As one door closes…

Immigration controls introduced under the 'war on terror' are restricting the flow of foreign researchers into the United States. With other countries moving in on this pool of talent, will the balance of scientific power shift?

Zhang is a fifth-year chemistry graduate student at the University of Wisconsin at Madison. He is hard-working, popular with his colleagues, and should be on the threshold of a rewarding future in science. Yet a 2002 visit to Zhang's native China nearly derailed that career. He is so scarred by the experience that he agreed to be interviewed only on condition that his real name was not used in this article.

Nature's reporters are used to Chinese scientists requesting anonymity before speaking openly on controversial issues. But Zhang is not worried about the attitude of the government in Beijing. Rather, he is wary of consular officers, FBI operatives and other officials of the US federal government who seem to regard him as a potential terrorist, rather than a valuable member of their country's scientific workforce.

Zhang's nightmare began in January 2002, when he left Madison to spend the Chinese New Year with his friends and family. Zhang knew that immigration controls had been tightened up since the terrorist attacks of the previous September, and sought advice from his university about how to avoid any problems getting back into the United States. He carried with him proof of enrolment, details of the courses he had taken, a letter from his department and government forms confirming his immigration status — which he assumed would allow him to get his student visa renewed. "I did all that I could have done," Zhang says.

But when he went to the nearest US consulate for an interview, Zhang was told he would have to wait. His particular field of study overlapped with a 'watch list' of technologies of potential interest to terrorists that had been supplied to consular officials. This meant that his application would have to undergo an interagency security review, involving security officials from agencies including the FBI and the Department of State.

> "People who were thinking about coming to the United States for graduate school are now thinking twice."

Days stretched into weeks, then months, with no news of progress with his application. Eventually, Zhang found himself working in the office of a shipping company to make ends meet, while his colleagues continued their research without him. Because he didn't know when he was going to return, he was forced to continue paying rent on his apartment in Madison. Zhang finally received his visa in September 2002, leaving him hopelessly behind with his PhD studies. "My whole plan for graduation has been postponed," he says.

Zhang is not an anomaly. "There have been enormous problems," says John Wright, who chairs the University of Wisconsin's chemistry department. Most of the students and postdocs whose applications to enter the United States have been questioned have eventually been let in. But Wright frets that the new immigration rules will deter future applications, weakening his department, which is currently considered among the best in the world. "The quality of research will decrease," he says.

Many US researchers and university officials share Wright's concerns. The United States is a nation of immigrants, and nowhere is this more evident than in the country's research labs. Strip away the legions of foreign PhD students, postdocs and tenure-track researchers, and the behemoth that is the US scientific enterprise would look much less impressive (see figure, overleaf). What's more, in recent years, other countries have realized the value of attracting the best of the world's young researchers, and have started taking steps to compete more effectively in this marketplace (see 'You're welcome', below).

So will the United States' draconian response to the terrorist threat cause a funda-

You're welcome

At this time of year, Britain and Australia could be on different planets. In London, Cambridge and Edinburgh, it's cold, dark and almost unremittingly wet; in Sydney, Melbourne and Perth, it's time to slap on the sunscreen and head for the beach.

But for many young scientists in Asia and elsewhere, these two countries have something important in common — they're among the most attractive destinations, now that delays in obtaining visas are restricting the flow of students and researchers into the United States.

Britain and Australia may be in the vanguard of the 'war on terror', but they don't share the US administration's view that foreign scientists should be viewed as potential terrorists. To government officials and university administrators alike, they're seen as valuable assets. This is especially true of fee-paying students, who bring a welcome influx of funding into the two countries' universities.

Australian universities have been particularly entrepreneurial in their efforts to attract students from Asia and the Indian subcontinent. "About five years ago, Australia wouldn't have entered the consciousness of Indian students looking to study abroad," says Rohan Arthur, an Indian PhD student who came to James Cook University in Townsville, northern Queensland, to study coral ecology. "But now it's a big option."

That's largely because of the efforts made by an organization called IDP Education Australia. It was established in 1969, primarily as an outreach programme to provide agricultural training for students from the developing world. Today, it has offices all over the world, which make strenuous efforts to attract students to Australian universities — IDP staff also assist visiting students in obtaining visas and accommodation.

