

Russian science: the quest for reform

After three decades of scientific stagnation in the world's largest country, some researchers are seeing signs of revival. **By Quirin Schiermeier**

In the twilight of a winter's afternoon on the outskirts of Moscow, a disc-shaped building stands out against dreary tower blocks and largely vacant car parks. This avant-garde architecture – called simply the Disk – hosts the Skolkovo Institute of Science and Technology (Skoltech), a private research centre founded in 2011. Inside its curved, gleaming halls, physicist Denis Kurlov describes how the centre attracted him back to Russia, more than seven years after he left his native country to work abroad.

When Kurlov moved to the Netherlands, he thought he wouldn't come back. "I didn't see any place in Russia where I would be able to do research in a stimulating environment and have enough money to make a living." But circumstances have brightened, Kurlov says.

When he visited Skoltech's quantum centre in 2013, Kurlov was surprised to find a modern lab much better equipped than anything he had encountered in his student years in the Russian city of St Petersburg. Last autumn, he joined the centre as a staff scientist working on simulations of quantum effects in ultracold atomic gases. "Something is happening here," he says.

Kurlov isn't the only scientist sensing change in Russia. After the collapse of the Soviet Union in 1991, Russia's economy plummeted and tens of thousands of scientists moved abroad or abandoned their careers. The country hasn't managed to recover its former levels of science funding (after adjusting for inflation) and its researcher workforce has fallen by one-third, although it remains the world's fifth-largest (see 'Russian science by the numbers').





President Vladimir Putin shakes a robot's hand at a telecommunications company in Perm, Russia.

But over the past decade, Russian President Vladimir Putin has been promising to reform his country's languishing science system to make it more competitive and attractive to foreign talent.

In 2018, Putin approved a national research strategy that stretches to 2024. It calls for more money, extra support for early-career scientists, and some 900 new laboratories, including at least 15 world-class research centres with a focus on mathematics, genomics, materials research and robotics. Last year, the government completed a sweeping evaluation of scientific performance at its universities and institutes; it has vowed to modernize equipment in the 300 institutes that made the top quartile. And it says it wants to strengthen previously neglected areas, including climate and environmental research (see 'Russia's climate-science ambitions').

The reality on the ground is mixed. There are patches of promise in some research sectors, but much of Russia's science remains poorly funded and little-cited; this year, hundreds of Russian-language papers have been retracted because of plagiarism. Researchers still complain about bureaucracy and political interference, and some Russians working abroad say they couldn't contemplate returning to a country that cannot guarantee its scientists safety and freedom of expression. "I would not want to live and do science in a country where there is continuing government repression of civil society," says Fyodor Kondrashov, a biologist at the Institute of Science and Technology Austria in Klosterneuburg.

But many scientists in Russia do feel the culture is changing for the better, says polymer physicist Alexei Khokhlov, who is a vice-president of the Russian Academy of Sciences (RAS) in Moscow. Academic salaries have risen, and merit-based competition is replacing academic networks built on insider relationships, he says. "Many research positions in Russia were in the past occupied by people who produced little, if any, real science. Now institutes must think about hiring people who will attract grants and write good papers."

The best and the rest

Kurlov and other researchers at Skoltech are set to benefit from a slew of national technology initiatives in the making, including a 5-year, 50-billion rouble (US\$790-million) quantum research programme announced last December. Russia is also building large research facilities, including synchrotron light sources in Moscow and Novosibirsk and an ion collider in Dubna.

Another important development was the 2014 establishment of the Russian Science Foundation (RSF) in Moscow. It is the country's first government-funded agency to award grants only on the basis of competitive, independent peer review – an effort to avoid the

ALEXEI DRUZHININ/TASS VIA GETTY

Feature

cronyism that has dogged Russian science, with much money being given directly to institutes by government ministries.

The RSF has been tasked with improving the quality of Russian science and is developing guidelines for dealing with suspected misconduct as well as for good scientific practice. This includes sensitive areas such as gene editing, for which Russia has attracted worldwide attention. Last year, Moscow molecular biologist Denis Rebrikov sparked concern when he told *Nature* he wanted to alter genes in human embryos with the aim of producing gene-edited babies. The RSF does not support that, says its director Alexander Khulunov, although he doesn't rule out funding "ethically responsible" work involving gene editing in humans in future.

