

Ireland's scientists seek a shift in support toward basic research

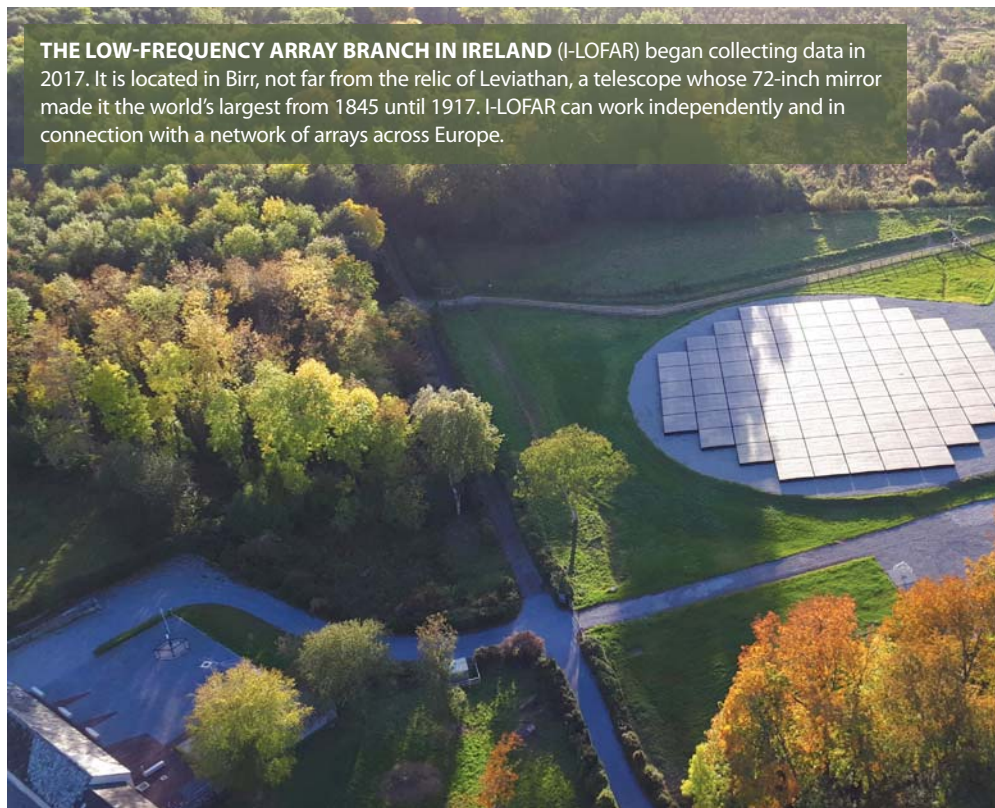
Their wish list: Support creativity and theoretical disciplines, maintain links with UK colleagues amid the uncertainty of Brexit, and continue the strong ties with industry that helped the country recover from deep recession.

With the establishment in 2000 of Science Foundation Ireland (SFI), the country rose rapidly from a scientific backwater to a full-fledged international player. Then the global financial downturn triggered a deep national recession that lasted roughly from 2008 to 2014. Although the government maintained SFI's budget, the foundation narrowed its funding portfolio to focus almost exclusively on applied and industry-oriented projects. Now that Ireland's economy is largely recovered, researchers say the government should invest more in science and education and rebalance how it divvies up support between fundamental research and research with short-term commercial goals.

Ireland's scientific community is "struggling to get back to where we were 10 years ago, when there was a sense that anything was possible," says physicist John McNerney of University College Cork and the Tyndall National Institute, which focuses on photonics and electronics. "We are trying to get that mojo back. You have to keep the innovation pipeline loaded. [The funders] took out the cool stuff, the emerging stuff."

Recent signs point toward a revival in basic research that the country's scientists deem critical. The Irish Research Council, the main national source of funding after SFI, last year introduced a new grant line, and this year SFI will call for proposals from individual investigators after a two-year hiatus. In October Ireland joined the European Southern

THE LOW-FREQUENCY ARRAY BRANCH IN IRELAND (I-LOFAR) began collecting data in 2017. It is located in Birr, not far from the relic of Leviathan, a telescope whose 72-inch mirror made it the world's largest from 1845 until 1917. I-LOFAR can work independently and in connection with a network of arrays across Europe.