As a result of these efforts, and similar moves by individual universities, the number of foreign

D. BALL/CORBIS

A place in the sun: Australia has made itself into an attractive destination for foreign students.

M HUMPHRIES

Fighting back: security clamp-downs on foreign researchers and students have sparked widespread protests at US universities.

students entering Australia was rising rapidly even before the current US immigration restrictions began to bite — averaging a brisk 13% per year over the 1990s, according to government figures. "I don't think Australia depends on negative sentiment towards the United States for its growth," says Anthony Pollock, vice-president international at Monash University in Melbourne.

But obstructive US visa policies have clearly accelerated the trend. Since 2001, the number of foreign science students enrolled at Australian universities has shot up by 32%. And according to IDP figures, the number of students in all disciplines coming from China jumped by 23% last year; for Indian students, the increase was a phenomenal 34%.

For young Asian scientists, Britain is less obviously appealing. "It's very rainy," observes Yingjie Liu, a Chinese pharmacologist who is studying towards a PhD at the University of Cambridge. The food isn't much to her liking either. But Cambridge and other leading British universities have an excellent international reputation, and are now exploiting this to attract Chinese and other foreign students in record numbers.

Every year, the Cambridge Chinese Students and Scholars Association holds a party to welcome new members. If present trends continue, they will have to move to a bigger venue. "Last year we had around 50 people at the party," says Changxin Wu, the society's president, who is studying for a PhD in veterinary science. "This year we had 120."

The number of foreign students at Cambridge has been growing steadily over the past decade. Cambridge and other British universities have an active presence at international education fairs, and British embassies are also helping with the recruitment drive.

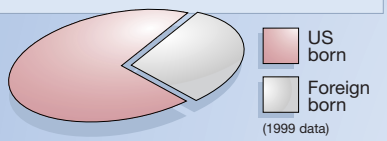
Universities in Britain and Australia have another important advantage — their native tongue is English, the lingua franca of science. For the same reason, Canada and Singapore are also benefiting from current US visa policies. But countries that don't have this inbuilt advantage are competing with increasing effectiveness in the international market for students and young researchers.

Officials in Germany, for instance, have long sought to dispel the popular notion that their country is hostile to foreigners. The government provides fellowships for visiting scientists and generous support for its universities' presence at international career fairs. The charitable Alexander von Humboldt Foundation, which similarly provides fellowships for foreign scientists, even gives an annual award to the 'friendliest' of Germany's immigration offices, which are responsible for issuing documents such as work permits.

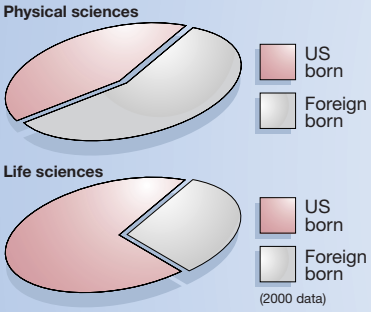
These policies are bearing fruit. Since 1999, the number of foreign students at German universities has increased from 113,000 to almost 200,000. Visiting researchers are also flocking to the 80 institutes of the Max Planck Society: since 1997, the number of scientists from the former Eastern bloc has more than doubled; over the same period, the number of guest scientists from China and India has tripled and almost quadrupled, respectively.

A foreign affair — immigrants and US science

PhD scientists working in the US

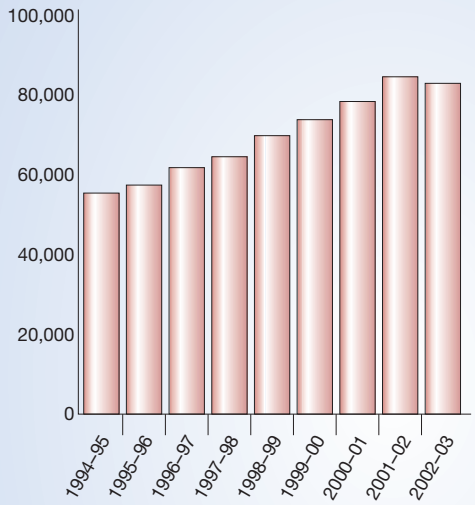


New PhDs awarded in the US



Source: National Science Foundation (NSF)