The RSF's budget is small: at 21 billion roubles this year, an order of magnitude less than that of comparable agencies in Germany or the United States. But by getting overseas scientists to review project proposals and striking bilateral agreements with funders in Germany, Japan, India and other countries, the RSF is boosting the quality of its research, says Khulunov.

One beneficiary of this is physicist Alexander Rodin, whose studies on the composition of the Martian atmosphere are funded

"If we refuse to compete in space, we refuse to be Russian."

by the RSF and the German research-funding agency, DFG. He became a group leader at the Moscow Institute of Science and Technology (MIPT) in 2016. "It was always my dream to start my own lab in Russia," he says. A laser spectrometer he developed will be used in a Mars lander that is set to launch in 2022 as part of the ExoMars programme, which Russia is conducting jointly with the European Space Agency. Rodin says that taking part in international space programmes is crucial for Russia's identity as a leading space-research nation. "If we refuse to compete in space, we refuse to be Russian," he says.

Rodin and Kurlov's facilities, however, are unusually well supported in a country where investment in research and development (R&D) is still extremely low. For two decades, R&D spending has hovered at around 1% of gross domestic product (GDP), a proportion much smaller than that of other large science nations. In 2012, Putin set a target for spending to reach 1.77% of GDP by 2018 – but that didn't happen. Nor did another Putin target: that by 2020, Russia should have 5 universities in the world's top 100. (It has none.) Current spending plans – if the government follows them – are projected to increase R&D investment only to 1.2% of GDP by 2024, noted an audit of the science sector published this February by the



The Skolkovo Institute of Science and Technology (Skoltech) near Moscow, known as the Disk.

country's accounts chamber, a parliamentary body that scrutinizes federal finances.

The auditors also pointed out that the bulk of Russia's total R&D – counting industrial and academic work – is still financed by the state, unlike in most leading science nations, where private companies finance the majority of research. Russian industry's neglect of R&D is a persistent problem, agrees Grigory Trubnikov, a deputy minister in the Russian ministry for science and higher education. Skoltech is supposed to help improve this – technology firms that move into a science park developing around the institute will enjoy tax incentives and government subsidies. So far, however, this hasn't led to a major boost in commercial innovation, says Sergei Guriev, an economist at Sciences Po in Paris, who left Russia in 2013.

Papers, please

One of Putin's targets seems to have borne fruit. After Russia's scientific output barely rose for two decades, Putin said that its scientists had to be more productive on the global stage. Universities began offering scientists bonuses depending on papers they'd published in international databases, says Khokhlov, the RAS vice-president. The number of such papers with Russian authors subsequently leapt, more than doubling between 2012 and 2018. In December last year, the US National Science Foundation recorded that, in the past decade, Russia has risen from 14th to 7th position in the list of the world's largest-producing science regions, as measured by publication output.

A closer analysis suggests the story is more complicated. The figures stem, in part, from decisions by international databases to start indexing more local Russian journals, making it unclear how much more work scientists are producing. And although Russia's scholarly impact measured by citations is slowly rising,

it remains far below the world's average.

This January, a publishing scandal made international headlines. The RAS announced that its Commission for Countering the Falsification of Scientific Research had revealed widespread plagiarism in papers in Russian-language journals. More than 800 were retracted, in fields covering the humanities, social sciences, medicine and agriculture, with further retractions likely to follow as the investigation continues. "We are getting serious about tackling this problem," says Khokhlov.

The papers involved were in journals that aren't indexed by international databases and don't contribute to counts of national output, so were not the type of work that Putin's target aimed to increase. Still, pressure on Russian scientists to publish more papers to advance their careers might entice misbehaviour, says Mikhail Gelfand, a bioinformatician at the Skoltech Center of Life Sciences, who was involved in the investigation. "Retracting plagiarized papers and shaming the worst offenders is exactly the right thing to do," he says.

