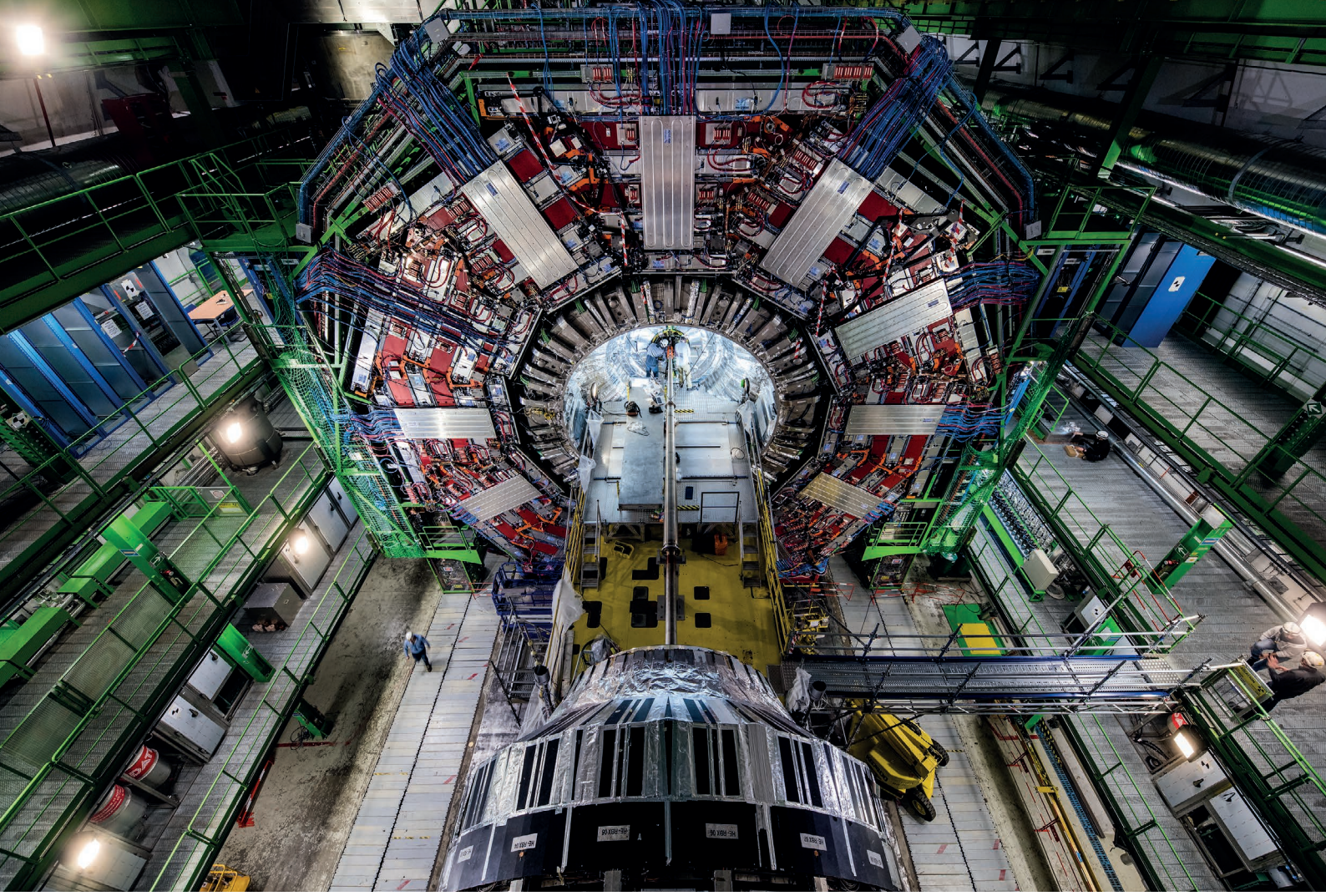


The CMS experiment forms part of the Large Hadron Collider near Geneva, a project that demonstrates Switzerland's commitment to scientific cooperation.

CERN

Big science in a small country

Switzerland's unique geography and economy put it at the centre of the world when it comes to scientific collaboration.