Total number of visiting scholars to the US by year



Source: US Institute of International Education

Foreign-born US residents with science or engineering doctorates

Place of birth	Number
China	37,900
India	30,100
United Kingdom	13,100
Taiwan	10,900
Canada	8,400
Germany	7,200
Iran	4,800
Former Soviet Union	4,600
South Korea	4,500
Philippines	3,400
Poland	3,200
Japan	2,800
Argentina	2,700
Other foreign-born	58,400

Source: NSF

mental shift in the international movement of researchers — and perhaps even alter the global balance of scientific power? It's difficult to say, because attaching firm numbers to such trends is all but impossible. Scientists travel to the United States on a wide variety of visa types, depending on the purpose and length of their stay. And because they make up a tiny proportion of the total number of foreigners entering the country each year, even a major decline would fail to show up in overall visa statistics. Data collected in different countries are also hard to compare: many nations don't separate visiting scientists from researchers in the humanities and other disciplines; some consider students separately from postdoctoral researchers, whereas others lump them all together.

J. RAEDLE/GETTY IMAGES

AP

Wrapped in red tape: some foreigners struggle to enter the United States and face security checks even after arrival (below).

"One of the great problems in dealing with this issue is that you get tons of anecdotes, but it is difficult to get data," says Norman Neureiter, who served as science adviser to US Secretary of State Colin Powell for three years until September 2003. *Nature*'s enquiries reinforce Neureiter's view of the anecdotal evidence. Our reporters found dozens of examples of scientists at every level who have experienced problems entering the United States. And in some cases, they found researchers now looking for work in countries such as Australia, Britain and Canada, rather than enduring the US immigration process.

Out in the cold

The sketchy data available suggest that such anecdotes illustrate a widespread problem — and that this is particularly acute for postdoctoral researchers in the 'hard' sciences and engineering. In November, for instance, the Association of International Educators, an organization based in Washington DC that promotes scholarly exchange worldwide, released a survey of more than 300 US colleges and universities. The survey revealed that the number of students whose start dates were delayed by visa problems was 48% higher in 2003 than at the start of the previous academic year; for 'scholars' — a broad category dominated by young postdoctoral researchers — the increase was 76%. More than three-quarters of the delayed students were in the physical sciences, biological sciences or engineering; among the scholars, these disciplines accounted for 93% of those who experienced significant delays.

Other surveys paint a similarly bleak picture. Last July, the American Institute of Physics reported that nearly a quarter of foreign students who applied to study towards a PhD in physics in the United States in 2002 were initially denied a visa. The number of

foreign researchers working at the five largest institutes on the National Institutes of Health campus in Bethesda, Maryland, declined in 2003 for the first time in the nine years over which records have been kept. Most strikingly, the total number of visiting scholars in the United States declined in the 2002–03 academic year for the first time in almost a decade (see figure, opposite).

For some observers, these statistics are enough to set off alarm bells about the future health of US science. "We're at a critical juncture now, and I think everybody senses it," says Irving Lerch, director of international affairs with the American Physical Society in College Park, Maryland. Although the likely consequences of the visa delays remain a matter of debate, their main cause is clear — new security procedures introduced following the terrorist attacks of 11 September 2001.

"There's a perception that visas are too difficult to get and the United States is an unwelcoming place."
— Victor Johnson

In the immediate aftermath of those events, the state department began expanding its 'Technology Alert List', designed to prevent dangerous technologies getting into the hands of terrorists or hostile states. It is now classified, but a version issued in August 2002 contained roughly 150 items, including such broad labels as 'microbiology', and common pieces of lab equipment such as low-energy lasers. So if you work on, say, infectious disease, or use relatively innocuous devices that have found their way onto the state department's list, your application to enter the United States is likely to be referred to the FBI and other federal agencies for a security review.

