



RESTLESS MINDS

Analysis of a vast set of public CVs reveals the world's most migratory scientists

By John Bohannon

Scientists are migratory beasts. It's just the nature of the job: You spend your days at the border of human knowledge. Depending on the topic, only a dozen people may deeply understand your research—let alone help you push it further—and they are scattered across the world. For many, completing a Ph.D., doing postdoctoral research, and landing a permanent job all in one country

is impossible. And so you wander.

Consider Rimantas Kodzius, possibly the most migratory scientist alive. Since leaving his home country of Lithuania in 1995 for graduate school in Austria, Kodzius, 42, has crossed 10 national borders. “I arrived in China just a week ago,” the synthetic biologist wrote in an email in March. “My home is wherever I work, where I live.”

Kodzius has built an impressive career, including prestigious research positions in

Germany, Japan, Sweden, and Saudi Arabia, where he started a biotech company and held a faculty position at King Abdulah University of Science and Technology in Thuwal. But last year he was invited to lead a well-funded new lab at Shanghai University in China. He couldn't resist, he says: “Life without activity and adventures is not fulfilling.”

Social scientists are eager to study the wanderings of nomads like Kodzius to understand how the global scientific enterprise is evolving. You might expect that to be an easy task, because scientists log and publish every milestone of their research. But the lives of the scientists themselves are outside the frame. Surveys and government reports yield some information, but no data set comprehensively tracks scientific migration worldwide. And surveys keep people's identifying information confidential, so individual migrations are impossible to track.

To find Kodzius and his fellow globe-trotters, *Science* analyzed data from a new source: ORCID, the nonprofit organization that assigns unique identity codes to researchers (<http://scim.ag/ORCIDid>). ORCID wasn't designed for that purpose, but its database of 3 million scientists—by far the largest public data set of academic CVs ever released—may become a vital tool for charting their flow around the world.

ORCID “is a big step forward,” says Paula



Genome scientist Rimantas Kodzius is one of the most migratory scientists alive. He has worked in 10 countries, most recently Saudi Arabia (pictured here).

Stephan, an economist at Georgia State University in Atlanta. She led a global email-based survey of scientific mobility—the largest ever at 17,000 people—published in *Nature Biotechnology* in 2012. However, she cautions that ORCID is an incomplete and biased sample of the world's scientists (see sidebar, right). Until researchers account for those quirks, or enough scientists fill out their ORCID profiles, it can't be relied on as a definitive picture of scientific migration. Even so, it reveals some surprising patterns and highlights individual stories, like Kodzius's, that otherwise would have remained hidden.

Even the basics about the global scientific workforce are surprisingly hard to nail down. Many countries do share data about their scientists, and the United Nations pulls those streams together into semi-annual reports on global science. As of 2015, the global head count comes to 8 million scientists. One in five is in an EU country, and 17% and 19% are in the United States and China, respectively.

How many of each country's research workforce are immigrants? In the United States, more than a third of doctoral degrees in the sciences and engineering are awarded to foreigners on temporary visas, according to a report last year by the National Science Foundation. But after the Ph.D., that data trail goes cold, Stephan says.

The global picture of migration has been

even more elusive. Building it requires information about all scientists around the world year after year. Yet that's just what ORCID could eventually offer.

ORCID's original purpose was simply to help scientists with common names—such as Michael Roberts or Wei Wang—get credit for all their publications by giving them unique identity codes, says Laurel Haak, ORCID's executive director, who is based in Bethesda, Maryland. The organization maintains a website through which users can add information to their profile, including education and employment history. Since its launch in 2012, the number of ORCID profiles has grown explosively. So far, 741,867 of the 3 million ORCID users have chosen to use their online profile as a public CV that chronicles their education and work history, and spans up to several decades for the most senior researchers.

Tracing ORCID users' countries of residence over time makes it possible to retrospectively trace each person's migration pattern. Supermigrators like Kodzius stand out in the data. (See the cover of this issue for a map of the paths that Kodzius and other globe-trotters have taken.) With roughly 10% of the world's scientists geographically tracked in ORCID, interesting patterns emerge that no other data set can capture.

For example, the data suggest that about 30% of the scientists who got their Ph.D. in the United Kingdom now live elsewhere, whereas the same is true for only about 15% of scientists who received their Ph.D.s in other EU countries (see graphic, p. 692).

The data also suggest an effect of the 11 September 2001 terrorist attacks: a slump in the migration of foreign scientists to the United States. Overall, the ORCID data show that the number of foreign researchers studying or working in the United States has grown smoothly since 1990, because the global pool of ORCID researchers has grown steadily. But there's one glaring exception: The number of foreign researchers immigrating to the United States plateaus in 2002. Further analysis reveals that the annual rate of immigration to the United States dropped by about 15% and did not recover until 2008 (see graphic, p. 692). Was that slump due to post-9/11 chaos in U.S. immigration and tougher visa requirements? If so, that could be one of the attack's longest-lasting costs: thousands of the most highly skilled workers avoiding the United States for years.