BY NIC FLEMING

In a competition to find the world's most multinational laboratory, Shriya Palchaudhuri's workplace would surely be a strong contender. The neuroscientist, who comes from India, has 11 scientist colleagues from 10 different countries.

"We sometimes get ten different approaches to the same problem," says Palchaudhuri, who is studying for a PhD on the mechanisms of fear conditioning at the Laboratory of Synaptic Mechanisms, part of the Swiss Federal Institute of Technology in Lausanne (EPFL) in Switzerland. "The international atmosphere can be really helpful. We benefit and learn from people with such a wide variety of backgrounds."

Working alongside colleagues from multiple countries is increasingly commonplace for researchers. Science, like many other fields of human endeavour, is much more international than it was a generation ago. A study published in 2015 found[1] that the proportion of papers co-authored by collaborators from multiple countries jumped from 10% to 25% between 1990 and 2011.

Switzerland is something of a United Nations of science. It provides generous fellowships to encourage its early-career scientists to study and work abroad, and a majority of faculty members in its universities have foreign passports. When *Times Higher Education* published a league table of the world's most international universities in February 2017, the Swiss Federal Institute of Technology (ETH) Zurich came first and EPFL second. A survey published by *Nature Biotechnology* in 2012 found Switzerland to be the only country among 16 leading nations with more than half of its scientists hailing from outside its borders[2].

"We attract a lot of people from other countries, but many Swiss researchers also go abroad to do research, so we're probably one of the best examples worldwide of brain circulation," says Mauro Moruzzi, head of international relations at the Swiss State Secretariat for Education, Research and Innovation (SERI) in Bern, Switzerland.

This churn of researchers coming to and ▶

from the country seems to have paid off. Switzerland is never far from the top of international league tables of academic publications per researcher, research impact, innovation or patents per capita. The country's science is a foundation of the economy — making its growth and protection a major priority for policymakers (see 'Knowledge sector').

SCIENCE AROUND THE WORLD

Proteomics pioneer Rudolf Aebersold, at the Institute of Molecular Systems Biology at ETH Zurich, has benefitted from this emphasis on mobility. After completing his PhD in Switzerland in 1983, he was awarded grants from the Swiss National Science Foundation (SNSF) to work as a postdoc at the California Institute of Technology in Pasadena. From there he subsequently held positions at the University of British Columbia, Canada, and the University of Washington in Seattle.

Aebersold is known for his development of analytical protein chemistry and proteomics methods, especially the use of isotope-coded affinity tags (ICATs) to identify proteins in complex mixtures. First described in 1999, this technique involves labelling amino acids in proteins with light and heavy isotopes, then measuring them with mass spectrometry. This makes it easier to analyse proteomic dynamics in cells, tissues and organisms, in both healthy and diseased samples.

Aebersold returned to Switzerland in 2004. Today, his group uses similar methods to compare proteins across populations of patients. This profiling can help to explain how cells respond to external stimuli, and can identify cells with abnormal levels of specific proteins. Swiss scientists in his lab are outnumbered by those from abroad — Germany, the United States, China, Iran, Italy, Austria, India and South Korea are all represented. "For a small country like Switzerland, being open and international gives us access to a much larger talent pool, and so for us it's existential," he says.

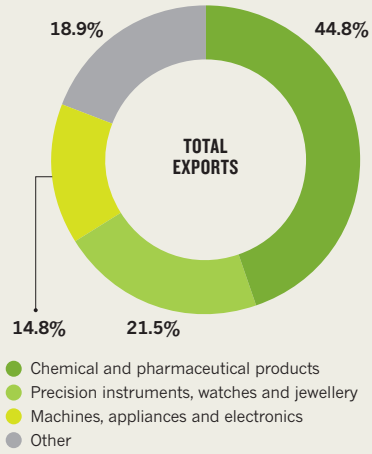
Apart from allowing Switzerland to recruit the best, this international atmosphere can also encourage a greater diversity of approaches, as Palchaudhuri has found. She and her colleagues are investigating how the brain comes to associate a neutral stimulus, such as a specific tone, with something that generates fear, like an electric shock. This is believed to take place in two almond-shaped sections of nervous tissue called the amygdalae, located deep in the centre of the human brain. Palchaudhuri hopes to identify the regions of the brain that send signals to the amygdalae, and find out which cell types encode these associations.