International friction

Another feature of Russia's science record is that its international collaboration rates have dropped sharply over the past decade. In part, that's because the surge in manuscripts with solely domestic authors has outpaced a small rise in international work. But it also points to political tensions. Russia's annexation of the Crimean peninsula in 2014 dented foreign science relations – particularly those with the United States. Scientists from the two countries collaborate, but official US–Russian science ties have been suspended since 2014, apart from a cooperation agreement signed last year between the RAS and the US National Academies.

Scientists will simply have to live with these realities, says Glenn Schweitzer, a

science-diplomacy scholar with the US National Academies. "The value of long-term US–Russian cooperation on global problems is clear," he says. "But science exchanges will continue to be turned off as one country develops policies that conflict with interests of the other." Schweitzer says he's hopeful the impasse will be temporary, because Russia and the United States did maintain research exchanges during past political conflicts such as the cold war.

Still, Russia is involved in large international research collaborations, including the International Space Station; Europe's particle-physics laboratory CERN, near Geneva in Switzerland; the international fusion reactor project ITER in France; and in Germany, the European X-ray Free-Electron Laser near Hamburg and the Facility for Antiproton and Ion Research (FAIR), under construction in Darmstadt.

Germany in particular is a key scientific partner for Russia, with almost 300 joint research projects currently under way. Collaborations include research in the geostrategically important Arctic. An ongoing project called MOSAiC (Multidisciplinary Drifting Observatory for the Study of Arctic Climate) – a one-year Arctic research mission involving 300 scientists on board a German research ship locked in sea ice – relies heavily on logistical support from Russian supply vessels, for example.

Red tape and interference

As far back as 2010, Russia's government launched a programme to entice leading overseas researchers to visit. So far, 272 scientists from 31 countries – 149 foreign scientists and 123 émigré Russian researchers – have received 'mega-grants' to set up labs in Russia. The programme could have done more for Russian science had the attached bureaucracy been less excessive, says Gerry Melino, a Italian cancer biologist at the UK Medical Research Council's Toxicology Unit in Cambridge, who received a \$4.9-million grant in 2010 to set up a cytology lab at the Saint Petersburg State Institute of Technology. He spent about three months each year there until the grant ended in 2016.

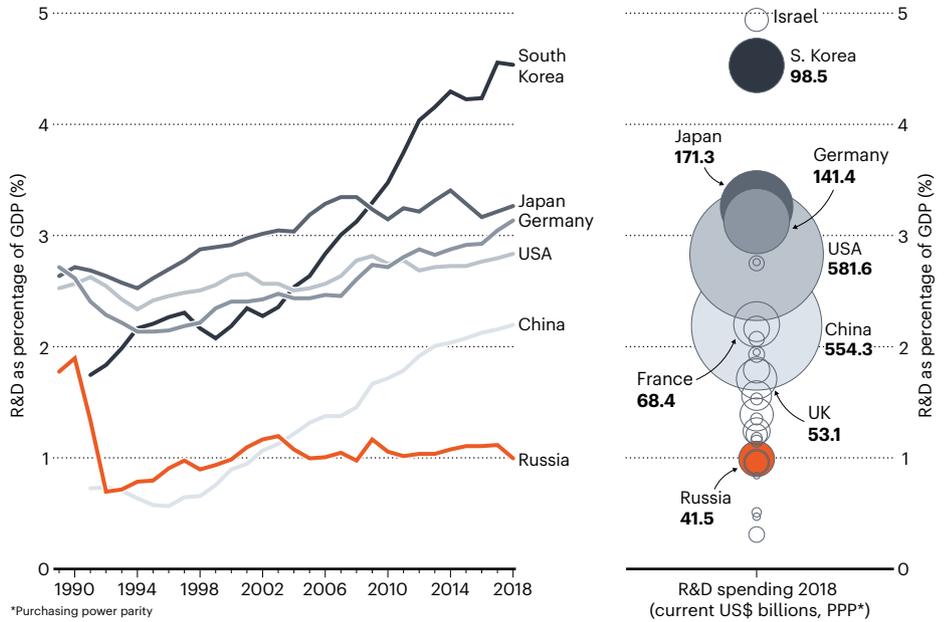
The students were excellent, Melino says, but local administrators in charge of signing off purchases and promotions were a pain. "How can the system change if you give the money to people who know little or nothing about modern science?" The system is particularly difficult for outside researchers to navigate. "It's almost impossible for foreigners who don't speak the language and don't know the mentality to understand Russian bureaucracy," Melino says.