Singled out

Scientists from China have borne the brunt of the new policy — even though its nationals have never been implicated in terrorism against US targets. The survey by the Association of International Educators, for instance, found that more than a third of all visiting students whose entry to the United States was delayed were from China. In part, the large number of Chinese who have been affected by the new restrictions reflects the fact that they make up the biggest single group of foreign scientists seeking employment or education in the United States. But some Chinese researchers, who point out that the current US administration was pursuing an aggressive policy towards their country even before the 2001 terror attacks, believe that they are being singled out for harsh treatment (see 'We are not the enemy', right).

Meanwhile, for researchers from countries such as Iran, and several others in the Middle East, security reviews have become an almost insurmountable barrier (see

We are not the enemy

You don't need to visit Beijing or Shanghai to witness the pain of young Chinese scientists who have found themselves locked out of the United States, frustrated in their attempts to obtain the necessary visa. It's laid bare on the Internet for all to see, in discussion forums run by associations of Chinese scholars.

The New York-based Columbia University Chinese Students and Scholars Association, for instance, runs an online bulletin board on which delayed visa applicants, who call themselves 'checkees', record their ups and downs, and trade advice on how to get their lives back in gear. "What happened is totally a nightmare. Waiting helplessly at home and watching my study being ruined is so disappointing and frustrating," states the entry from Guoyuan Liu, a chemistry graduate student who went home to get married in December 2002 and waited 12 months for a visa to return to his studies. The delay cost him his financial support at Vanderbilt University in Nashville, Tennessee, forcing him to transfer to the PhD programme at the University of Maryland. On a similar site run from Tsinghua University in Beijing, one checkee who finally gained a visa in late October 2003 issues a stark warning to those who might consider a similar trip home: "Exercise extreme caution."

On another page of its website, the Columbia association collates information on checkees trying to enter institutions across the United States. Last updated on 9 September, the list covers 679 visa applications, 280 of which had been approved and 399 were still pending. There had been no outright rejections, but the average delay before approval was 154 days.

Some Chinese researchers suspect that concerns about security are being used as an excuse to discriminate against them. Many remember the aggressive stance adopted towards China by President George W. Bush in the early days of his administration, before the terrorist attacks of 11 September 2001. Wendy White, who directs the Board on International Scientific Organizations at the National Academies in Washington DC, suspects that concerns about industrial espionage may explain some of the heightened scrutiny facing Chinese researchers. She adds that sources in the FBI have told her that the delays being faced by Chinese visa applicants often reflect genuine difficulties in conducting security checks caused by the similarity between many Chinese names.

Qikun Xue, a materials scientist at the Chinese Academy of Sciences' Institute of Physics in Beijing, was once a regular visitor to the United States. But since 2002, visa difficulties have caused him to miss the American Physical Society's March 2002 meeting and prevented a collaborative project with a US colleague. "The experience gives me the feeling that the delay in issuing the visa might be done intentionally," he says.

Whatever the reason, the delays do seem to be having an impact on the flow of Chinese scientists into the United States. In the 2002 academic year, the number of visiting Chinese scholars declined for the first time in a decade; the number of US visas issued to Chinese students is also down 24% since 2001. It's not difficult to see where these young scientists are going — in Australia, Britain and Canada, the number of Chinese students has roughly doubled since 2000.

For the United States, the consequences of this trend could be severe. About one in five of the foreign scientists currently working in the country are from China — and if you doubt their importance, take a quick scan for Chinese names on papers from US labs in the top journals in your field. "There's going to be a long-term impact on the United States' ability to attract the best students and researchers," says Bing Su, an evolutionary geneticist at the University of Cincinnati, Ohio, who also has a position at the Chinese Academy of Sciences' Institute of Zoology in Kunming.

- **bbs.columbiachinese.org/viewforum.php?f=8**
- **www.columbiachinese.org/checkee_list.html**
- **www.smth.org/bbsdoc.php?board=Visa**
- **www.smth.org/bbsdoc.php?board=VisaCheck**

No entry: a Chinese student displays his visa rejection stamps from the United States.

NG HAN GUAN/AP

A. WONG/GETTY IMAGES

On the record: new rules dictate that all foreigners who need a US visa must be photographed and have their fingerprints taken when they cross the border.

