 1989**

**Professor Sir Brynmor Jones.**

His department at Hull University became famous for the development of liquid crystal display technology.

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**1903 – 1945**

**Evan James 'Desin' Williams.**

b. Cwmsychnant.

Desin Williams became a physicist who worked with the giants of international physics of the day and predicted the

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existence of a new atomic particle, the meson.

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**1903 – 1977**

**Sir Oliver Sutton.**

b. Cwmcarn.

Director of Meteorological Office from 1953 – 1965 where he emphasised the use of computers for forecasting.

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**1903 – 1963**

**Sir Horace Evans.**

b. Merthyr Tydfil.

Physician to Queen Mary, King George V and Queen Elizabeth.

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**1902 – 1977**

**Hugh Iorys Hughes.**

b. Bangor.

Civil engineer who designed the bridge and pier units for the Mulberry Harbour used in the Normandy landings of WWII.

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**1893 – 1973**

**Sir Clement Price-Thomas.**

b. Abercarn.

Pioneer of the treatment of chest disorders with radium.

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**1888 – 1962**

**Dr Ezer Griffiths.**

b. Aberdare.

Leading authority on the study of heat and refrigeration.

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**1886 – 1926**

**Ernest Thompson Willows.**

b. Cardiff.

Designed his own airship at the age of nineteen, made his first flight in 1905 and the first to fly across the English Channel, from London to Paris, in 1910.

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**1881 – 1945**

**Sir Thomas Lewis.**

b. Cardiff.

A cardiologist who coined the term 'clinical science' and championed applying the experimental method to clinical problems and the clinical application of the electrocardiograph.

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**1880-1941**

**Henry Grindell Matthews.**

b. Winterbourne, Gloucestershire.

Inventor of the 'Aerophone' or radiotelephone in 1911, first demonstrated in Cardiff. Talking pictures followed and claims that he invented an electric ray

in 1923 gave him the nickname of 'the death ray man'. By 1934 he was living and working at Tor Clawdd on Betws Mountain above Ammanford where he died in 1941.

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**1877 – 1910**

**The Hon Charles Stewart Rolls.**

b. Monmouth.

Motorist, aviator and joint founder of Rolls-Royce.

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**1872 – 1970**

**Earl Bertrand Russell.**

b. Trellech, Monmouth.

Pioneer of the study of mathematical logic.

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**1866 – 1959**

**Clarence Seyler.**

Leading authority on the analysis of coal, carrying out his chemical classifications at Swansea.

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**1857 – 1932**

**Dr Martha Maria Cannon.**

b. Llandudno.

Pioneer of health measures and women's rights in the USA, where she had emigrated with her parents in 1858, becoming one of the first Utah women to receive the degree of M.D. and the first woman state senator.

**1856-1932**

**Richard Stephens.**

b. Cwmbran

Early designer of motor cars. Setting up a bicycle-making business in Clevedon he designed and built his first car in 1897/8. Amongst his many improvements was the adjustable drum brake shoe, the basis of all such shoes in use today.

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**1851-1925**

**Elizabeth Phillips Hughes MBE.**

b. Carmarthen.

Educationalist, who established a training college for women in 1885 in Cambridge which would be named after her, Hughes Hall; the only Cambridge College to be named after a woman. Retiring to Barry, she established the 20th Century Women's Club.

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**1850 – 1885**

**Sidney Gilchrist Thomas.**

And his cousin Percy Carlisle Gilchrist. Developed furnace linings at Blaenafon enabling enabled iron to be smelted from phosphatic iron ores and then used in steel making. The 'basic' slag from the smelting

became a valuable phosphate fertiliser.

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**1834 – 1913**

**Sir William Henry Preece.**

b. Caernarfon.

Electrical engineer and inventor who developed his own system of wireless telegraphy and telephony in 1892 but who would later champion Guglielmo Marconi's system and assist with his experiments and in securing funding.

