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Spread your wings

Most PhD students who love what they do and who want a career in academic research will find that it's not so easy. Someone needs to help them find out what other sectors have to offer.

For his 2012 PhD thesis, the sociologist Chris Platts surveyed and interviewed more than 300 young footballers — aged 17 and 18 — at UK club academies who were hoping to pursue a career in the game. He told the newspaper *The Guardian* this month that just four of them currently have gained a professional contract. That's a drop-out rate of 99%.

For our Careers section this week, *Nature* surveyed more than 5,700 early-career scientists worldwide who are working on PhDs (see page 549). Three-quarters of them, they told us, think it's likely that they will pursue an academic career when they graduate, just like Platts — now a senior lecturer in sport development and sport business management at Sheffield Hallam University, UK. How many will succeed?

Statistics say these young researchers will have a better chance of pursuing their chosen job than the young footballers. But not by much. Global figures are hard to come by, but only three or four in every hundred PhD students in the United Kingdom will land a permanent staff position at a university. It's only a little better in the United States.

Simply put, most PhD students need to make plans for a life outside academic science. And more universities and PhD supervisors must make this clear.

That might sound like an alarmist and negative attitude for *Nature*. But it has been evident for years that international science is training many more PhD students than the academic system can support. Most of the keen and talented young scientists who responded to our survey will probably never get a foot in the door. Of those who do, a sizeable number are likely to drift from short-term contract to short-term contract until they become disillusioned and look elsewhere.

As *Nature* has said before, it is good for PhD students and postdocs to pursue careers outside academia. Many will find similar challenges and rewards in industry. And it is surely of benefit to science and society at large that a sizeable number of well-educated and well-trained scientists spread to other sectors, and take with them healthy scepticism and respect for evidence. It is certainly better for young scientists to take a realistic view early in their career path, when they still have time to adjust their ambitions. So why do people in science still see this reality as a dirty secret?

Our survey, for example, shows that one-third of respondents do not have useful conversations about careers with their PhD supervisors. And non-academic jobs are low on the agenda when future options are discussed. Almost one-third of the students disagreed or strongly disagreed with the statement that their supervisor has useful advice for non-academic careers. That's about the same as was reported in *Nature*'s previous PhD survey, in 2015. If you supervise a PhD student or know someone who does, then please help to shrink that number by the time the next survey goes out, in 2019. Supervisors are busy people but they are often the face of the university and the academic system for students, and so the most obvious place to seek guidance. At the very least, they should be willing to point students towards the university careers service, which should also focus more on options outside academia. It's not just undergraduates who benefit from a variety of possibilities. Indeed, postgraduates arguably need more attention and advice because so many people — including themselves — believe that they are now on a path to a professorship.

Another major point worth making from the 2017 survey is about mental health. More than one-quarter of the students who responded listed mental health as an area of concern, and 45% of those said they had sought help for anxiety or depression caused by their PhD. One-third of those got useful help from their institution (which of course means that two-thirds did not). Still, just 5% said no help was available there or elsewhere, which, given the general difficulty in accessing mental-health support in many countries, suggests that young people in the education system are perhaps better served than many outside it.

"It's not just undergraduates who benefit from a variety of possibilities."

If the outlook for junior scientists in academia is mixed, then, luckily for science, most don't seem to let it put them off. Indeed, it's striking to note that nearly eight in ten of the young scientists surveyed said they were satisfied with their decision to start a PhD. That reflects well on the excellent opportunities, facilities and supervision that many receive. Just like the footballers, some will succeed, and they will find a career in academic science to be as thrilling, rewarding and satisfying as they hope. But someone needs to tell the rest what happens next. ■

Nuclear landscape

The US Department of Energy should classify and dispose of nuclear waste on the basis of risk.

The United States has a single deep geological repository for nuclear waste. Since 1999, the Waste Isolation Pilot Plant (WIPP), 655 metres down in a massive salt formation near Carlsbad, New Mexico, has received 12,000-odd shipments of what it calls transuranic waste. This is clothing, tools and other detritus from the nuclear-weapons programme that are contaminated by elements heavier than uranium. It's more hazardous than low-level waste, which can be buried closer to the surface, but not as dangerous as high-level waste, for which a disposal site has yet to be found.

WIPP was closed for three years after radiation escaped from a ruptured drum in 2014. It was given the all-clear to reopen only

in January; an enquiry determined that the drum had been packed improperly before shipment from the Los Alamos National Laboratory in northern New Mexico. Concerns remain about safety, as well as the long-term risk of human intrusion into a facility that will remain dangerous for thousands of years after its eventual closure. But by and large, WIPP has functioned as designed, and it could do even more to help the US Department of Energy (DOE) address the fallout from the country's nuclear-weapons programme.

Much high-level waste — produced during the reprocessing of spent nuclear fuel into plutonium — is highly radioactive and dangerous. But the evidence suggests that some of the waste that is labelled 'high level' technically qualifies as transuranic. This material is still barred from direct disposal at WIPP, purely because of how it was produced. But labels can be changed. If wastes that meet the transuranic criteria could be shipped to WIPP, it would save considerable time and effort as the DOE continues to struggle with the country's radioactive legacy.