Causation will be hard to pin down, however, says Kirk Doran, an economist at the University of Notre Dame in South Bend, Indiana. In addition to global economic forces that cause labor markets to ebb and

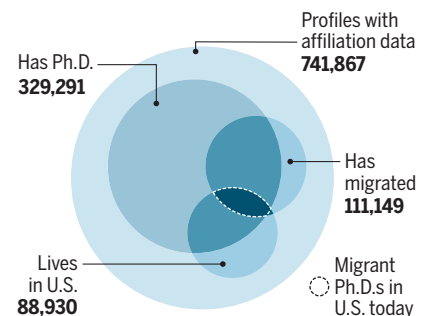
Introducing ORCID

ORCID wasn't intended as a massive longitudinal survey of human migration, but with 3 million profiles and growing, it is becoming just that. So far, 25% of the world's researchers have added personal information to their public ORCID profiles, including the years, locations, and descriptions of their education and employment.

This data set has biases. ORCID users skew young, and certain countries are over- and underrepresented. The raw data sets are available at <http://scim.ag/2pO820I>.

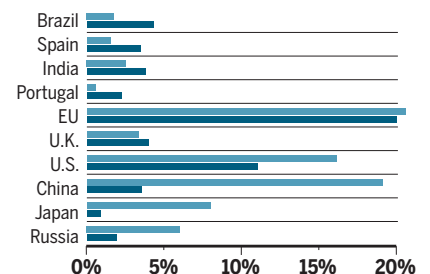
Revealing subsets

ORCID users voluntarily have created a giant and growing database.



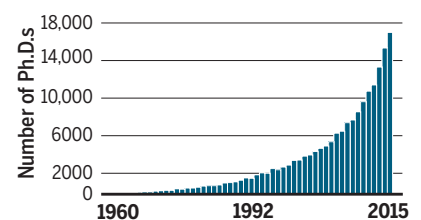
Quirky sampling

ORCID is not a random sample of the world's scientists. Countries are not equally represented, as revealed by a comparison with 2013 figures from the *UNESCO Science Report*.



Youthful picture

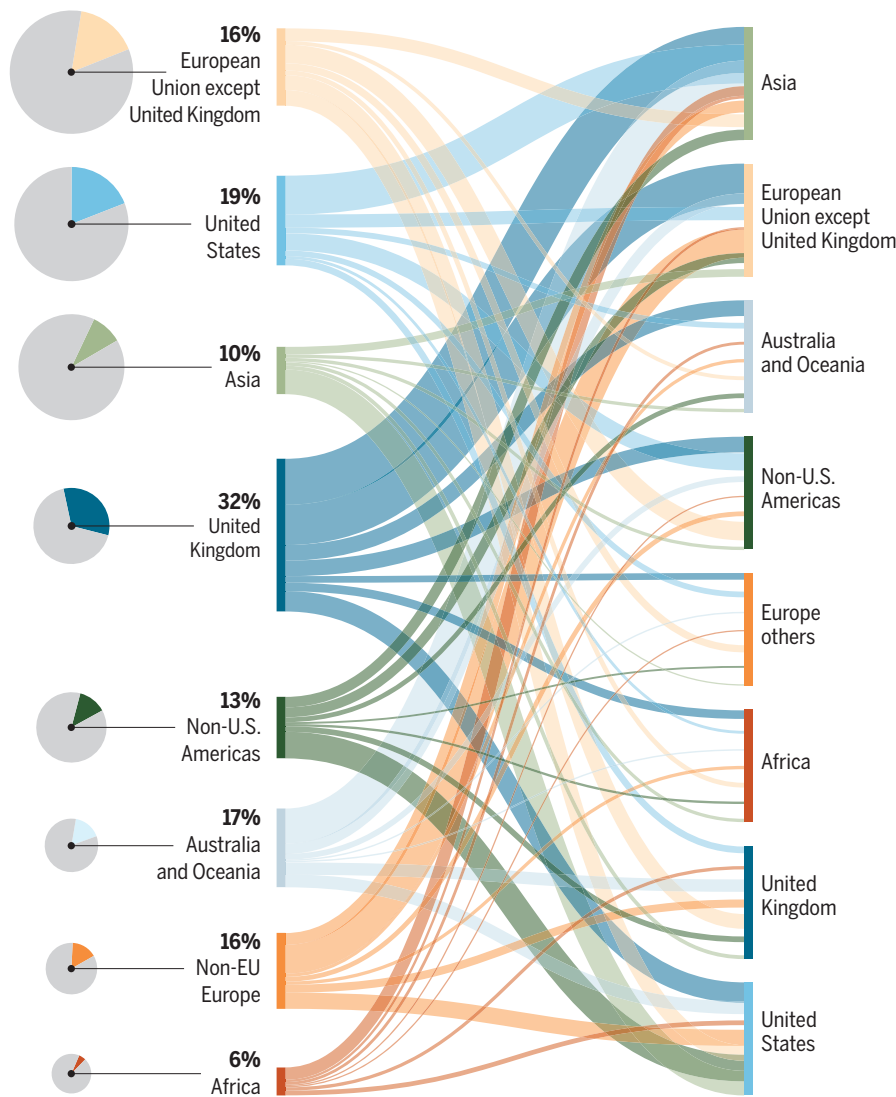
People with more recent Ph.D.s are overrepresented in the data set, reflecting its recent growth and the fact that younger researchers are signing up for ORCID more quickly than older ones.