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**1823 –1913**

**Alfred Russel Wallace.**

Born in Usk he trained as a surveyor and worked for Brunel but is best remembered as a anthropologist and biologist who independently proposed a theory of natural selection, prompting Charles Darwin to publish his own theory.

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**1821 – 1894**

**Henry Hussey Vivian.**

b. Swansea.

With his father, John Henry Vivian (1785-1855), he established Swansea as the centre of the world copper industry with Hafod

Copperworks in the lower Swansea valley, becoming the largest refiner and producer of copper and other metals in the world.

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**1811 – 1896**

**William Robert Grove.**

b. Swansea.

Improved the voltaic cell and developed the gas battery, the precursor of the fuel cell.

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**1810-1882**

**John Dillwyn Llewelyn.**

b. Swansea.

Industrialist who established an observatory in 1851 at Penllergaer near Swansea. With his daughter Thereza Llewelyn, 1834-1926, (later Thereza Story-Maskelyne), they took some of the earliest photographs of the Moon.

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**1801 – 1880**

**William Miller.**

b. Llandovery.

Applied mathematics to the study of crystals and devised Millers Indices for the identification of crystal faces.

**1789 – 1864**

**Richard Roberts.**

b. Llanymynech.

Engineer and inventor best known for his work in the spinning and weaving of cloth and railway locomotives. He devised a machine to accurately punch holes in the iron plates for the Conway tubular bridge using Jacquard cards.

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**1785 – 1852**

**Sir Josiah John Guest.**

Dowlais ironmaster whose iron products, especially rails, were exported world wide.

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**1781 – 1847**

**Lucy Thomas.**

b. Llansamlet.

Coal proprietor, known as; 'The mother of the Welsh Steam Coal Trade'.

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**1774 – 1852**

**Captain Sir Samuel Brown RN.**

Introduced the iron chain cable into shipping and established the Brown Lenox works at Pontypridd.

**1725 – 1804**

**Nathaniel Pigott.**

Astronomer, who with his son Edward (1753 – 1825), were noted for observing astronomical phenomena such as eclipses, a transit of Venus and comets. A number of double stars noted using the telescopes erected at Frampton House, near Llantwit Major.

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**1719 – 1789**

**William Edwards.**

b. Groes-wen.

Independent minister, architect and engineer. Famous as a builder of bridges, in particular Pontypridd bridge. Other bridges and industrial buildings followed, such as Wales' earliest planned industrial village for John Morris's copperworks near Swansea. His sons Thomas, David and Edward would continue his bridge-building tradition.

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**1675 – 1749**

**William Jones.**

Welsh mathematician and the first to use the symbol  $\pi$  to represent the ratio of the circumference to the diameter in 1706.

**1664 – 1734**

**John Hanbury.**

Pioneer of the rolling of sheet iron and established Pontypool as the foremost producer of tinplate and Japanware in the 1800s.

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**fl. 1563 – 1588**

**John Trew.**

Glamorganshire mining surveyor and engineer, engaged in 1564 to build the Exeter canal, the first pound lock canal in Britain.

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**1560 – 1631**

**Sir Hugh Myddelton.**

The Welsh businessman, engineer and goldsmith responsible for the 'New River' project which brought fresh water to the City of London.

