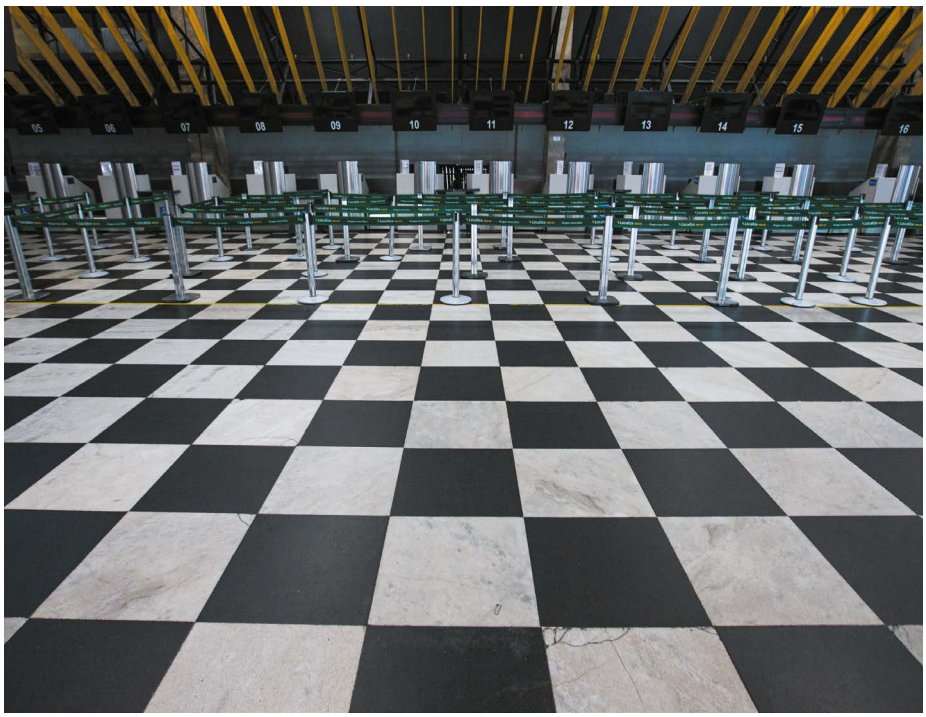

ALEXANDRE SCHNEIDER/GETTY

**Travel restrictions could encourage scientists to take fewer flights in the future.**

# SCIENTISTS' WORLDS WILL SHRINK IN THE WAKE OF THE OUTBREAK

## Research has the potential to be greener and more democratized.

In mid-March, Nancy Reid was settling into a sabbatical in Australia when Canadian Prime Minister Justin Trudeau called on all Canadians to come home. Within days, Reid was on a flight back to Toronto, cutting short a three-month stint meant to deepen collaborations with mathematicians in Australia. "We left with heavy hearts," says Reid, a statistician at the University of Toronto.

Reid and nine other researchers, all visiting Australia through a programme funded by the Sydney Mathematical Research Institute at the University of Sydney, flew home as borders began closing. Of the 50 planned visits by researchers to the institute, 30 have been postponed or cancelled. Reid says that opportunities for her to take sabbaticals come around only once every half a dozen years. "It could be a while before any of us take short hops to faraway places."

The pandemic has forced researchers to grapple with how restrictions on their movement will affect the way science is conducted. Some fear that these limitations could lead to a world that favours elite scientists and established teams with less need to network, while others lose collaborators and become marginalized, and fieldwork becomes a luxury. Or, the opposite could turn out to be true: travel restrictions could help to democratize science, if virtual working allows access to more connections for people who cannot easily travel. Many researchers will have to reimagine their projects in a world where travel is limited.

### Elite club

The pandemic might already be closing off some collaborations. Caroline Wagner, a science and policy researcher at the Ohio State University in Columbus, has compared coronavirus-related publications in the two years before December 2019 with peer-reviewed papers and preprints on the same topic posted between January and April 2020.

Wagner found that, since the outbreak, research teams — measured by the number of authors on a paper — have become slightly smaller and involve fewer nations. Co-authorship links between China and other scientifically dominant countries have strengthened, whereas participation from developing countries has dropped off, which Wagner says suggests that researchers are working with those with whom they already have strong, established connections. She posted her team's results as a preprint on the social-sciences repository SSRN on 8 May (C. V. Fry *et al*. preprint at http://doi.org/10.2139/ssrn.3595455; 2020).

International collaborations can enrich research and enhance creativity — but they take time to establish, says Wagner. "If you're working on a crisis timescale, then the transaction costs of adding new, additional people is not going to be worth the price in time."

If existing collaborations with developing-country scientists are faltering, then new ones could slow to a trickle, even in areas outside coronavirus science, says Wagner. The majority of relationships start with an in-person meeting, she says. "If people can't work side by side for short periods of time, it's going to dramatically cut international collaboration." Early-career researchers who haven't had the opportunity to make those interpersonal connections will be hit hard, says Richard Woolley, a sociologist at Ingenio (CSIC-UPV), Polytechnic University of Valencia, Spain.

