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Polarstern's Arctic mission carried hundreds of scientists to perform climate research.

A research giant stays the course

National bodies thrive under funding certainty, but some universities suffer cuts. **By Hristio Boytchev**

In October 2020 the colossal German research icebreaker, *Polarstern*, docked in the city of Bremerhaven on the North Sea coast. The 118-metre vessel had spent most of the largest-ever Arctic expedition locked in a giant slab of moving sea ice. On board, hundreds of researchers were carried thousands of kilometres for almost 13 months through the central Arctic to study one of the world's largest uncharted areas, crucial to climate research.

"The researchers have unearthed a treasure trove of data that will benefit generations to come," Germany's federal research minister, Anja Karliczek, said on 12 October. "Data obtained in the epicentre of climate change will help close crucial knowledge gaps."

As the fourth-largest economy in the world, behind the United States, China and Japan, and largest economy in Europe, Germany is equipped to lead immense undertakings

such as the *Polarstern* expedition. Known as MOSAiC (Multidisciplinary drifting Observatory for the Study of Arctic Climate), the €140-million (US\$165-million) international collaboration involved researchers from more than 80 institutions and 20 countries. The Alfred Wegener Institute in Bremerhaven, which spearheaded the project, is a member of the Helmholtz Association of German Research Centres, the country's largest scientific organization, which draws from an annual budget of €5 billion. In 2018, Germany's public and private investment in research and development (R&D) was €104.7 billion, according to the Federal Ministry of Education and Research.

The traditions that established Germany as a science powerhouse have spread around the world, such as the idea two centuries ago from Prussian educator Wilhelm von Humboldt that university professors should pursue

cutting-edge research as well as teaching. Germany's chancellor since 2005, Angela Merkel, a physicist before she was a politician, has continued a tradition of strong science funding. Under a pact between the federal government and the *Länder* (states), Germany's four major organizations (Helmholtz Association, Max Planck Society, Fraunhofer Society and Leibniz Association) and its central research funding organization, the German Research Foundation (DFG), jointly funded by the two levels of government, enjoyed a guaranteed annual research funding increase of 5% for the 10 years to 2015. The annual increase from 2015 until 2030 is set at 3%.

In June, the government introduced a €60-billion stimulus package to shore up education, research and innovation against the impact of COVID-19. It includes tax cuts to R&D-intensive companies and earmarks around €13 billion to support medical innovations as well as technologies, such as green hydrogen, quantum technologies and artificial intelligence.

The number of international academics at German universities has nearly doubled since 2006, and they make up 20% of the academic staff at the non-university research institutions. One example, Emmanuelle Charpentier, director at the Max Planck Institute for Infection Biology in Berlin, shared the 2020 Nobel Prize in Chemistry for her in work on CRISPR-Cas9 gene-editing technology. Charpentier

moved from Sweden, where she conducted her breakthrough work, to Germany in 2013, where she was initially based at the Helmholtz Association before moving to Max Planck.

Germany has shown very strong performance in traditional fields such as chemistry and the physical sciences, as well as newer ones such as sustainability science. It is the third most prolific country in the Nature Index after the United States and China for research output in the 82 high-quality natural-sciences journals tracked by the index. But issues such as gender and generational equality need to be addressed, or the country is at risk in falling behind in multi-disciplinary, future-oriented fields.

“The research landscape is not adequately prepared for the major trends such as digitalization, networking technologies, circular economy or smart living,” says Ortwin Renn, professor for technology assessment and environmental sociology at the University of Potsdam in northeast Germany. “Transfer from universities to industrial applications is also still lacking.”

Funding certainty has earned Germany a reputation for supporting blue-sky research, a term referring to projects for which ‘real-world’ applications are not immediately apparent. As Merkel said in 2017, “I came from basic research myself, and have always said, you can’t predict things, you just have to leave space.” For Martin Wikelski, director at the Max Planck Institute for Animal Behaviour in Radolfzell, southern Germany, this attitude translates to opportunities that can be difficult to fund elsewhere. Wikelski is leading an international effort to create an ‘internet of animals’ by tagging birds, bats and other flying creatures with transmitters that communicate with an antenna system on the International Space Station. Called ICARUS (International Cooperation for Animal Research Using Space), the project aims to monitor thousands of migration routes.

