Wales wants more scientists

Wales may be small but it has big plans for science. New initiatives to fund over 100 new fellowships and hire up to 30 top scientists, combined with infrastructure investments in the physical sciences, are turning Wales into a land of opportunity. **By Gunjan Sinha**

Mumbles Lighthouse, Wales

Advanced materials aren't usually associated with Wales, but it's high time they were, says **James Durrant,** professor of photochemistry at Imperial College London. In 2013, Durrant accepted a joint appointment as the Sêr Cymru (Stars Wales) Solar Energy Research Chair at Swansea University in Wales. Now he also coordinates research to build the country's reputation as a pioneer in new materials that expand the reach of solar energy. At Swansea's Sustainable Product Engineering Centre for Innovative Functional Industrial Coatings (SPECIFIC), Durrant helps develop technologies that enable buildings to produce, store, and release their own energy. Durrant already leads a successful research lab at Imperial, but his joint appointment now allows him to connect fundamental science expertise at Imperial with engineering and manufacturing expertise at Swansea. "Imperial is a world-class place for research, but London is not an environment that focuses on manufacturing," he says. Swansea was historically a manufacturing hub and remains so—and today that legacy continues at the university's campuses, where you are just as likely to see industry experts roaming the labs at SPECIFIC as you are to spot academics, Durrant says.

Durrant was one of the first beneficiaries of the Welsh Government's Sêr Cymru initiative, which was announced in 2012 as part of the government's science strategy to identify areas of research where Wales "has a fighting chance to be the best in the world," says **David Allen,** chair of the Higher Education Funding Council for Wales. The first phase of Sêr Cymru committed up to £50 million (US$66.2 million) to bring prestigious research chairs to Welsh universities and also to support national research networks in three "grand challenge" areas: life sciences and health; low carbon, energy, and environment; and advanced engineering and materials. These networks are intended to "get the Welsh universities to think horizontally rather than vertically," says Allen, and to strengthen their reputation as centers for scientific enquiry. A second £60 million (US$79.5 million) phase of Sêr Cymru, launched in December 2015, is further boosting research capacity by offering fellowships to mid- or early-career scientists and those currently on a career break. Through both initiatives, Wales hopes to draw in 20 to 30 "rising star" researchers and support 120 fellows "to produce critical mass around our strengths," says **Julie Williams,** chief science adviser to the Welsh Government. "Our ambition is to grow research."

Rosalind Dodd

To boost capacity even further, the Welsh universities of Cardiff, Swansea, Bangor, and Aberystwyth have also been investing heavily in infrastructure such as new buildings and equipment.

Like other countries that see knowledge-growth as a pillar of their economies, Wales has created a science agenda that aims not only to expand academic science, but to translate science and technology into applications that lead to economic growth. Consequently, it is inviting industry to work with academics in research areas deemed to have the greatest promise of commercial success, adds Williams.

World-class brain imaging at Cardiff

At Cardiff University, the goal of close industry collaboration has morphed into a new physical space: the £300 million (US$393.6 million) Innovation Campus. The campus, which is being constructed in phases, aims to bring business development staff on hand to assist with access to university research, facilities, and services. It will feature social networking and creativity spaces to encourage problem solving, open innovation, and collaboration. The campus will house other research facilities in the future, and is already home to the Cardiff University Brain Research Imaging Centre (CUBRIC)—a £44 million (US$58.3 million) facility financed by a combination of public funds and charitable trusts.

Among its five new scanners, CUBRIC boasts Europe's most powerful microstructural brain scanner, the Siemens 3 Tesla Connectome magnetic resonance imaging (MRI) system, a specially adapted MRI scanner of which there is only one other in the world, located at Harvard University in the United States. Because its powerful technology can measure microstructural features in the brain, such as cont.>

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the diameter of nerve cell axons, it enables researchers to answer entirely new questions, says CUBRIC director **Derek Jones.** "Rather than merely brain mapping, we can start to address more biologically specific questions like, 'How do individual differences in axon diameter correlate with differences in impulsivity?'" he says.

Jones arrived at Cardiff in 2006 as codirector of CUBRIC. His job was to establish a neuroimaging research program where none existed. A medical physicist by training, Jones had the good fortune to work alongside two other physicists with complementary backgrounds. Together they came up with the idea and a business plan for establishing a new, comprehensive neuroimaging research center at Cardiff. The proposal dovetailed nicely with Wales' greater science agenda to establish itself as world class in a few key areas. "I think they were excited at the vision of the university having something genuinely unique," Jones recalls. Their plan was approved. The new CUBRIC boasts a combination of imaging equipment that is unique in all of Europe.