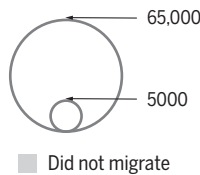
Scientific migrants: a view from ORCID

Although the data set overrepresents some EU countries and underrepresents China, *Science's* analysis reveals intriguing migration patterns. For example, about a third of those who earned their Ph.D. in the United Kingdom were living in another country by 2016. But only about 15% of Ph.D.s from other EU nations migrated away. Also, ORCID chronicles steady growth since 1990 in the number of foreign scientists immigrating to the United States (bottom). But in 2002, that annual influx stagnated, possibly because of the 2001 terrorist attacks.

Proportion of Ph.D.s migrating from...

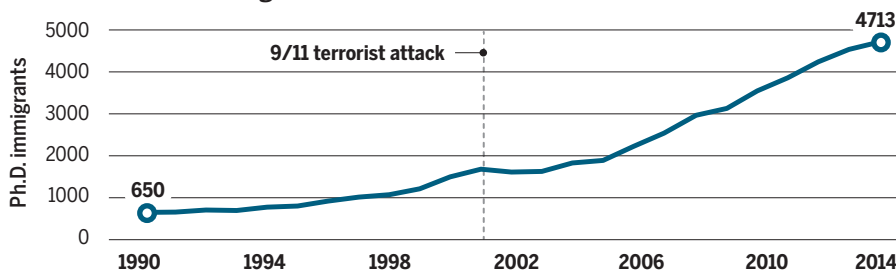


Number of people who earned Ph.D.



Residence in 2016

Annual scientific immigration to the United States



flow, ORCID itself “has many confounding factors,” he says. For example, Spain and Portugal are overrepresented in ORCID because their funding institutes require scientists to use the system. Also, the people most motivated to sign up with ORCID are academic researchers who publish, Stephan notes, whereas industry scientists may be largely missing. However, the ORCID data do reproduce many of the same broad patterns of scientific migration seen in the United Nations reports (see <http://scim.ag/2pO820I>).

As ORCID grows into a more comprehensive sample, policymakers will likely use it to track the impact of their efforts to entice research talent. Meanwhile, the data offer a unique glimpse into the migratory lives of the world’s knowledge producers.

Consider Danny van Noort, age 54, a biotechnology engineer who studied in Sweden and the Netherlands but is based in Singapore—for now. “After 4 months in Cambodia, I packed my bags again and went back to Sweden in 2014,” he recalls. “I got an offer from a former colleague to join him in Australia a few months later as a research fellow.” Each move offered a chance to push his research to a higher level by working with top experts or at cutting-edge facilities, he says. “I am ready to settle down somewhere nice, but my career doesn’t let me.”

Then there’s Delanyo Dovlo, a public health researcher for the World Health Organization (WHO) based in Brazzaville. “My first major migration was from Ghana to Namibia in 1999,” he says. By then, he had already studied in the United Kingdom and the United States. Then came “political interference” in Namibia, followed by “an opportunity to be well paid for once” at WHO. So he kept roving, migrating three more times between Europe and Africa.

The enticements—a bigger paycheck or access to top researchers—had better be good because there’s often a personal cost, Van Noort says. Migration “uproots you. It is a lonely existence, as friends are hard to come by and maintain. And there is no stability and security,” Kodzius echoes that sentiment: “I am still single,” he says bluntly.

Others see migrations as an end in themselves. “I only wish I could secure funding for more,” says Helena Pinheiro, 56, a biological engineer at the Superior Technical Institute in Lisbon, who has crossed national borders five times so far. “Living and working in another country ... makes you more humane and understanding, provides happiness in so many unsuspected ways.” Then again, she notes, “crossing borders has always left me with the wish that borders would cease to exist.” ■



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John Bohannon (May 18, 2017)

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Editor's Summary

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