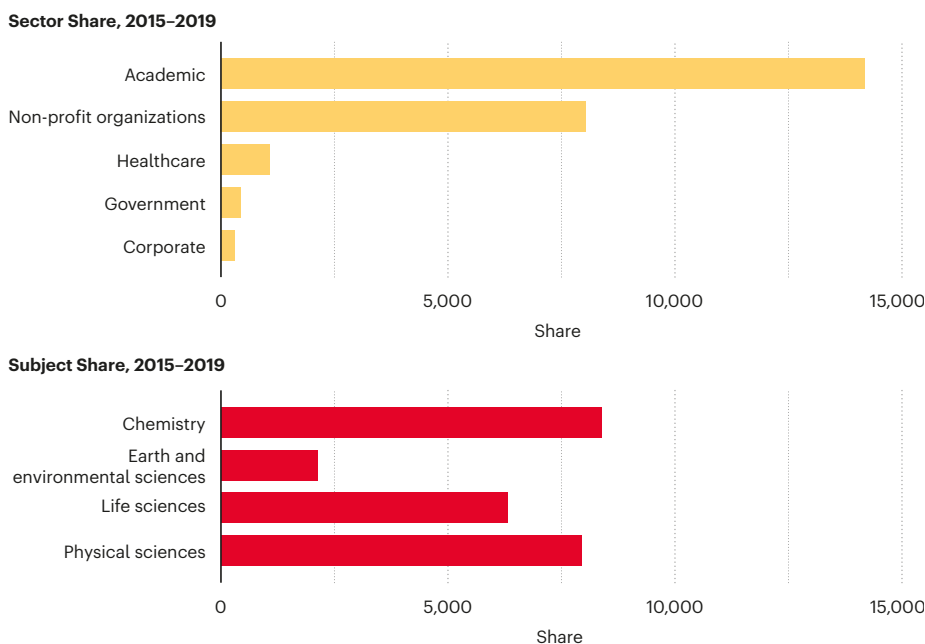
Wikelski says the idea was turned down by decision-makers at NASA when he pitched it in 2003, but he was met with interest by the German Aerospace Center, a member of the Helmholtz Association. NASA has since expressed interest in collaborating, Wikelski says.

It’s a reflection of German science that flagship projects such as ICARUS and MOSAiC take place at non-university institutions such as the Max Planck Society and Helmholtz Association, according to Wilhelm Krull, the founding director of The New Institute, a scientist-run think tank in Hamburg, and former secretary general of the Volkswagen Foundation, the largest private research funder in Germany.

The non-university research institutions, primarily financed by the federal government, have profited “enormously” from consistent budget increases over the past 15 years, says

GERMANY'S SHARE BY SECTOR AND SUBJECT

In Germany, the gap in Share between the academic and non-profit sectors is much narrower than in comparable countries including the United States and China where the academic sector out-performs all other sectors. Chemistry was the only subject for which Germany’s Share increased in absolute terms between 2015 and 2019.



Krull. But in the universities, he says, which are primarily funded by the states, funding has failed to keep up with the cost of educating growing numbers of students and maintaining ageing infrastructure.

In 2019, Germany’s three most prolific institutions in the Nature Index, the Max Planck Society, Helmholtz Association and Leibniz Association, had a total Share of 1,449.97. These publicly funded, large-scale non-university organizations encompass multiple institutions that contribute to their considerable research output. By comparison, the country’s three most prolific universities, Ludwig Maximilians University of Munich (LMU), the Technical University of Munich (TMU), and Heidelberg University, ranked 4th, 5th and 6th in Nature Index’s top 50 institutions in Germany, had a total Share of 476.6.

Increasing pressure

Universities in some states have sustained cuts to their core budget. Some have been partly compensated by an increase in external funding, but not without consequences. Krull says there has been a “radical shift” towards competition for project-based funding and short-term grants, which has weakened the capacity of universities to autonomously define their research agenda. A shift towards short-term funding places pressure on young researchers, says Jule Specht, a psychology professor at the Humboldt University of Berlin, as

the opportunities for professorships wane. “Researchers need to stay flexible until about age 40, which complicates starting a family, especially for female researchers,” says Specht. In 2017, the DFG stated that 22% of professors (not counting junior professors) in Germany were women, as were just 35.4% of scientific staff at non-academic research facilities in 2015 – the second-lowest figure in the European Union after France, *Nature* reported in 2019.

Competition for external funding also threatens to erode the relatively uniform performance and reputation of its academic institutions. Uwe Cantner, chairperson of the government-appointed Commission of Experts for Research and Innovation, based in Berlin, says this uniformity has precluded more German universities from joining the international elite. In an effort to boost the performance of academic institutions and thereby attract international talent, the federal government launched the Excellence Initiative (now the Excellence Strategy) in 2005. Three categories receive funding under the Excellence Strategy: Universities of Excellence, Clusters of Excellence (see page S116) and Graduate Schools.

Critics are concerned, however, that the strategy introduces inequalities. “The apprehension is that a ‘closed shop’ of a few top universities will be created,” says Cantner.

Hristio Boytchev is journalist based in Berlin.