Buying lab equipment and reagents from foreign suppliers remains a problem, even for scientists who are Russian. "If I work outside our homeland, I get the reagent I need tomorrow," Olga Dontsova, a biochemist at Lomonosov Moscow State University told Putin at a 2018 meeting. "In our country, I have to wait at

RUSSIAN SCIENCE BY THE NUMBERS

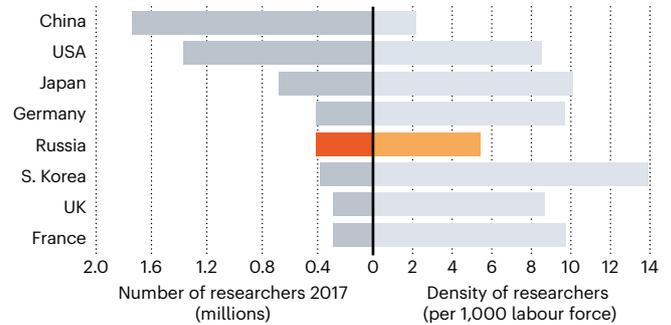
Spending

Russia is in the world's top ten nations in terms of spending on research and development (R&D), when investments are adjusted for 'purchasing power', which reflects differences in local wages and costs. But it invests only slightly more than 1% of its gross domestic product (GDP) on R&D: a figure that hasn't shifted much in two decades and trails other large science nations.



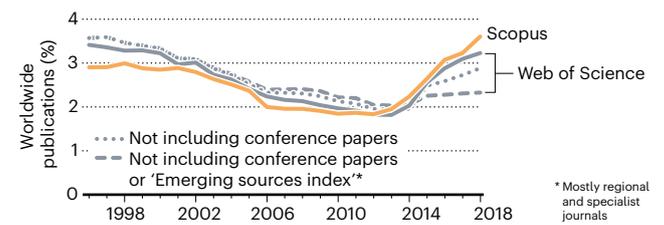
Science workforce

Russia has almost as many scientists as Germany. But it trails other large nations in terms of the density of its scientific workforce.



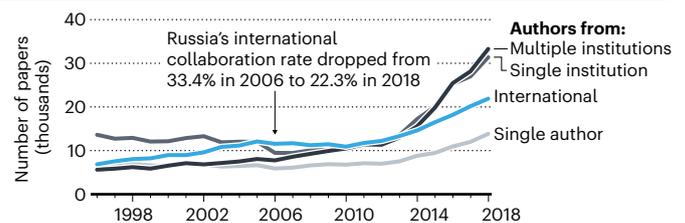
Publication surge

Russia's share of the articles that appear in international indexes seems to have surged since 2012, when President Vladimir Putin ordered an increase. The extent of the surge depends on which types of paper are counted, however.



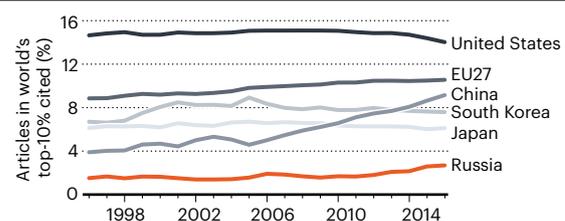
Collaboration dropping

Numbers of papers written solely by Russians have risen faster than those including international co-authors, and the country's international collaboration rates have gone down.



Low impact

Papers with Russian authors are much less likely than those of other large science nations to be among the world's most-cited articles.



RUSSIA'S CLIMATE-SCIENCE AMBITIONS

A warming Arctic is spurring Russian interest in climate research — and not just for scientific gain.

After decades of being closed off, Russia is finally opening up to environmental and climate researchers from other countries. At least, that's the government's plan; Igor Ganshin, head of international cooperation in the Russian science ministry, points to several projects that promise more collaboration. A planned Russian–German climate-research programme, he says, is in its early stages but should help to spur joint research on topics such as Arctic permafrost melting and carbon transport around Siberia's rivers and forests. Russia also plans to set up a year-round international research platform on the remote Yamal peninsula in northwestern Siberia. A luxurious US\$12-million station called Snezhinka ('snowflake'), designed by engineers at the Moscow Institute of Physics and Technology and powered by carbon-free hydrogen energy, will open to researchers worldwide in 2022.

