apoptosis, oxidative damage, and upregulation of T cells and macrophages (Tumpey *et al.*, 2004). The intrinsic properties of the 1918 strain's haemagglutinin and neuraminidase proteins obviously caused a more severe immune response, culminating in a far more destructive infection, according to the authors.

Another study of the 1997 H5N1 Hong Kong strain showed that it potently induces tumour-necrosis factor- α (TNF- α), which can cause serious complications through an exaggerated inflammatory host response (Seo *et al.*, 2004). Robert Webster from St Jude's Children's Research Hospital showed that, unlike other influenza viruses, the H5N1 subtype is resistant to the anti-viral effects of interferons and TNF- α , which he believes could also explain the extreme host response to the 1918 strain. He found that the pathogenicity of this virus is also related to the immune status of the host and the dose to which they are exposed—what proves fatal to one patient might be less serious for another. "But the ability to escape the first line of host immune defence may be an important determinant of pathogenicity of the influenza virus in humans, in whom interferon and TNF- α play an important role in reducing viral burden," Webster commented.

The current US flu vaccine shortage holds important lessons to be learned—and fast—if we are to face a potential pandemic, said Webby. Faster vaccine production, new vaccines, and improved and coordinated international efforts to report and contain outbreaks are imperative. At one extreme lies the threat of the 1918 pandemic. At the other extreme lies the situation that occurred in 1976, when US President Gerald Ford pressured Congress to allocate funds to vaccinate hundreds of millions of Americans against swine influenza (Figs 2,3). The epidemic never materialized—only liability cases from individuals who developed Guillaine-Barré syndrome after being vaccinated. "The bottom line is that, unless the government authorities of every country implement mechanisms that equitably limit vaccine liability, no prospective vaccine for H5N1, H7N7 or any other threatening influenza virus is likely to be produced for universal human use," according to Webby & Webster (2003). For a virus that specializes in variability, scientists and policy-makers must walk a narrow line between over-reaction to vaccine shortages and under-reaction in light of a possible avian influenza pandemic.

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A focus on the individual

Germany has begun to reform its university system to make it more attractive to both foreign and German scientists and students

In January 2003, *Time* magazine published a feature article on the 'brain drain' of the brightest researchers in Europe to the USA (Chu, 2004) and cited two German scientists who, on returning from the USA, were so upset about the situation that they planned to cross the Atlantic again as soon as possible. *The Scientist* was another journal that ran several articles about this problem (Stafford, 2004). The foreign press are not alone in highlighting the problem—these criticisms are also shared by German scientists. Thomas Tuschl, an assistant professor at Rockefeller University (New York, NY, USA), explained why he left a group leader position at the Max Planck Institute for Biophysical Chemistry in Göttingen, Germany, to work in the USA. "I had to get really good postdocs in order to withstand the competition," he said, and he found it easier to attract them to his laboratory at Rockefeller University than if he had stayed in Germany. Gunter Meister, one of Tuschl's postdocs who actually plans to return to Germany, was even more blunt. "[Science in] Germany is not attractive, not even for Germans," he said, referring to the arcane and unpredictable career paths for young scientists. Many science policy-makers and administrators in Germany share his view. "It is safe to say that the new academic generation was not sufficiently supported over the last few years," commented Hans-Jürgen Prömel, Vice President for Research at Humboldt University in Berlin, Germany.

Rather than nurturing the best and brightest, the post-war educational system in Germany focused on equality and equity, which ensured free and broad access to education but created mediocrity in many areas, including research

The good news is that the problem has dawned on both university presidents and the federal government in Berlin. Since she took office in 1998, Edelgard Bulmahn, the German Minister for Education and Research, has initiated various schemes to make Germany more attractive to both German and foreign students and scientists alike. The main initiatives are the creation of junior professor positions to give young scientists more independence earlier in their career, along with financial support for selected universities. In addition, the German government has increased its budget for education and research, despite strained finances: in late November 2004, the Ministry of Education and Research announced that the 2005 budget will see another increase of 4%. Although these developments are welcomed by many scientists and science administrators, for Germany to be able to compete effectively with the USA and other nations, these must be the beginning, not the end, of much needed reforms.