Such research may eventually be used to help people with post-traumatic stress disorder. "If we could get some sense of the circuits that are involved, we could at least work out how it's affecting patients," Palchaudhuri says. "But this is looking far into the future."

Her lab members tackle this research in different ways, and the differences in approaches can sometimes be drawn along national lines. "I don't mean to sound in any way stereotypical, but I have found Germans value precision and quality a lot, Americans are extremely professional and practical, and it's difficult to match the Chinese in how industrious they are," says Palchaudhuri.

KNOWLEDGE SECTOR

Switzerland's economy is highly dependent on knowledge-based exports. Data from 2016.



> OUR ECONOMIC SUCCESS HAS LONG **RELIED** ON RECRUITING THE **BEST BRAINS.**

As well as these new methodologies, Palchaudhuri has enjoyed what she's seen of her new country. "I haven't done much travelling yet. Some hikes here and there — Switzerland is beautiful. For anyone applying, Lausanne is a great place to be." Although, she cautions, the high salaries are matched by a high cost of living, which is exacerbated by high demand for accommodation. In Lausanne, at least, "there's a huge number of students and not enough places", she says.

INVESTING IN INTERNATIONALISM

Although not a member of the European Union, Switzerland still contributes to, and benefits from, its pooled research-funding programmes as an 'associated country'. Researchers at Swiss institutions received €2 billion (US$2.4 billion) from Framework Programme 7, the EU funding programme that covered 2007–13. During this period they were granted €584.5 million in European Research Council grants, the fifth-highest national total.

Switzerland has a long history of large-scale collaboration. It is joint home (with France) to CERN, the European laboratory of particle physics near Geneva, which was established in 1954 and now operates the Large Hadron Collider. Switzerland is also a major contributor, both financially and in research terms, to ITER, the world's largest nuclear-fusion experiment, currently being built in southern France. And it is a founding member of both the European Space Agency and the European Spallation Source, an advanced pulsed-neutron source under construction in Lund, Sweden.

"Switzerland is always happy to pull its weight in major international projects," says Lutz-Peter Berg, head of science and innovation at the Swiss embassy in London. "In order to be a major scientific player, to attract highly trained foreign staff and to train your own staff, you need to be linked in to international centres of excellence."

Beyond Europe, scientists at Swiss institutions engage easily in collaborations with colleagues from countries such as the United States, Canada, Australia and Singapore. Government agencies have in recent years focused their efforts on driving partnerships with the five major emerging economies: Brazil, Russia, India, China and South Africa. They are also building relationships with Japan and South Korea, nations that are culturally remote from Switzerland.

"The ideal is that scientists from different countries meet, say at a symposium, and decide to work together without any need for government involvement," says Moruzzi. "However, in the case of emerging countries, we recognize there is sometimes a need to help kick-start things."

Moruzzi leads such efforts, drawing up joint funding calls to encourage collaborations between Switzerland and emerging, non-EU nations, and in some cases bilateral agreements on issues such as intellectual property and publication credits. He also heads Swissnex, a network of advisers based in more than 20 countries that helps Swiss scientists make international connections.

STAYING OPEN

The SNSF provides generous funding for early-career Swiss scientists to spread their wings. In 2016, it awarded international mobility fellowships to 171 doctoral students and 512 postdocs. In 2017, the living allowances provided by these were 36,000–48,500 Swiss francs (US$38,000–51,000) for those doing PhDs and 37,000–53,500 Swiss francs for postdocs.

For those travelling in the opposite direction, the Swiss federal government seeks to enhance the country's attractiveness as a place to study and work by keeping laws and paperwork for immigrants simple. "It's important that there are low barriers and simplicity in these systems to reduce the costs and hassles for foreigners coming to work with us," says

SWISS FEDERAL CUSTOMS ADMINISTRATION

BORDERS AND BRAINS

A cautionary tale

On 10 February 2014, scientists in Switzerland awoke with a collective headache — one that should perhaps give those negotiating the United Kingdom's withdrawal from the European Union pause for thought.