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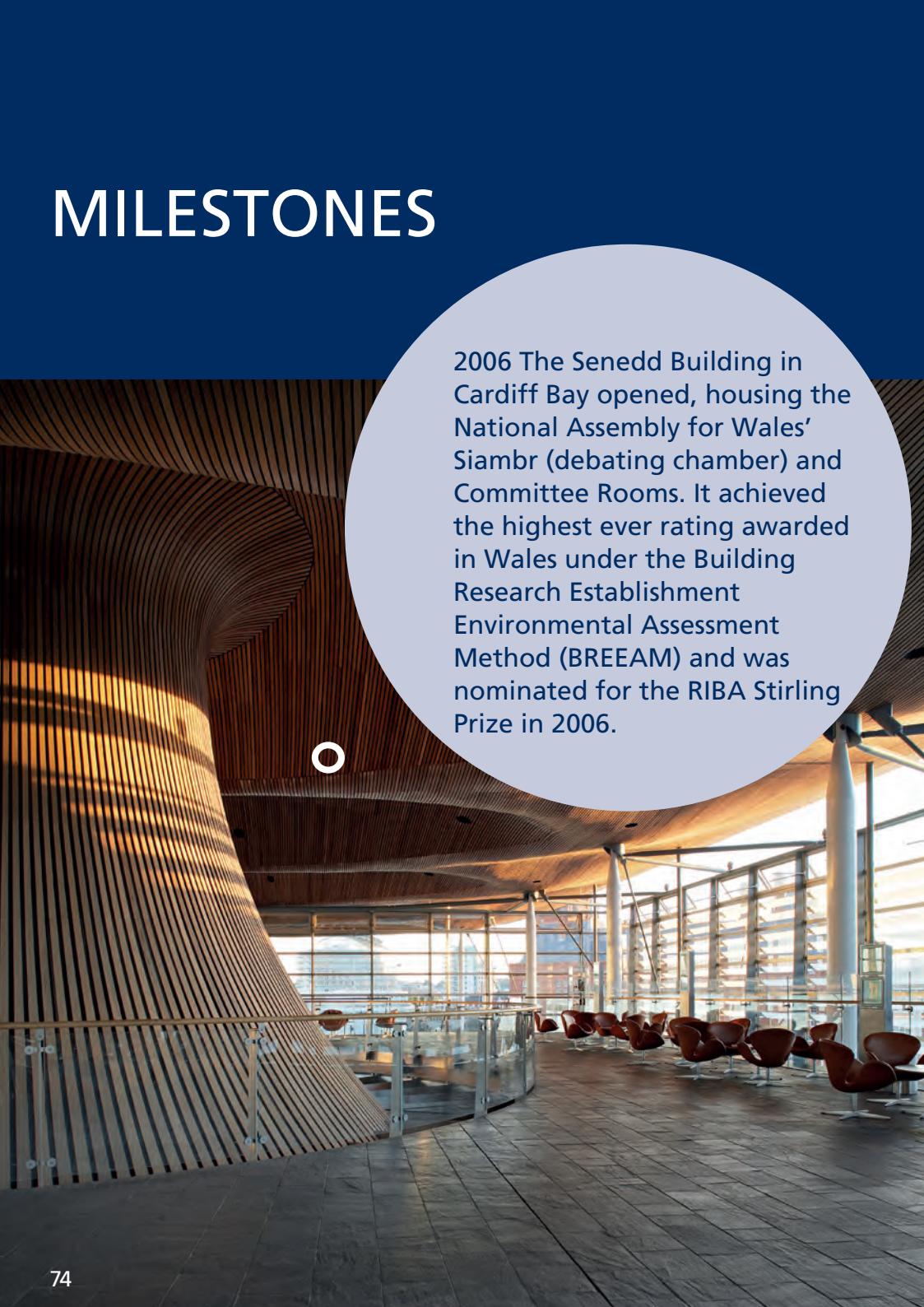
**1510 – 1558**

**Robert Recorde.**

b. Tenby.

Leading physician and Comptroller of the Mint, he was also a mathematician whose symbol for the 'equals' sign has become the standard.

# MILESTONES

A photograph of the interior of the Senedd Building in Cardiff Bay. The space features a large, curved wall covered in vertical wooden slats that curve upwards towards the ceiling. Sunlight streams in through large windows on the right side, illuminating the floor and the wooden walls. In the foreground, there is a circular white graphic element containing text. The floor is made of large, light-colored tiles.

2006 The Senedd Building in Cardiff Bay opened, housing the National Assembly for Wales' Siambwr (debating chamber) and Committee Rooms. It achieved the highest ever rating awarded in Wales under the Building Research Establishment Environmental Assessment Method (BREEAM) and was nominated for the RIBA Stirling Prize in 2006.