The fact that people have started to worry about research in Germany is the result of a slow decline after World War II, before which German scientific excellence was undisputed. The Ruprecht-Karls University in Heidelberg, the Georg-August University in Göttingen or the Humboldt University in Berlin were once on a par with institutions such as Cambridge in the UK, and Harvard, Princeton and Yale in the USA. Wilhelm von Humboldt's idea of a university that is independent of state and religion, where teaching and research go hand in hand and benefit each other, was the model for many American universities in the early twentieth century—Johns Hopkins University (Baltimore, MD, USA) was once called 'Heidelberg in Baltimore'. However, Nazi Germany changed a great deal, not just because it forced the country's outstanding Jewish scientists to emigrate. Its spectre loomed even after the war, when the concept of an elite was anathema to German society. Rather than nurturing the best and brightest, the post-war educational system in Germany focused on equality and equity, which ensured free and broad access to education but created mediocrity in many areas, including research. This was further exacerbated by a combination of typical

The federal government now plans to adopt the tenure system to allow universities to retain their best scientists

German problems, such as heavy-handed bureaucracy, lack of autonomy for universities, prohibitive labour regulations and a career structure that does not support independence for younger scientists. Many universities also have dwindling budgets and an increasing number of students, which leaves them little room to support their research.

Whereas Chancellor Gerhard Schröder originally envisioned German elite universities competing with Harvard or Stanford in the USA, the expectations have now shrunk to more modest, but realistic, hopes

However, the situation is not as bad as it might seem. Peter Gruss, President of the Max Planck Society, pointed out that Germany still enjoys a comfortable third place worldwide when ranked by the cumulative impact factor of its publications. In addition, various German research institutions rank among the world's best, he said. The Max Planck Society, with a total budget of €1.3 billion, has a higher cumulative impact factor than Stanford University (CA, USA) with a budget of US\$1.9 billion. "The fact is, the research itself is not the problem," Gruss commented. Rather, it is career paths and structural problems at German universities that need to be improved. But as Tuschl pointed out, the Max Planck

Institutes are not enough. "You cannot really compare this," he said, "[Germany has] one so-called elite university with 80 million citizens compared to 10 elite universities and 300 million citizens in the USA."

One major difficulty is the long and twisted career path towards a full professorship. Traditionally, a German researcher has to write a habilitation under the tutelage of his professor to qualify for a permanent professor position. Although this ensures financial and other support, it does not necessarily further independent thought and research, particularly if the same professor sits on the committee that decides on permanent positions. To break up this system, the federal government introduced the junior professor position in 2002 to replace the habilitation pathway and give young scientists more independence. However, this plan suffered a serious blow in July 2004 when it was ruled unconstitutional, because the federal government must not interfere with research policy, which is the exclusive right of the *Länder* or states. Nevertheless, many states have already changed their laws to give the junior professorship equal status to the habilitation. Even those states that sued the federal government in the constitutional court have stated that they would support junior professors—so far, more than 600 of these positions have been created. "I'm fully convinced that this measure of the junior professor will be successful," Gruss said.

Table 1 | The 2004 ranking of German universities by the Free University of Berlin

Rank	University
1	Ludwig-Maximilians University, Munich
2	Ruprecht-Karls University, Heidelberg
3	Free University, Berlin
4	Technical University, Munich
5	Humboldt University, Berlin
6	Tübingen University
7	Georg-August University, Göttingen
8	Technical University Aachen
9	Friedrich-Wilhelms University, Bonn
10	University of Stuttgart

These rankings were based on the amount and size of research grants and prizes, the number of foreign scientists and the number of students who become entrepreneurs. Source: Free University, Berlin.

However, this might require further changes. "The junior professor is a step in the right direction, but these people must be supported accordingly," said Ernst Wimmer, a former junior professor at the University of Bayreuth, Germany, and now a full professor at Göttingen University. "The [junior professor] is supposed to be independent, but often has no financial support of his own. [...] This is yet another idea that has been realized without providing the necessary additional money." It is, indeed, a problem for those who are not supported by their university. Wimmer has a junior professorship position in his department; but as he pointed out, the junior professor will be unable to start his own research if Wimmer does not support him financially. This, as Wimmer commented, is effectively the old system of tutelage in disguise. "In the end, you have to think this through," Prömel agreed. Although Humboldt University has created 45 positions for junior professors and plans even more, Prömel also conceded that they clearly need more support to be successful, which is often not easy for cash-strapped universities.

In addition, "in Germany, you can be as good as possible, but after some years, you have to leave for another university," said Wimmer, addressing the problem of labour regulations—apart from those with a tenured professorship, nearly all

scientists have limited contracts. "Why should we go through all these efforts to find the best, when they leave after a few years?" Prömel asked. This is the reason why Meister, for instance, on returning to Germany, will follow the traditional career path. "If you want to keep all possibilities open, you still have to do the habilitation," he said. Tuschl agreed: "Somehow they have not really thought this through. [...] If you have professorship positions without tenure, you won't necessarily get the best people." The federal government now plans to adopt the tenure system to allow universities to retain their best scientists. Although Gruss welcomes this, he pointed out that such decisions should be made only on the basis of external peer review in order to get the best candidates.