Anyone can approach the center with a research proposal, says Jones, and it will work with both academics and industry partners on brain stimulation technologies, including pharmaceutical companies investigating the effects of experimental medicines. Jones's own research employs the center's equipment to achieve the best estimates of myelination, axon characteristics such as density and diameter, and brain connectivity. He then uses that information to understand individual differences in brain electrophysiology and cognition. A recent experiment, for example, showed that six weeks of cognitive training could produce detectable differences in brain microstructure.

Translating research at Swansea

At Swansea, much of the research for Sêr Solar (funded under Sêr Cymru) is focused on commercialization. Durrant and his colleagues at Imperial's Centre for Plastic Electronics are working on developing and understanding new ink-based coatings that can be printed onto surfaces as semiconductor materials in order to capture solar energy. Researchers at Swansea, in collaboration with industry, are taking these printable materials and focusing on the challenges of scalability and stability to develop new classes of solar cells. "The vision is to print the ink directly onto roofing products," he says.

Durrant is an academic at heart. "I'd love my research to be useful," he says, "but I'm not very good at applying it." At Swansea he can concentrate on basic research, while others working alongside him can develop applications. He points out that the CEO of SPECIFIC previously worked in the steel industry. "That type of industrial perspective permeates the culture of SPECIFIC, and so you have a huge drive to turn science into practical applications. I'm happy to be involved," adds Durrant.

A pilot plant for the coated roofing has already been built at the Innovation and Knowledge Centre—located about 16 km (10 miles) away from Swansea University's Singleton Park campus. The £20 million (US$26.5 million), five-year SPECIFIC project will develop coated steel and glass products to incorporate into new and existing buildings, enabling walls and roofs to generate, store, and release energy. Such coatings on buildings could reduce the United Kingdom's CO_2 output by millions of tons a year. The project is a partnership that in addition to Swansea, involves several universities including Imperial College, Bangor, and Cardiff, as well as multinational companies such as Tata Steel and BASF International.

Swansea University recently expanded and in 2015 opened its Bay Campus, a £450 million (US$580.6 million) science and innovation space situated on a 65-acre beachfront site not far from the Singleton Park Campus. The campus currently hosts the College of Engineering and the School of Management and boasts a hall that seats 800, an extensive library, and student housing, among other amenities. The multipartner, public-private project was largely funded by the university and the Welsh Government through the European Regional Development Fund.

Wales builds strength in environmental science

In striving for excellence in select areas, Wales is following a tried and tested recipe. **Chris Thomas** came to Aberystwyth University in 2007 to help build up the Institute of Biological, Environmental and Rural Sciences (IBERS). Thomas is a wildlife biologist by training, but he now uses technology such as satellite remote sensing and software applications such as geographic information systems to model vector disease transmission. "I was attracted to Wales by the big investment in environmental and agricultural studies," Thomas says. "We are very proud of what's gone on there."


David Thomas

In 2013, Thomas was appointed Pro Vice-Chancellor of Research at Aberystwyth. His primary goal is to ensure the success of the current science strategy. With translational research high on the agenda, Thomas is also overseeing the conception and construction of the new £40.5 million (US$53.6 million) Innovation and Enterprise Campus at Aberystwyth, which will focus on agricultural innovation. The university is already world renowned for research in pasture-based agriculture, which encompasses many areas including grass breeding, nutritional characterization of different grass breeds, and the use of different plant species in applications ranging from flood control to altering the nutritional value of meat and milk via the grasses animals eat.

Through the £7 million (US$9.2 million) Sêr Cymru National Research Network for Low Carbon, Energy and Environment—one of the three grand challenge areas—Welsh universities hope to capitalize even more on their expertise in pasture-based agriculture. The network encourages interdisciplinary research across departments and universities, so that environmental scientists collaborate with energy scientists, for example, and architects with plant scientists, says **David Thomas,** director of the Bangor University-based network. "The network has been the catalyst to bring them into the same room," he adds. "It encourages collaborations to be more innovative."