Significant events marking increases in human knowledge punctuate history. The benefits from innovations in science, engineering and medicine spill over into society and Wales has experienced many of these at first hand.

The first recorded journey of a 'railway locomotive' on the Merthyr Tramroad was to alter the face of the world and commerce in a short space of time. The use of a novel lining in a blast furnace at Blaenafon in 1878 was to revolutionise steel making. Even though many milestones were placed on the historical road some years ago, their significance remains, just as more recent ones commemorating stages in the electronics revolution will have importance in years to come...



1999 Opened in time to host the Rugby World Cup in Cardiff the 75,000 seat, all-weather Millennium Stadium was, at the time, the world's largest arena with a retractable roof.

- 2013** Ford announce major investment (£24m) at its Bridgend engine plant.
- 21 March marked the official start of both the Antarctic winter and Sir Ranulph Fiennes Antarctic Expedition, which is taking thermal blanket covers, developed by Architen Landrell of Chepstow, to provide a 'lifesaving' insulated zone.
- Port Talbot's Blast Furnace No 4 begins production – the UK's largest industrial engineering project in 2012. Incorporating the latest technology, the £185 million blast furnace is part of a £240m investment by Tata in the site.
- 2012** GE Healthcare open cell science laboratory complex in Cardiff. The company's Maynard Centre will help advance the emerging fields of cell therapy and cell bioprocessing and support the development of new medicines.
- Wales win a record seven Olympic Games medals and equal their score of 14 medals won in Beijing at the Paralympic Games four years ago. London 2012 saw the striking of 4,700 Olympic and Paralympic Games medals at the Royal Mint in Llantrisant. These were the largest and heaviest Olympic and Paralympic Games medals ever made.
- Scientists and engineers at Glyndŵr University, begin work on part of the European Extremely Large Telescope (E-ELT), the world's largest telescope, in Chile. A €5m project producing prototype mirror segments for the telescope's primary mirror.
- 2011** Roath Lock, the new drama production studios for BBC Wales opened in the Porth Teigr area of Cardiff Bay. The centre is home to dramas Casualty, Upstairs Downstairs, Pobol Y Cwm and Doctor Who, as well as future commissions.
- Aberystwyth University's Institute of Biological, Environmental and Rural Sciences (IBERS) wins the first ever BBSRC 'Excellence with Impact' award.

Cardiff University's Morgan-Botti Lightning Laboratory for the study of lightning strikes on aircraft to gain a better understanding of the effects and to optimise composite materials' electrical properties for protection.

- 2010** One of the UK's most technically sophisticated electron microscopes is installed at Swansea University's Multidisciplinary Nanotechnology Centre (MNC), this cryo-scanning electron microscope, capable of magnification of up to one million times, will allow examination of single cells or even single molecules.

The Welsh Government appoints its first chief scientific advisor, Professor John Harries.

- 2009** The Centre for NanoHealth, the first facility of its kind in Europe, is established at Swansea University to focus on the diagnosis of disease and medical intervention at a molecular level.

Time magazine this year nominated Aberystwyth University's 'Adam' robot as the fourth most significant scientific discovery and Professor Julie Williams work on Alzheimer's disease at Cardiff University as one of the world's top ten medical breakthroughs.

- 2008** Opening of the Penderyn distillery visitors centre, using a unique design of still and the only whisky distillery in Wales, whose product went on sale in 2004.

- 2005** Arup's Cardiff and Bristol office, design the innovative 'glass sea' as part of the dehumidification project for the SS Great Britain at Bristol.

The National Waterfront Museum is opened at Swansea combining old and new architecture in a design recognised by the UK Regeneration Awards.

Opening of the Liberty stadium, a world-class multi-use sporting venue, at Landore, Swansea.

Completion of the Senedd Building in Cardiff Bay.

First flight of Airbus A380.