'Never apply for a US visa again!' opposite). Because the US government sees Iran as a sponsor of terrorism, its scientists cannot enter the United States without undergoing an interagency review. Even senior Iranian officials with longstanding ties to the US scientific community have been unable to attend major conferences. "I have had many invitations, but I had to say no," says Reza Mansouri, a physicist and the deputy of research at the Iranian Ministry of Science, Research and Technology in Tehran.

Scientists from other countries need not face a full security review, even if their work appears on the state department's watch list. But a memo sent in August 2002 along with a revised version of the list ensnared many scientists who expected to sail through the immigration process. The paper instructed that, "when in doubt", consular officers should send applications to the state department's headquarters in Washington DC. As the consular staff involved were mostly inexperienced, they were in doubt all too often. The resulting backlogs caused delays of up to a year.

The memo is still causing problems. The state department claims that more than 80% of cases referred to Washington are dealt with in 30 days. But Wendy White, who directs the Board on International Scientific Organizations at the US National Academies, disputes this figure. "For the scientists we hear from, the average wait time is still over five months," she says.

Delays were exacerbated last July by a new rule requiring virtually all visa applicants to be interviewed face-to-face by a consular officer. Most scientists were already being pulled into US embassies for interviews, but they suddenly found themselves part of a much longer queue. When Thomas Brunold, an assistant professor in chemistry at the University of Wisconsin, went home to Switzerland for a short visit last June, he had to wait for three months to get an interview to renew his US visa. "I told them I had a research group of nine people to run," Brunold says. But his pleas fell on deaf ears, and the resulting delay cost Brunold a month's salary.

> "You can't go to a large international scientific meeting without visas being the issue on everyone's mind. I think there's going to be a solidarity movement against the United States."
> — Wendy White

For many researchers, the most frustrating thing about the new immigration requirements is their inconsistency. As a result, some visa applications shoot through the system whereas others are held up for months. And when this happens, there is usually no explanation. "The transparency in the process is completely missing," says Olexei Motrunich, a Ukranian physicist who has worked in the United States since 1994, but has been stranded in his home country since July, unable to take up a postdoctoral position at the University of California, Santa Barbara.

"I have been telling my relatives and friends how great America is; how one does not feel foreign in this country," says Motrunich. "Now I have to explain to the same people why, after more than eight years of doing science in the United States, I have a hard time receiving a visa to continue my work."

Number one no more

For some visiting scientists, the problems don't end at the US border. Catheryn Cotten, who directs the International Office at Duke University in Durham, North Carolina, says that foreign nationals are finding it more difficult than ever to secure social-security numbers, driver's licences and other essential documents. Mansouri adds that press reports of assaults against Iranian students at US universities are causing many of his country's young scientists to think instead about studying in Britain or Australia.

Such comments are worrying organizations that strive to promote international scholarly exchange. "There's a perception that visas are too difficult to get and the United States is an unwelcoming place," says Victor Johnson, associate executive director for public policy at the Association of International Educators.

Not surprisingly, researchers and university administrators in other countries who are recruiting from the pool of scientists now experiencing problems entering the United States are quietly satisfied with the turn of events. Countries such as Australia, Britain and Canada were already increasing their intake of foreign students before US visa restrictions were imposed — and this trend has accelerated since then.

Perhaps even more significant is the calibre of the students and researchers now considering destinations other than the United States. "I've had professors tell me that the quality of the Iranian students is phenomenal," says Amy Aldous, graduate-studies recruitment manager at the University of Waterloo in Ontario, Canada. Baowen Li, a theoretical physicist at the National University of Singapore, says that he is now seeing many more applications from China's élite universities. "The change is not in quantity but quality," says Li. "We have benefited a lot from the US policy."

But is this the start of a trend that could ultimately undermine the United States' leadership in science? Andreas Schleicher, who heads the Indicators and Analysis Division at the Organisation for Economic Co-operation and Development in Paris, argues that US dominance is so overwhelming that this is unlikely. "More than a quarter of all students studying abroad still travel to the United States," he says. But Neureiter, who has wrestled with the issues from inside the US administration, is not so sanguine. "I tend towards an apocalyptic view," he says.