Observatory (ESO), which gives the country's astronomers access to telescopes (and its companies the opportunity to bid for tenders). In 2017 a radio telescope—the westernmost site in the Low-Frequency Array that stretches to Poland—started collecting data in Birr, in Ireland's center.

More industry, less creativity

In 2002 chemist John Boland returned to Ireland to work at Trinity College Dublin after 23 years in the US, in large part because of SFI. "It was the first time in Ireland's history that we invested in science. That attracted me and many others back to Ireland."

From the get-go, SFI focused on biotechnology and on information and communications technology. Ireland is a small country, and the idea was to focus, not to try to do it all, says William Harris, SFI founding director, who had earlier served as assistant director for mathematical and physical sciences at the US's NSF. For a country that was famous for poets, writers, and education, not for

huge investments in research, he says, "the government's decision to fund SFI was bold and significant." It helped Ireland strengthen university research and attract tech companies. About 10% of SFI's budget went to frontier research in any field, he adds.

But in the late 2000s, says Lorraine Hanlon, a high-energy astrophysicist at University College Dublin, SFI let it be known that it would no longer fund astronomy or particle physics. The recession accelerated the agency's shift toward research with identifiable economic outcomes.

As part of its growing emphasis on industry-facing research, SFI began concentrating its grants on large multi-institution centers over individuals. It now funds 17 centers around Ireland, in research areas that fit with strategic national priorities, such as green energy, big data, and medical devices. Centers each get between €2 million (\$2.3 million) and €4.5 million annually for six years. SFI's total budget this year is €189 million.

ALISON DELANEY, EDUCATION OFFICER AT BIRR CASTLE



The SFI money makes up about a third of a center's budget, with the centers required to raise the rest equally from industry and other sources. "A third from industry is a big ask," says Michael Coey, who works in spintronics and magnetism at the Advanced Materials and Bioengineering Research (AMBER) center at Trinity. "The danger is, the more of their money you take, the more you focus on their short-term projects."

In the early years, SFI put 80% of its budget toward grants for individual investigators, and the rest toward a few centers. The agency says the split is now 50-50. But researchers both with and without center affiliation say the portion that goes to centers is higher, largely because calls for proposals typically emphasize contributions to society and the economy, a requirement that matches the capabilities at centers. "The centers are hoovering up too much of the budget," says Hanlon. The focus on centers and on industry-oriented research is "deeply flawed," she says. "It excludes a

lot of capable people and hollows out the base."

Following the money

With SFI's change in funding priorities, researchers have mostly realigned their work or turned to European and other external funding sources. Some have left the country or watched their research programs dry up. Researchers who could shift their work to collaborate with industry have done well, says Trinity's Jonathan Coleman, who developed a scalable method to produce graphene. "If you weren't able to do that, you were screwed."

After joining the faculty at Trinity in 2009, Matthias Möbius turned from basic research to applications related to foams, emulsions, and complex fluids. One of his projects involves replacing water with foam in paper production. Another involves nanosuspensions for ink-jet printers. "The money was the motivation for changing my research," he says, "but the questions are still interesting to me."

Peter Gallagher, an astronomer at the Dublin Institute for Advanced Studies, also followed the money: "I became more industry focused [but still] tried to keep my research program balanced." Power-grid operators and insurance companies support his research on solar flares.

"It depends where you start from and how far you are willing to realign your research interests," says theoretical particle physicist Sinéad Ryan of Trinity. For many in string theory, particle physics, and mathematics, it's quite difficult to fit into the priority themes and short-term applications. "It has been very difficult to sustain vibrant research programs," she says.

Among theoretical physicists and pure mathematicians, says Ryan, "we are 'out,' so there is a sense of collegiality." But the funding disparities across the broader field can create tensions. For example, promotion and recruitment may become difficult. "If you have two people from the physics department, and one has three grants and the other has none—because they do fundamental research—you can imagine it requires dexterity to see beyond this simple metric and also

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STEFANO SANVITO (RIGHT) AND MUNUSWAMY VENKATESAN of Trinity College Dublin melt metallic powders to create new magnetic compounds. Sanvito's team uses computer simulations to design magnetic materials and has created many of them.

promote the person with no grants or fewer publications."