At present, the high-level waste is scheduled to be encased in glass logs for disposal in a separate repository at Yucca Mountain in Nevada. Despite decades of delays and controversies, there are signs of progress at the DOE's flagship vitrification facility at the Hanford Site in Washington. But even if current plans hold, that facility will not begin processing high-level waste until 2032. Nor is it clear where the logs will actually go. Yucca Mountain was shut down by former president Barack Obama, only to be revived by President Donald Trump. Its long-term prospects are far from certain.

Reclassifying some high-level waste at Hanford, as well as at two facilities in Idaho and South Carolina, offers an alternative path for some of that waste, and one that would reduce an ongoing threat to workers and the environment. More than one-third of the 177 underground storage tanks at Hanford have leaked and contaminated groundwater.

The problem is inertia, compounded by fear, distrust and politics. The DOE is operating under a complex web of rules, regulations and legal agreements, and shifting course isn't easy. Although the agency has the authority to look through its nuclear-waste inventory and reclassify wastes that meet the WIPP transuranic criteria, it has resisted such a move because it fears that this would spark political uproar — and quite probably legal challenges.

Washington state, which has in place a court-ordered clean-up agreement for Hanford, has been particularly resistant to change. And New Mexico has tied the DOE's hands at WIPP by banning the disposal of tank wastes and any other materials managed as high-level waste — even if they meet the WIPP criteria. Watchdog groups, meanwhile, are concerned that nuclear-waste reclassification is simply a way of changing the rules and lowering the bar for public and environmental safety.

"The problem is inertia, compounded by fear, distrust and politics."

The proposal briefly bubbled up to the surface several years ago, but political attention shifted after the leak at WIPP. Now a coalition of local governments from communities across the nuclear-weapons industry is reviving the idea. In a white paper published last month, the Energy Communities Alliance urged a two-pronged approach involving the DOE as well as Congress, which could clarify the definition of high-level waste legislatively. The alliance estimated that the DOE could save at least US$40 billion over the lifetime of its clean-up programme — more than 15% of the estimated $257-billion price tag.

After spending some $11 billion on the as-yet-unfinished vitrification plant over the past two decades at Hanford, some may hesitate to change course. But as former DOE secretary Steven Chu said, the worst thing you can do in a multi-decade project such as nuclear-waste clean-up is to close the door to alternatives. In this case, the solution is simple enough: nuclear waste should be managed on the basis of the risk it poses and not the process that produced it. ■

Emergency access

Data platforms can help to steer emergency responses and ensure aid money is well spent.

Over the past decade, non-profit organizations have sent millions of small stoves to families in the developing world. These appliances are intended to stop people from cooking over open flames indoors — an activity linked to four million deaths per year, attributable to household air pollution.

But economists and public-health researchers have published studies that question the benefits of this effort. One randomized controlled trial (RCT), reported in 2012 and involving 15,000 households in rural India, found no evidence of improved lung function in women in the first four years after they received a stove (see go.nature.com/2zjgwny).

The RCT suggests that these efforts might be revised. But as useful as RCTs are in development economics and global health, they have limits. Findings in one place might be wildly different in another. And in a crisis, first responders are typically too busy trying to provide shelter, health care and bare necessities to design and carry out a controlled set-up.

But humanitarian groups can still improve their efforts in the short and long term through evidence obtained with new technology. A *Nature* News Feature this week (page 444) highlights software called the Dharma Platform, which enables workers on the front line of hurricanes, outbreaks or other crises to record, share and analyse useful data — for example, the spread of disease in rural villages. Dharma is being tested by Médecins Sans Frontières (or Doctors Without Borders), the World Health Organization and other groups combating crises in the Middle East. And it is just one of many new technologies that will make data faster to collect and easier to exchange.

The rush to provide food, shelter and health care can be as chaotic as the disaster itself. Hundreds of millions of dollars flood into the world's largest agencies and non-governmental organizations, which often subcontract delivery to dozens of smaller groups. In such a system, the best source of data is a person on the ground — often someone low in an organization's chain of command. It's this aid worker who listens as a mother describes how she's received four sacks of rice, yet her babies have nothing to eat. This essential feedback is typically recorded on paper. If it makes it into a report, weeks or months will pass by the time it gets to headquarters, where managers then adjust the system.

Platforms such as Dharma that collate real-time data could quicken this response time by informing groups of what people need, and help to reassure donors that their money is being spent wisely. After an acute crisis, researchers can use data collected in the heat of the moment to answer big-picture questions. For example, how might assistance better prevent tragedies that follow disasters, such as the cholera epidemic in the wake of Haiti's 2010 earthquake, or blindness in survivors of Ebola? As long as data collection is organized, consistent and secure, researchers distanced from those delivering aid can evaluate projects objectively.

Requesting more data and analysing them coldly will make failures more evident. In turn, philanthropists, taxpayers and governments that donate money should evaluate each inefficiency sensibly, and not be unforgiving. For example, a tiny fraction of donated insecticide-treated bednets may be used as fishing nets — but that fact should not negate an intervention that has been shown to reduce cases of malaria caused by *Plasmodium falciparum* by up to 62% (C. Lengeler *Cochrane Database Syst. Rev.* http://doi.org/c4f9c7; 2004). Failures at all scales must be upheld as lessons in the continuing struggle to do what's right — and not as arguments to abandon aid completely. ■