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FEATURED PARTICIPANTS

Aberystwyth University
www.aber.ac.uk

Bangor University
www.bangor.ac.uk

Cardiff University
www.cardiff.ac.uk

CUBRIC
sites.cardiff.ac.uk/cubric

Higher Education Funding Council for Wales
www.hefcw.ac.uk/home/home.aspx

Institute of Biological, Environmental and Rural Sciences
www.aber.ac.uk/en/ibers

Learned Society of Wales
www.learnedsociety.wales

National Research Network for Low Carbon, Energy and Environment
www.nrn-lcee.ac.uk

SPECIFIC
www.specific.eu.com

Swansea University
www.swansea.ac.uk

Institute of Biological, Environmental and Rural Sciences at Aberystwyth University

PHOTO: COURTESY OF ABERYSTWYTH UNIVERSITY

The collaborative environment is what **Rosalind Dodd** enjoys most about working in the network. "We've got some great researchers who are very engaged and great to work with," she says. Dodd came to Bangor University in January after completing a postdoc at the University of Arkansas in the United States. She found the work in Arkansas interesting, but wanted "something more ambitious in terms of size and scope." Dodd is part of a cluster within the network focused on smart grass: Her group studies the impact of extreme weather on different varieties of grass and the ecosystem. The research will become important across agricultural regions, she says, as climate change is expected to increase the frequency of extreme weather events around the world.

A sustainable future built on strong science

Agriculture has and continues to make up a major share of Wales' economy—support for research in this area continues to be strong. Wales' science agenda is not only driven by its existing strengths in the life sciences, but also by a vision of where it wants to go. "Wales is trying to brand itself as a sustainable nation," says Allen. "It defines the sort of Wales we want to be."

Population growth, climate change, environmental destruction, and aging populations are global challenges. There is a widespread belief that only science and technology can provide solutions to these potentially catastrophic societal and environmental issues. Wales isn't the only country investing in the science of sustainability—but it has found niches in which it either already excels or has the potential to shine.

The country's recent capacity-building initiatives are not arbitrary. The Welsh Government's Sêr Cymru program was largely based on studies showing that Welsh universities were not winning the percentage of competitive Research Councils UK grants commensurate with the size of the Welsh population (5% of the UK total). Evidence gathered by **Peter Halligan**, chief executive of the Learned Society of Wales, showed that the problem lay not in the quality of science but rather in the number of researchers. Wales has had a deficit of researchers—over 600 fewer relative to its population than Scotland, for example. Among the largest deficits have been researchers in science, technology, engineering, mathematics, and medicine—areas largely funded by high-spending agencies such as the Medical Research Council and the Engineering and Physical Sciences Research Council.

Despite this work force deficit, Welsh science overall now outperforms many other similarly small countries such as Norway, Ireland, and New Zealand, according to commonly used measures of efficiency and science quality. Using field-weighted citation impact (a recognized measure of mean citations per article, normalized for subject field), Wales' citation impact increased from 39% above the world average in 2004 to 68% in 2014. Citations per Welsh researcher also moved from an average of 7.6 in 2007–2011 to 9.6 in 2014—"that's two percentage points above the UK average," says the Learned Society of Wales' Halligan. As Wales' first national academy, the Learned Society of Wales—established in 2010—brings together the nation's most successful and talented fellows to advance and promote research excellence in all scholarly disciplines.

Halligan's research provided valuable support for extending Sêr Cymru into its second phase. Sêr Cymru II is a suite of schemes partly funded by the European Commission through the Horizon 2020 Marie Skłodowska-Curie Actions COFUND scheme, or by the Welsh European Funding Office through the European Regional Development Fund. In addition to funding fellowships and promising scientists, Sêr Cymru offers 12 additional fellowships to scientists returning to their fields after a long absence.

The level of government commitment has made a powerful impression on researchers. "I have been stunned at how accessible the leadership in Cardiff has been to me," Durrant says. "Wales has the level of political engagement and the determination to focus their resources that is creating really world-class centers."

Welsh universities also provide other perks that go beyond the quality of their science offerings. "People are very open and relaxed when talking about ideas," says Dodd. "They don't seem to worry about how they are going to be perceived." This sentiment was echoed by Jones: "This university is the most collegial place I've ever worked."

And contrary to the stereotypical view of a small institution being a professional handicap, "I haven't needed to be in a large institution to be a successful scientist," says Bangor University's Thomas, who has been in Wales for over 20 years. Also worth mentioning is the proximity to ocean, mountains, and other natural beauty that together, says Thomas, make Wales "a blindingly good place to live."

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