"We won't get interest from SFI if we talk about gamma rays or an unbelievable breakthrough in astrophysics," says Hanlon. "But if we hide the astrophysics and talk about a new technology, we may get funding. It's a weird dynamic." Around when SFI stopped supporting her work, funding came through from the European Space Agency. She and her group are working on a miniaturized gamma-ray detector that will be one of three experimental payloads to fly on Ireland's first satellite, *EIRSAT-1*, which is slated to launch in 2020.

Some researchers relocated, but for many, "leaving in a time of crisis is impossible," says Gerard O'Connor, head of physics at the National University of Ireland, Galway. "They've taken a mortgage and have negative equity. It's a trap. Generally, people have had to reinvent

themselves." In his department, he says, people struggled most to get funding for astronomy; the SFI priorities were easy fits for researchers in climate change, atmospheric physics, and biomedicine. The western part of Ireland is known for producing disposable medical equipment, he notes, with about a third of the world's contact lenses and nearly 80% of stents sold worldwide made there.

Reverberations

The effects of the recession on scientists are wider than SFI's sharpened focus on research impact and centers. For example, all public employees took repeated pay cuts. For university faculty, those cuts were as high as 20%. College enrollments swelled, while over the past decade government funding per undergraduate has shrunk by 50%, according to Ireland's Higher Education Authority. In some cases, teaching loads grew to the point

that scientists didn't have time for research, says O'Connor. With more students and less money, university international rankings dropped. "The universities have worked hard to hold the show together with continually decreasing budgets," says Coleman. "But you only do more for less for so long before the house of cards collapses."

Degradation of scientific equipment is widespread. In a survey last year by the Royal Irish Academy, 90% of respondents in science, technology, engineering, and mathematics reported gaps in the availability of infrastructure in their discipline; 35% said they are not generally able to access the research infrastructure they need; and 77% said the infrastructure that is available is not adequately funded or maintained.

Stefano Sanvito, a condensed-matter theorist who heads the Centre for Research on Adaptive Nanostructures and



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A CT SCAN of a cellulose fiber structure (9 mm to a side) made by Matthias Möbius of Trinity College Dublin and colleagues helps them study how the fiber's structure affects its mechanical properties. Like many scientists in Ireland, Möbius has aligned his research to work on problems that are interesting to, and generate funding from, companies.

Nanodevices at Trinity and is a member of AMBER, notes that workhorse instruments like NMR machines are aging. "We haven't been able to replace them. There are many things at this level. The bread and butter of the university has been undermined."

Travel money can also be hard to

come by. James Gleeson, a mathematical physicist at the University of Limerick and a member of two SFI centers, works on modeling of information spread relevant for studying epidemics and online social networks. He says that graduate students can sometimes attend conferences using fellowships from the Irish Research Council, but their advisers often can't muster the money to join them. That slowing of international scientific exchange makes collaborations harder to sustain and is "a disincentive to bring researchers here to join our intellectual ecosystem."

Looking ahead

Despite some complaints, researchers acknowledge that SFI's strategy contributed to the country's economic recovery. And they point to many scientific achievements and their community's quick rise in the international arena. "No country on the planet has outputs like we do," says Boland, a member of AMBER. "With just 1.2% of our GDP going to R&D, half the OECD [Organisation for Economic Co-operation and Development] average, our centers compare with the best in the world."

Ireland continues to attract multinationals, the economy is strong, and, says Gleeson, "engagement between universities and industry is far improved. Now it's the norm, and you can credit the SFI funding model." Says Boland, "We need the centers. They provide scale—industry doesn't want to work with single investigators. They need the right collection of people. The center provides an interface."