- 2004** Wales Millennium Centre, with a 1,900 capacity, opens in Cardiff Bay.
- Completion of the new Usk road bridge at Newport.
- 2003** Toyota produces diesel engines for the first time in the UK at Deeside plant.
- 2002** Airbus A380 wing production line operational at Broughton plant.
- 2000** Cardiff's Techniquest becomes the first purpose-built science centre in the UK.
- 1999** Opened in time to host the Rugby World Cup in Cardiff the 75,000 seat, all-weather Millennium Stadium, was at the time, the world's largest arena with a retractable roof.
- 1997** THRUST SuperSonic Car (SSC) breaks the sound barrier at 763mph with expertise from Swansea University contributing to the aerodynamic design.
- 1996** Dr Chris Evans sets up Merlin Ventures to assist in founding life-science companies such as Cyclacel and Vectura.
- The Second Severn Crossing, a 16,800 ft (5,100 metres) long cable-stayed design, opens.
- 1986** One of UK's first earth sheltered 'berm' houses opened at Caer Llan Study Centre, Monmouth. One of the two lowest energy houses in Europe, it wins a Euro-solar prize in 1995.
- Newbridge Networks, Newport, opens to manufacture asynchronous transfer mode equipment.

- 1984** Dinorwig pumped storage scheme opened, at 1800 megawatt the largest in Europe.
- 1982** The HTV television studio complex, at Culverhouse Cross, Cardiff, opened as the largest purpose built television studio in the world.
- 1979** The A470 bridge, across the Usk on the Brecon by-pass, is the first glued segmental concrete bridge in the UK.
- 1978** The world's first test tube baby, Louise Brown, achieved through the ground-breaking work of Professor Robert Edwards, a graduate of Bangor University in 1951, who developed IVF technology with Patrick Steptoe.
- 1973** Britain's highest dam completed at Llyn Brianne with a height of 300' (91 metres).
- 1972** Sir Terry Matthews founds the Mitel Corporation and builds a factory at Caldicot to manufacture and supply private exchanges (PABXs) for organisations worldwide.
- 1971** 1180 megawatt Magnox nuclear power station opened at Wylfa, largest in the world on its completion.
- Robert Wynn & Sons Ltd, originally established in Newport in 1863, haul the largest load on a British road.
- 1969** Admiral Desmond Hoare patents the rigid inflatable boat (RIB) after research and development at Atlantic College, St. Donats.
- 1967** Britain's first motorway tunnel opened on the M4 at Brynglas, Newport.
- 1966** First Severn/Wye Crossing opened by HM The Queen incorporating deck units manufactured at the Fairfield-Mabey yard in Chepstow.
- 1964** George Street bridge, Newport opened as earliest example in the UK of a cable-stayed cantilevered bridge.

- 1963** Commissioning of the UK's first major pumped storage power facility at Ffestiniog of 360 megawatt capacity.
- 1962** World's first scheduled hovercraft service opened between Rhyl and Wallasey.  
Hymac produce first excavator in the UK to be operated solely by hydraulic power.
- 1960** Llanwern Steelworks becomes the first UK steel works to rely entirely on the basic oxygen process.
- 1957** DeHaviland Aircraft Co at Broughton produces the world's first jet airliner, the Comet.
- 1950** World's first scheduled helicopter service opened between Cardiff, Wrexham and Liverpool.
- 1948** Statimeter Ltd, Rhydymwyn, devised and patented a system for maintaining constant pressure on rolling mill rolls which became widely adopted.
- 1947** While on his farm in Anglesey, Rover's Technical Director Maurice Wilks and his brother Spencer Wilks, Rover's Managing Director, see a gap in the vehicle market. They sketch the outline of a vehicle in the sand of a nearby beach and the 'Land Rover' is born.
- 1946** First experimental microwave television transmission by the Post Office across the Bristol Channel from Newport.
- 1944** The success of the Mulberry Harbour in the Allied invasion of Europe owes much to Welsh engineer Hugh Iorys Hughes who developed his 'Hippo' piers and 'Crocodile' bridge units on the Conwy Morfa.
- 1941** The top secret Valley Works at Rhydymwyn in Clwyd tests atomic bomb components. Scientists working there before assignment to the Manhattan Project in Los Alamos included German refugees Rudolf Peierls and Klaus Fuchs.