Geographically remote countries such as Australia are also exposed because of their highly international scientific workforce, says Keith Jones, a reproductive biologist at the University of Adelaide. Data from the Australian government show that around 35% of Australia's more than 65,000 PhD and master's students are from overseas; a report by the Australian Academy of Science published on 8 May (see go.nature.com/2u2dznj) estimates that some 9,000 international students will not resume their research in the country this year owing to financial constraints or travel restrictions resulting from the pandemic.

Such shifts can have long-term implications, says Cassidy Sugimoto, an information scientist at Indiana University Bloomington. "As soon as you start down a research path and get into a pattern of collaborations, it takes a long time to turn that ship around."

At least in the short term, some researchers will have to change the questions they ask and the projects they work on in a movement-restricted world. As a programme director for the US National Science Foundation, Sugimoto says she has to consider how the research can be done without travelling. "What happens if anthropologists can no longer go to their site? Do we still fund the research?"

Sebastien Kenmoe, a virologist at the Pasteur Centre in Cameroon in Yaoundé, leads a study on febrile illness in sub-Saharan Africa. He had to cancel a trip to the Central African Republic, and is instead developing ways to monitor outbreaks, including those of coronavirus, remotely.

But for some disciplines there are no substitutes for international mobility. Since the pandemic, Jonah Choiniere, a palaeontologist at the University of the Witwatersrand, Johannesburg, has had to cancel several trips, including ones to the United Kingdom, the United States and Zimbabwe. Without access to fossils in other countries, he plans to redouble efforts to collect data from universities and museums in South Africa. But it is a partial fix. "I can't really completely function without international travel – it's the backbone of my research," he says.

Many researchers expect that travel for fieldwork will not be affected in the long term. But Choiniere says that the travel freeze – even if it doesn't last – will affect his productivity two years from now, when the data from his cancelled trips would have been processed. And Sugimoto says that institutions should account for the greater impact of the pandemic on researchers in travel-dependent disciplines when considering whom to promote.

### Virtuous science

But travel restrictions could also help to democratize research, says Choiniere. "Platforms like Zoom talks and virtual scientific meetings level the playing field because they are inexpensive and non-exclusive, and they can result in collaborations quite quickly."

Last week, when one of his PhD students presented an online lecture about her work on the dinosaur *Massospondylus*, an attendee based in Argentina contacted Choiniere asking to collaborate on projects during lockdown and to pursue more ideas after it ends.

Researchers should consider ways to share data without requiring a physical presence, says Sugimoto. This could help to improve access – both during and after the pandemic – to resources for people who are less mobile because of care responsibilities or disabilities. Fewer flights could make research greener, too. Grounded researchers might begin to re-evaluate their work trips, says Woolley, who used to fly every two weeks. The research community has long grumbled about the climate impact of scientific travel, he says. "COVID-19 has brought an existential health threat into that mix."

Some travel is necessary for knowledge production, but a lot of it isn't, he says. "Conducting science responsibly should mean doing your best to reduce greenhouse-gas emissions and not contributing to the spread of a pandemic."

Researchers might well approach travel with more thought after the pandemic. And that's no bad thing, says Reid. "It seems unlikely to me that we will be as carefree about travel as we have been in the past."

**Smriti Mallapaty** is a senior reporter with *Nature* in Sydney, Australia.

# CHINA'S RACE TO THE TOP HITS A SPEED BUMP

## The country is rapidly gaining on the United States in research, but problems threaten to slow its rise.

When COVID-19 hit, China was close to surpassing the United States as the leading science funder, two years after it took top place as the biggest producer of scientific articles. And the country has boosted science around the world by supplying other regions with graduate students and postdoctoral scholars, who now number in the hundreds of thousands a year.

The pandemic could slow that momentum by shrinking funding for scientific research in China and severely squeezing the pipeline of Chinese students to other countries. And in the United States, researchers fear that the pandemic will exacerbate growing tensions stoked by anti-China rhetoric from President Donald Trump and his administration. This conflict has driven a wedge between the two countries, hampered some collaborations and made the United States less attractive to Chinese students and investigators. At the same time, however, researchers say the pandemic has led many to embrace virtual communication options, and these could enhance international science ties over the long term.

Like all countries, China is facing severe economic losses from the pandemic, and that will certainly have a negative impact on scientific research, because funding will be reduced and projects will be delayed, says physicist Wang Yifang, director of the Institute of High Energy Physics in Beijing. Some universities have already announced a cut in funding. The research budget given by the education ministry to Jiangnan University in Wuxi, for example, will drop by more than 25% for 2020, and other universities are facing similar reductions. "An overall budget cutting of government spending on higher education is highly possible, though the level and scope may vary by regions, universities and fields," says Tang Li, a science-policy scientist at Fudan University in Shanghai.

> **"This is a very positive development, and more companies may follow suit."**

Universities in the United States are particularly vulnerable to a drop in the number of students from China (see 'Student surge'). Chinese students account for one-third of the nation's one-million-plus international students at undergraduate and graduate levels, and in 2018, they contributed close to US$15 billion to the US economy, according to the Institute of International Education in New York. According to a survey by the institute, nearly 90% of US universities expect a drop

### STUDENT SURGE

Universities in the United States have seen a rapid rise in the number of students from China.