

THIS WEEK

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Make the most of PhDs

The number of people with science doctorates is rapidly increasing, but there are not enough academic jobs for them all. Graduate programmes should be reformed to meet students' needs.

It is hard to argue against the idea that a workforce should be highly educated. The media, politicians and universities all believe that a scientific background will not only benefit individuals, but also drive science, innovation and the economy. As a result, the number of people entering higher education in the sciences and engineering has been on the rise for decades. Between 1995 and 2012, the Organisation for Economic Co-operation and Development reported an overall increase in university graduation rates of 22 percentage points. In the same time frame, the PhD production rate has doubled, even though PhDs account for only a small percentage of higher-education graduations.

Getting a science PhD can be a very fulfilling experience, in which students spend a few years enjoying the rigour and freedom of academic research. Many pursue a PhD because they love the science, to satisfy their curiosity about the world or to contribute to a growing body of knowledge. All hope to emerge with the skills to pursue career goals, within or outside academia.

They have a good chance of doing so, too. Science PhD holders experience very low unemployment rates — just 2.1% of people with doctorates in science, engineering or health in the United States were unemployed in 2013, according to the National Science Foundation (NSF) Survey of Doctorate Recipients. The overall national unemployment rate for people aged 25 or older was 6.3%.

But the chances of getting a faculty job in academia — the career dream of many — are slim. Of the employed doctorate holders in the NSF survey, just over 50% were working outside academia across a variety of sectors, including industry, federal government and non-profit organizations. Many young researchers feel that their graduate training does not adequately prepare them for these different careers. Nor do they feel that they are being properly informed of their future prospects or the realities of the training. Many principal investigators, universities, funding bodies and governments are keen to keep pushing the message that a science PhD is good, and that there are plenty of jobs in academia. Job markets are not fixed, and can change substantially between the start and end of a lengthy PhD.

The opportunity cost of a PhD can also be substantial for young people. Not all have the luxury of being able to spend several years on a PhD with low pay and no clear destination — they can't afford it, might miss out on other opportunities, or prefer to pursue deep training in another sphere that is more appropriate for their skills and chosen careers.

If we accept that there are positives to having lots of PhD holders, then we need to work out how the system should change to support them all. As a News Feature on page 22 explores, various suggestions are bouncing around. One is to revamp the PhD so that it combines research with development of workplace skills. Several institutions, such as the University of California, San Francisco, run courses that offer graduate students training in management, communication and entrepreneurship.

Students could also skip the PhD entirely. Many who are contemplating a doctorate but aren't sure of its value to their future could instead experience postgraduate research through a master's degree.

A more controversial idea — around since the 1970s — is to cut the total number of graduate students entering the system. This has met with stiff resistance from faculty members, university funding bodies and governments.

The biggest problem for early-career researchers seems to be a lack of data on the career trajectories and opportunities available to them. Although some information-gathering efforts exist, none is substantial enough to provide the detail needed for students to make informed decisions about their futures.

To create a happy, sustainable PhD population, collaborative efforts between students, academics, industry and government leaders are needed. A science PhD is no longer an apprenticeship in science for academia, but an apprenticeship in scientific thinking that is beneficial for all walks of life. There are already some grass-roots campaigns in this direction, but they are not enough. The welfare and future of the economy and science rest on the shoulders of young, highly educated workers. Policymakers need to start putting the graduates' needs first. ■

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Root causes

Research has a part to play in identifying the factors that breed terrorism.

How can research best contribute to understanding and fighting terrorism, and to improving counterterrorism policies? A common focus is a narrow concept of radicalization that explores why individuals turn to extremism.

Since the 11 September terrorist attacks in the United States in 2001 — and the deadly bombings in Madrid in 2004 and London in 2005 — an entire industry of government-funded consultants and researchers has grown up around this idea. But many researchers find such emphasis problematic; they argue, for example, that it can distract from the need for a broader understanding of the roots of terrorism. They also fear that counterterrorism policies based on it may be ineffective, and risk being counterproductive.

Research to understand why and how people, such as the young people who carried out the attacks in Paris on 13 November, become

radicalized is crucial, and as a News story on page 20 describes, such research has provided some important insights. But there is no typical profile of those who turn to violent extremism, and the causes are highly diverse. Radicalization has become a central plank in national counterterrorism policies, with efforts made to identify individuals and groups showing signs of radicalization or vulnerability, and to de-radicalize them.

Under Britain's 'Prevent' programme, the government earlier this year made it compulsory for staff in schools, universities, councils, prisons and other bodies to monitor or refer such individuals to the authorities. Yet it's clear that only a tiny minority of the vast numbers of people flagged by counter-radicalization efforts risk turning to terrorism — and spotting which ones is extremely difficult.