- 1940** Edward Bowen from Swansea developed airborne radar for use as a reliable, operational system in World War II.
- 1935** The Felinfoel Brewery in Llanelli is the first company in Europe to market beer in tin-plated steel cans.
- 1926** JG Parry Thomas broke the world land speed record at Pendine Sands, Carmarthenshire at 171.02 mph.
- 1921** Britains first major oil refinery opened at Llandarcy.
- 1920s** Portmeirion Village completed by Sir Clough Williams-Ellis as an extravaganza of architectural styles.
- 1913** The Barry docks complex, of which the first dock basin opened in 1889, becomes the largest coal exporting docks in the world. In the same year that the first recorded million-pound business deal in the world is rumoured to have been struck on the floor of the Coal Exchange in Cardiff.
- 1911** The first airborne radio telephone transmission, made by Harry Grindell Matthews to communicate from the ground to the air with pilot B.C. Hucks flying from Ely Racecourse in Cardiff. In the same year he sends the first wireless press message from Newport to Cardiff.
- 1907** The Queen Alexandra dock is opened, the largest masonry dock in the world.
- 1906** Newport Transporter Bridge opened to provide a road crossing over the River Usk without hindering ship access.  
Rolls Royce founded to manufacture cars and aeroplane engines.
- 1902** Ludwig Mond opens the Clydach Nickel smelter using the nickel carbonyl process.
- 1899** First hydro-electric station opened in Wales at Monmouth.

- 1897** Weavers Building, Swansea, is Europe's first multi-storeyed reinforced concrete building.
- Gugliemo Marconi made the first over-water transmission of radio waves between Lavernock and the island of Flat Holm in the Bristol Channel.
- 1896** The Snowdon Mountain Railway opens, the highest railway, and the only rack railway system, in Britain.
- 1886** Severn Railway Tunnel opened; at 7.2km, was the longest railway tunnel within the UK for well over 100 years.
- 1879** The Lord Nelson Hotel Ballroom at Milford Haven is the first in Britain to be lit by electricity.
- 1869** The Landore Works near Swansea is built to promote steelmaking by the Siemens-Martin open-hearth method.
- 1862** Deepest railway cutting in UK at Talerddig.
- 1857** Tallest viaduct in Britain opened at Crumlin.  
Dowlais ironworks open the world's most powerful rolling mill.  
The first steel rail in the world is rolled at Ebbw Vale.
- 1856** Dowlais ironworks become the first to take out a licence to use the Bessemer steel process.
- 1855** David Hughes from Bala invents the type-printing telegraph used by the Western Union Telegraph Co throughout the USA. He later invented the carbon granule microphone, (of which the original is in the Science Museum), and made the first transmission of electromagnetic waves in 1879.
- 1852** Brunel completes the Chepstow railway bridge over the River Wye at Chepstow to connect south Wales to London.

At the time of the death of Sir John Guest, the Dowlais ironworks is not only the largest ironworks but the largest manufacturing complex in the world.