A day earlier, 50.3% of the Swiss electorate had voted to introduce annual quotas to limit immigration. This threw into question the country's commitment to the core EU principle of free movement of people, and led to Switzerland being frozen out of funding from Horizon 2020, the EU's €80-billion (US$95-billion) pooled research-funding programme for 2014–20.

Swiss scientists could still participate in Horizon 2020 projects but could no longer get EU funding to do so, including European Research Council (ERC) grants. The federal government stepped in with money to fill the gap in June 2014, but scientists across Europe continued to think twice about working with Swiss colleagues. A 2016 report found researchers in Switzerland to be participating in 1.8% of Horizon 2020 projects and coordinating just 0.3% of them — down from 3.2% and 3.9% respectively under Framework Programme 7, the European pooled funding programme for 2007–13.

Only when the Swiss parliament passed a law that again guaranteed free movement in December 2016 did the country's scientists regain full access to Horizon 2020 funding. Discussions to determine the conditions for participation in future EU-backed science projects will continue into 2018.

Scientists in Switzerland are now warning their counterparts in the United Kingdom that losing access to key funding streams will be just one of their problems, should Brexit lead to their exclusion from EU research programmes.

"Horizon 2020 is the world's largest research programme, but it is not just about money," says Olivier Küttel, head of European public affairs at the Swiss Federal Institute of Technology in Lausanne. "It facilitates cooperation enormously, and saves a lot of time and effort by defining common rules on things like funds, intellectual property and publication credits. If the UK is excluded from the ERC, it would be disastrous for UK science." **N.F.**

Gabriel Aeppli, professor of physics at ETH Zurich and EPFL.

As head of synchrotron radiation and nanotechnology at the Paul Scherrer Institute in Villigen, Switzerland, Aeppli will oversee photonics at SwissFEL, a major new research facility set to begin operations at the institute in late 2017. It will produce extremely short pulses of X-ray light to provide insights into a wide range of chemical, biomedical and engineering processes. "The involvement of our scientists in high-profile collaborations with international colleagues, the ability to test experiments at foreign machines and do exchanges at an engineering level have been absolutely vital for SwissFEL," says Aeppli.

Geography and demographics go a long way towards explaining why science flows so freely across Swiss borders. Around one in four of its inhabitants is foreign-born. A small, mountainous country, it has to import raw materials and much of its food. A lack of natural resources and coastlines has moulded the highly successful Swiss economy, based as it is on knowledge, innovation, specialized labour and technology. Its location in the heart of Europe has made it a natural gateway for people and goods flowing across the continent.

"Switzerland has always been an open country, it's in our DNA," says Olivier Küttel, head of European public affairs at EPFL. "Our economic success has long relied on recruiting the best brains, and with such a small population we just couldn't do that if we weren't open to those coming in." (See 'A cautionary tale'.)

Beyond anecdotal evidence, there have been efforts to work out whether greater international scientific collaboration drives better science. In one such analysis carried out this year[3], science-policy specialist Caroline Wagner of the Ohio State University in Columbus, combined data on scientific-workforce mobility with proportions of co-authored publications involving international collaboration to create an index of international openness.

In results presented at the 2017 American Association for the Advancement of Science conference in Boston, Massachusetts, Switzerland came top of 36 leading nations for both openness and co-authored publications. Wagner also found that 80% of national research quality, measured by citations, could be explained by how open countries are. "Our findings support the idea that international brain churn is really important to creativity and top-level science," she says. ■

Nic Fleming *is a freelance writer based in Bristol, UK.*

1. Wagner, C. S., Park, H. W. & Leydesdorff, L. *PLoS ONE* **10,** e0131816 (2015).
2. Franzoni, C., Scellato, G. & Stephan, P. *Nature Biotechnol.* **30,** 1250–1253 (2012).
3. Wagner, C. S. *2017 AAAS Annual Meeting* (2017).