"I can understand that Americans are worried about their security, but I don't understand why people like me are a threat to their security." — Zahra Fakhraai

How things unfold will depend on whether the visa delays experienced by visiting scientists represent teething troubles or a more lasting obstacle. State-department officials argue that they are now taking steps to improve the situation. New rules should let students jump to the front of the interview line so that they do not miss their start dates. And by March, a new computer system should connect embassies overseas directly to security agencies in the United States. The idea is to speed the interagency security reviews, preventing cases such as Motrunich's from getting stuck in limbo.

Still, the ongoing focus on security means it will be impossible to handle applications as quickly as they were dealt with before 2001. "I think the best we can do is to try to keep with our goal of processing all of the cases within a 30-day period," says Janice Jacobs, deputy assistant secretary of consular affairs at the state department.

Some US universities report that things do now seem to be getting back on track: at Duke, for instance, the number of foreign students studying the sciences rose once more in 2003, after two years of zero growth. But Neureiter is worried about the potential impact of a rule implemented last week that requires the fingerprinting of all visa applicants, and of another that will soon demand that students and visiting scholars pay a non-refundable fee of $100. "You can't go to a large international scientific meeting without visas being the issue on everyone's mind," agrees White. "I think there's going to be a solidarity movement against the United States."

Back in Madison, Zhang is now applying for postdoctoral positions, while writing up his PhD thesis. Despite his experiences, he says that he would rather stay in the United States, where he knows the research community. "But people who were thinking about coming here for graduate school are thinking twice," he warns. While Zhang was in China working at the shipping company, he befriended his boss's family. The executive's two daughters were thinking of studying medicine. Last year, they began their courses in Britain. ■

Written and reported by Geoff Brumfiel, with David Cyranoski, Carina Dennis, Jim Giles, Hannah Hoag and Quirin Schiermeier.

Never apply for a US visa again!

Zahra Fakhraai (pictured) and Sina Valadkhan had it all worked out. In May 2002, they were planning to relocate from Tehran to Massachusetts, having each received an offer to study towards a PhD at a prestigious US institution. Fakhraai would conduct research in polymer physics at Boston University, while her husband, Valadkhan — a gold-medal winner at the 1996 International Physics Olympiad in Oslo, Norway — would study mechanical engineering across the Charles River in Cambridge, at the Massachusetts Institute of Technology.

Because the United States has no diplomatic representation in Iran, the pair travelled to the US embassy in Ankara, Turkey, to apply for the necessary visas. They took medical records, academic records from Tehran's Sharif University of Technology, photographs, passports and letters that declared their intent to return to Iran after their studies. But their applications were rejected on the spot.

Two weeks later the couple tried again and were rejected a second time. On this visit, Fakhraai claims they were laughed at and granted only brief interviews by US consular officers. Fakhraai says that officials dismissed her husband's documents as possible forgeries. "They told me that I didn't have enough evidence that I would go back to Iran," Fakhraai adds. When she pointed out a standing offer to resume her research at the Institute for Studies in Theoretical Physics and Mathematics in Tehran, Fakhraai says that the officer told her he didn't need to see it.

The couple persevered and tried again in June — this time at the US embassy in Dubai, in the United Arab Emirates. The end result was the same, says Fakhraai: their applications were rejected. "I can understand that Americans are worried about their security, but I don't understand why people like me are a threat to their security," says Fakhraai.

Discouraged, the pair returned to Tehran, deferred their admissions to the Massachusetts schools, and applied to the University of Waterloo in Ontario, Canada. The new offers arrived in October, and the couple returned to Dubai again. At the American embassy the officer rejected their visa applications once more. When Fakhraai asked why, she claims she was yelled at: "Never apply for a US visa again!"

She didn't. The couple returned home, and in November 2002, Fakhraai and Valadkhan were granted study visas from the Canadian government on the day of their application. One year into her studies at Waterloo, Fakhraai is pleased with her move to Canada. "You never feel like a foreigner," she says. "Living and studying here is one of the best experiences I've had."