Some researchers argue that such policies are justified on the grounds that the immediate terrorist threat to democracies is so great that everything must be done in the short term to stop people from becoming radicalized and to spot violent extremists, while also addressing the broader causes and dynamics of terrorism. But other researchers question the effectiveness of such policies, and argue that the focus should be more on community policing and on reinforcing intelligence to identify the recruiters and ringleaders of terrorist networks. Social profiling, they add, comes at a potentially high cost. It risks stigmatizing further Muslims and those of immigrant origin, and inadvertently legitimizing the anti-Islam, and often racist, rhetoric of extreme-right-wing parties. The resulting social division risks making matters worse and increasing the pool of potential terror recruits.

As Nadia Fadil, who specializes in Islam in Europe at the University of Leuven in Belgium, points out, policies based on targeting

Muslim populations also risk harming existing community-based prevention methods. In Belgium, youth workers, teachers and other officials who were previously considered trustworthy bridge-builders are increasingly distrusted in the communities in which they work because they are now perceived as state spies.

Shortcomings of radicalization research itself were highlighted in a 2013 review of the research literature by Alex Schmid, a director of the Terrorism Research Initiative, an international consortium of researchers and research centres. It concluded that the search for the causes of radicalization of young people has produced "inconclusive results", and that counter-radicalization and de-radicalization programmes lack rigorous evaluation.

Most worryingly, the review highlighted blind spots in radicalization research. Much, it concluded, is "one-sided", in that it looks only at the radicalization of Islamist, non-state actors, and ignores the fact that radicalization of Western governments can also occur, combining in a vicious circle that can fuel strife and terrorism.

That is an unpopular view, and is often considered by politicians and the media to be making excuses for terrorism. But it must be taken into account to develop more effective policies and to identify those that are ineffective or even harmful.

Research can do its bit, by bringing an evidence-based, neutral and broader perspective that can enlighten counterterrorism, social, educational and other policies. That need is now greater than ever. ■

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Take more risks

Scientific innovation is being smothered by a culture of conformity.

Suppose you are devising a technique to transfer proteins from a gel to a plastic substrate for easier analysis. Useful, maybe — but will you gain kudos for it? A notable finding of last year's survey of the 100 most cited papers on the Web of Science (see *Nature* 514, 550; 2014) was how many of them reported such apparently mundane methodological research (this protein-transfer method came in at number six).

Not all prosaic work reaches such bibliometric heights, but that does not deny its value. Overcoming the hurdles of nanoparticle drug delivery, for example, requires the painstaking characterization of pathways and rates of breakdown and loss in the body — work that is probably unpublishable, let alone unglamorous. One can cite comparable demands for detail to get just about any bright idea to work in practice — but it's usually the initial idea, not the hard grind, that garners the praise. The incentives for such boring but essential collection of fine-grained data to solve a specific problem are vanishing in a publish-or-perish culture.

Meanwhile, a recent analysis of discovery and innovation in biomedicine, using the molecules studied as value markers, finds that the choice of research problems is becoming more conservative and risk-averse (A. Rzhetsky *et al. Proc. Natl Acad. Sci. USA* 112, 14569–14574; 2015). One might quibble with the scope of the study, but its general conclusions — that current norms discourage risk and therefore slow down scientific advance, and that the problem is worsening — ring true.

Attempts to hit the publishable 'sweet spot' by avoiding both the prosaic and the risky are likely to reduce the efficiency of scientific discovery. But a fashionably despairing cry of 'Science is broken!' is not the way forward. The wider virtue of Rzhetsky *et al.*'s study is that it floats the notion of tuning practices and institutions to accelerate

the process of scientific discovery. The researchers conclude, for example, that publication of experimental failures would assist this goal by avoiding wasteful repetition. Journals chasing impact factors might not welcome that, but they are no longer the sole repositories of scientific findings. Rzhetsky *et al.* also suggest some shifts in institutional structures that might help promote riskier, but potentially more groundbreaking, research — for example, spreading both risk and credit among teams or organizations.

The danger is that efforts to streamline discovery simply become codified into another set of guidelines and procedures, creating yet more hoops for grant applicants to jump through.

A better first step would be to recognize the message that research on complex systems has emphasized: efficiencies are much more likely to come from the bottom up. The aim is to design systems with basic rules of engagement for participating agents that best enable an optimal state to emerge. Such principles typically confer adaptability, diversity and robustness. There could be a wider mix of grant sources and sizes, say, less rigid disciplinary boundaries, and wider acceptance that citation records are not the only measure of worth.

But perhaps more than anything, the current narrowing of objectives, opportunities and strategies in science reflects an erosion of trust. Obsessive focus on 'impact' and regular scrutiny of bibliometric data betray a lack of trust that would have sunk many discoveries and discoverers of the past. Bibliometrics might sometimes be hard to avoid as a first-pass filter for appointments (see *Nature* 527, 279; 2015), but a steady stream of publications is not the only, or even the best, measure of potential.

Attempts to tackle these widely acknowledged problems are typically little more than a timid rearranging of deckchairs. Partly that's because they are seen as someone else's problem: the culprits are never the complainants, but the referees, grant agencies and tenure committees who oppress them. Yet oddly enough, these obstructive folk are, almost without exception, scientists too (or at least, they once were). Inefficiencies can exact a huge price. It is time to oil the gears. ■

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