Climate and environmental research in the rapidly warming Arctic is a cornerstone of the country's science strategy. Next year, Russia will chair the Arctic Council, an intergovernmental forum promoting collaboration among eight nations that have territory in the Arctic. Russia will aim to speed up implementation of an agreement to enhance international research in the Arctic, says Ganshin.

But Russian Arctic-research activities go beyond environmental science. They are also driven by military and economic interest in the region's rich mineral resources. In January, Prime Minister Mikhail Mishustin unveiled a multi-billion-ruble package, including

generous tax incentives, for exploration and development of untapped oil and natural-gas resources in the Russian Arctic.

Russia's economy depends heavily on fossil fuels, and hasn't yet experienced the climate protests seen in other parts of the world. There is even a sense that warming might benefit the country: a national climate adaptation plan adopted in December last year aims to mitigate the harmful effects of climate change, but also highlights the advantages that warming might have in areas such as energy use, agriculture and navigation in the Arctic Ocean.

Russia has signed the Paris climate agreement, which aims to limit global warming to well below 2°C above pre-industrial temperatures. But the Climate Action Tracker, a consortium of scientists and policy specialists, has judged the country's current policies as "critically insufficient" to contribute a fair share to the 2°C target.

As heatwaves and wild fires have become more common, it is dawning on policymakers and the public that global warming will have an effect in Russia, too, says Anna Romanovskaya, director of the Institute of Global Climate and Ecology in Moscow. Scientists there helped to develop a strategy for low-carbon economic development, which the Russian government is expected to adopt this year, she says.

"The wrong view, orchestrated by the Russian coal and gas industry, that the Paris agreement will kill our economy is losing its appeal," insists Romanovskaya, who is also a member of Russia's negotiating team in international climate talks.

least three months and pay two or three times more. This is a problem that is forcing young people to prefer to work abroad."

After that discussion, the government reduced the paperwork required for importing lab materials. Common reagents and plastics are now available from Russian delivery companies, but the supply of chemicals that are produced only in the United States or the European Union is still a problem, says Dontsova.

"We still have to wait up to four months until certain antibodies and cell cultures are delivered from abroad," she says. Also, she says, Russian scientists must get advance permission to exchange experimental samples with collaborators outside the country.

Researchers are also worried about political interference. International non-governmental organizations, including conservation and HIV-prevention groups, have been blocked from working in Russia if they receive foreign funding. And in 2015, a private science funder called the Dynasty Foundation, based in Moscow, was closed after the Russian ministry of justice labelled it an undesired 'foreign agent'.

Late last year, leading scientists with the RAS condemned a police operation at the Lebedev Physical Institute, one of Russia's leading physics centres. In October, heavily armed police stormed the facility and charged its director, Nikolai Kolachevsky, with assisting in the illegal transfer of items to Germany — specifically, a pair of glass windows allegedly for military use, which had been made by one of the institute's spin-off companies. The police later dropped criminal charges but are still investigating the case, says Kolachevsky. He rejects accusations of smuggling or other wrongdoing. "It is very unhelpful for a research institute to be described as a place of contraband when my task is to attract young talent," he says.

There are signs that the government is starting to listen to criticism. The country's science minister, Valery Falkov — who took office last month — began his tenure by scrapping a much-criticized 2019 order that had obliged Russian scientists to get official approval for foreign researchers to visit their institutes. Falkov's deputy in the science and education ministry, Trubnikov, insists that the tide is turning. "We want to be an open and reliable international science partner with transparent rules," he says.

Conditions for researchers are improving, but the pace of change is too slow, says Kolachevsky. After years of neglect, Russia has lost a generation of scientists. The Lebedev Physical Institute, he says, has an ageing research staff and a paucity of mid-career scientists, and he now needs to develop new leaders from young PhD students. "Too little has happened for too long," he says.

Quirin Schiermeier is a senior reporter for *Nature* based in Munich, Germany.



A Russian icebreaker (right) brings supplies to a German research vessel in the Arctic.