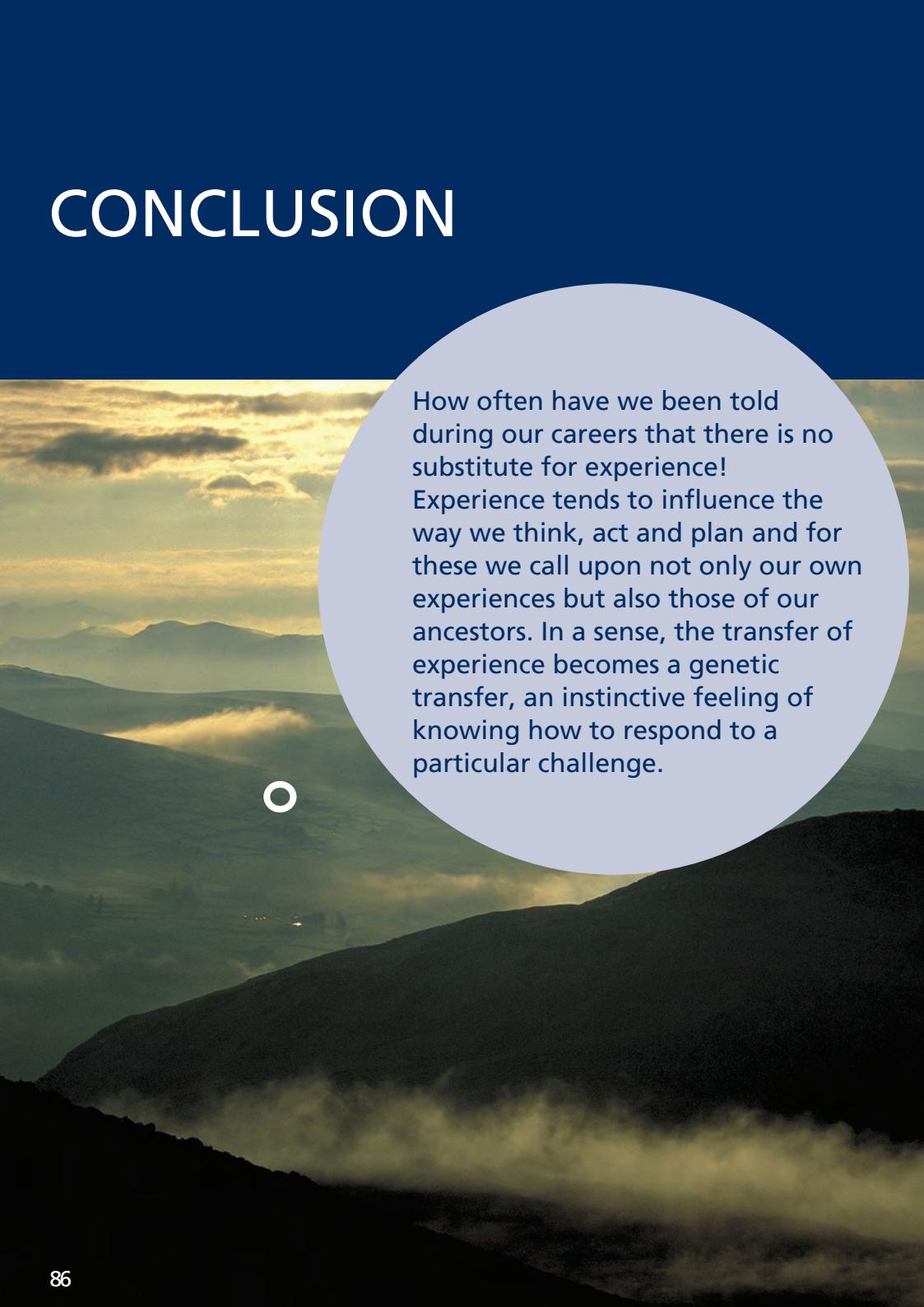
- 1850** The first electrically powered boat, using Grove cells, is operated by John Dillwyn Llewelyn on Penllergaer lake. A pioneer photographer, he and his daughter take some of the earliest lunar photographs from his observatory.
- George Parry improves blast furnace charging with his bell and hopper arrangement.
- 1842** Newport Town Dock opens with a 61 ft wide lock entrance, then the largest in the world.
- 1839** The Bute dock at Cardiff is opened as the largest masonry dock in the world.
- 1838** Muntz Metal is produced under licence at Upper Bank Copper Works, Swansea and used for sheathing ship's hulls.
- 1826** Telford's Menai Suspension bridge opened, the world's first large iron suspension bridge.
- 1822** Dowlais ironworks overtakes Cyfarthfa ironworks as the largest in the world.
- 1821** Swansea is the first town in Wales to have gas lighting of its streets.
- 1820** The first iron suspension bridge with a level road deck, is opened across the river Tweed and still links England to Scotland, with Welsh iron made by Brown Lenox of Pontypridd.
- 1807** Oystermouth railway, Swansea, becomes the world's first fare paying railway.
- 1806** Merthyr Tydfil's Cyfarthfa ironworks is the largest in the world until overtaken by Dowlais in 1822.