The presence of multinational companies speaks to Ireland's education

Sundry Stats

- ▶ In 2016, nearly 1.8% of Ireland's workforce was employed in R&D, the fifth-highest of the 36 countries in the Organisation for Economic Co-operation and Development (OECD). Denmark, Finland, Israel, and Sweden lead the list.*
- ▶ In 2016, 1.18% of GDP was invested in R&D; the average for the 28 European Union countries was 1.93%.*
- ▶ Ireland is ranked 11th worldwide in overall quality of scientific research, after Singapore and before Germany. Switzerland tops the list. The US takes the 6th spot.†
- ▶ Of awards to individual investigator groups by Science Foundation Ireland (SFI) in 2001–17, women made up 23% of lead applicants, were awarded 20% of grants, and received 13% of the total funding.‡
- ▶ In 2017, SFI award holders reported 2443 collaborations with counterparts in 66 countries. The largest number was with the UK (563, of which 89 were with Northern Ireland), followed by the US (447), Germany (201), France (145), Italy (137), Spain (116), and China (87).§

* OECD.

† InCites Essential Science Indicators, April 2018.

‡ SFI data, analyzed by Derek O'Callaghan.

§ SFI, 2017 annual report.

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system and the high quality of college graduates it produces, says Alexander Chamorovskiy, senior researcher at Superlum, a company in County Cork that produces broadband semiconductor light sources. "It's getting hard for small companies to hire Irish students," he says. "We can't compete with big multinationals, which offer much higher salaries."

And it's not just scientists with the SFI centers who support a rebalancing of funding, with more going to fundamental research; the scientists who struggle for national funding say that the centers should continue. "I would not argue that the centers should get less funding," says Ryan. "Funding needs to be increased across the board and diversified to support excellence in all disciplines." She also wants to see Ireland join CERN.

Ciarán Seoighe, SFI deputy director general, notes that the agency's responsibility has always been for "oriented basic,

with applied research added in 2013." Over several months in late 2018, he met with 1000 or so researchers to take the pulse of the community for a new five-year strategy, which SFI aims to set by year's end. "We are looking at the whole ecosystem and looking for gaps," he says. "We may come out of this quite a different organization. Our core objectives may change."

Meanwhile, not far from anyone's mind is Brexit, the impending departure of the UK from the European Union. (See PHYSICS TODAY, March 2017, page 24.) As Britain's close neighbor, Ireland will undoubtedly be strongly affected by Brexit. But what it means for science is still anyone's guess. Séamus Davis, who works in experimental quantum matter and in January moved to University College Cork and Oxford University after decades in the US, says the long-standing ties between Ireland and the UK will survive the change whatever form it takes. Seoighe

points to Davis's new split position as part of the glue to keep the ties strong and says the science communities in both countries are looking for new ways to partner.

In Ireland as elsewhere in the European Union, researchers are backing away from UK partnerships in anticipation of funding difficulties. Irish universities are seeing an uptick in inquiries about faculty jobs. And in the wake of Brexit, Ireland could become more attractive for scientific partnerships by virtue of being the main English-speaking country in the European Union.

"Everybody is waiting to see what will happen," says Eucharía Meehan, head of the Dublin Institute for Advanced Studies and former director of the Irish Research Council. "But a lot of people are thinking creatively about how to keep the UK as part of the European scientific landscape."

Toni Feder

Side trips on the road to fusion

A private company pursuing an alternative path to fusion energy is banking on revenues from inventions it makes along the way.

A California startup has a multipronged approach to help pay for its decade-long quest to demonstrate fusion at a commercial scale. The approach includes a novel concept to become a part-time scientific user facility funded by the Department of Energy. TAE Technologies also is soliciting tax breaks and other financial inducements from state and local governments as it decides on a site for a new \$500 million test reactor. The company is reporting initial success in commercializing several technologies it has developed as it has built its experimental devices.

Based in Orange County, the 160-employee TAE is the largest of a handful of privately held startups that are pursuing alternative approaches to controlled fusion. Others include General Fusion in British Columbia, Canada; Commonwealth Fusion Systems in Cambridge, Massachusetts; and Tokamak Energy, near Oxford, UK.

TAE remains focused on demonstrating commercially viable grid-scale fusion by the late 2020s, says CEO Michl Binderbauer. In the meantime, it is look-

ing for revenue sources to offset some of the company's \$50 million annual operating expenses and attract additional in-

vestors. Spin-off technologies, in particular, "create the opportunity for investors to feel we are more than a one-