- 1805** Opening of Pontcysyllte aqueduct, Thomas Telford's 1007ft (307 m) long multi-arch iron and masonry structure carrying the canal in a cast-iron trough 126 ft (38 m) high over the river Dee. Then the highest aqueduct in the world.
- 1804** Steam locomotive built by Richard Trevithick makes the first steam railway journey in the world from Merthyr Tydfil to Abercynon.
- 1793** World's first iron railway bridges, at Pontycrafnau and Cyfarthfa, in Merthyr Tydfil.
- 1774** John Wilkinson invents high-accuracy boring of cylinders at Bersham, used firstly for the production of cannons and later for steam engine cylinders.
- 1766** Richard Evans surveys the first major canal in Wales; Thomas Kymer's canal at Kidwelly.
- 1762** World's earliest recorded railway tunnel, Landore.
- 1755** Pontypridd bridge completed by local mason William Edwards across the river Taff. At 140 ft (42 metres) the UK's largest arch bridge for three quarters of a century.
- 1715** First Newcomen atmospheric steam engines erected in Wales, at Ewloe on the Hawarden coalfield (one of the few engines that Thomas Newcomen worked on personally) and at the Talargoch lead mines at Dyserth.
- 1700** The world's first water-powered rolling mill at Pontypool enables the mass production of sheet plate iron.
- 1568** Tintern produces the first brass in Britain.
- 1563** First pound lock canal built by Glamorganshire engineer John Trew.



Hafod Eryri, the new visitor centre on the summit of Snowdon that is served by the highest railway in Britain.

# CONCLUSION

A landscape photograph showing rolling hills and mountains under a dramatic sky filled with clouds. The sun is low, casting a warm glow on the clouds and the tops of the mountains. A large, semi-transparent white circle is positioned in the upper right quadrant of the image, containing the text.

How often have we been told during our careers that there is no substitute for experience! Experience tends to influence the way we think, act and plan and for these we call upon not only our own experiences but also those of our ancestors. In a sense, the transfer of experience becomes a genetic transfer, an instinctive feeling of knowing how to respond to a particular challenge.

The experience gained by generations working in the traditional industries of Wales, in coal, steel, textiles, farming and building stone have now, through economic changes, been channelled into the newer more diverse sectors such as electronics, bioscience, aerospace, telecommunications and materials technology.

The highly acknowledged ability of the Welsh workforce to adapt to the challenges of working in a new technology has come about as a direct result of drawing upon this wealth of experience and applying it to new situations.

The teamwork so vital to the safety and efficiency of working in a mine or in a steel plant has proved eminently suitable for working in these newer sectors and the ability of the team and individuals to develop innovative solutions has blossomed with the availability of, for example, new materials, control systems and sensors.

The electronics revolution has demonstrated the benefits inherent in low-energy systems and has enabled us to make smaller, complex items more accurately. Portability of sensing and analysing equipment is now becoming the norm and the quest

for even smaller electronic and mechanical systems in the nanotechnology range is opening up tremendous opportunities in healthcare, environmental protection and manufacturing.

Given encouragement, innovation through experience can be a potent force for positive change in society. In Wales, we have the experience, we are being given the encouragement and the ideas are flowing.

**Make history and become part of this tradition.**





Image supplied by Swansea University



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