Wimmer would like to go even further and free scientists from the constraints of labour regulations, as research personnel at German universities are treated as public employees, which limits the personnel choices. In addition, European law requires that contracts have to be made permanent after 5 years. Most universities, therefore, do not keep young scientists employed for longer than 5 years, even at the risk of losing outstanding researchers (Dillon, 2003). One solution, Wimmer thinks, would be an independent tariff scheme for scientists at universities, although he remains pessimistic about this idea. "I don't know how large the problem has to become before ver.di [Germany's labour union for public employees] will agree to such changes," he said.

Another important initiative, which has ironically come from the Socialist-Green Government, is the creation of elite universities. This scheme will define the top 10 German universities and support them with an additional €1.9 billion from federal and state funds. Although this goes against the German distrust of elites, many scientists and politicians have embraced the idea. "It would be detrimental for the whole reform movement if this project were not realized," Gruss said. "This movement shows that universities need more financial support," he commented, "but the universities also have to be open to critical suggestions on how to improve." Indeed, this scheme will put more pressure on them to become more competitive. "One clearly has to say that our structures are paralyzing," Prömel said.

Table 2 | Positions of German universities in the Jiao Tong University (Shanghai, China) ranking of 500 universities worldwide

Rank	University
48	Ludwig-Maximilians University, Munich
58	Ruprecht-Karls University, Heidelberg
60	Technical University, Munich
91	Georg-August University, Göttingen
95	Free University, Berlin
102–151	Friedrich-Wilhelms University, Bonn
102–151	University of Cologne
102–151	Albert-Ludwigs University, Freiburg
102–151	University of Hamburg
102–151	Julius-Maximilians University, Würzburg

Source: Academic Ranking of World Universities 2003, Jiao Tong University, Shanghai, China.

"US universities are often administered like a company while many German universities look like a public administration."

Nevertheless, this initiative has already triggered change. For once, ranking universities has become a popular pastime in Germany, which would have been unthinkable a few years ago (Leffers, 2004; Tables 1,2). But many universities are not waiting for the official verdict—scheduled for 2006 (Schiermeier, 2004)—and are already moving ahead with their reforms. Whereas Chancellor Gerhard Schröder originally envisioned German elite universities competing with Harvard or Stanford in the USA, the expectations have now shrunk to more modest, but realistic, hopes. American elite universities have much more autonomy and flexibility in recruiting research personnel and selecting students, and they can draw on massive finances thanks to huge endowments, tuition fees and grant overheads—none of which applies to German universities. Instead, various German universities are now focusing on selected areas in which they already excel, and are reforming their structures to make themselves more attractive to students and scientists. They are also introducing Bachelors and Masters degrees in addition to the time-consuming German diploma to become more attractive to foreign students. The Max Planck Society, which is free from many of the legal and labour constraints that plague publicly funded universities, is already successful in attracting good scientists to its

"The individual must be more important—you have to create an environment that offers challenges and you need to help outstanding people"

Table 3 | Results of *Der Spiegel*, Kinsey and AOL online survey of German universities in selected subject areas

Rank	University		
	<i>Medicine</i>	<i>Biology</i>	<i>Mathematics</i>
1	Private University Witten/Herdecke	University of Bayreuth	Georg-August University, Göttingen
2	Technical University Munich	University of Stuttgart	University of Ulm
3	Ruprecht-Karls University, Heidelberg	University of Leipzig	Technical University Munich
4	Albert-Ludwigs University, Freiburg	University of Konstanz	University of Kaiserslautern
5	Wilhelms University, Münster	Albert-Ludwigs University, Freiburg	Ruprecht-Karls University, Heidelberg
6	Ludwig-Maximilians University, Munich	Technical University Dresden	University of Augsburg
7	Friedrich-Wilhelms University, Bonn	Ruprecht-Karls University, Heidelberg	University of Trier
8	Medical University, Hanover	Humboldt University, Berlin	University of Stuttgart
9	Humboldt University, Berlin	University of Regensburg	Albert-Ludwigs University, Freiburg
10	Julius-Maximilians University, Würzburg	Martin-Luther University, Halle	University of Bayreuth

Source: *Der Spiegel*, 20 November 2004

group leader positions; but as Gruss pointed out, they only employ 270 full professors compared with more than 12,000 such posts at universities.

One success story is Humboldt University, which essentially started from scratch in 1990. After the fall of the Berlin Wall, the former East German university had to replace all of its professors, Prömel explained; but it used this opportunity to renew its staff. In addition, Jürgen Mlynek, its current president, has begun reforms with the aim of further improving strong areas, and attracting good students and researchers. These seem to be paying off: despite the fact that Humboldt University suffers from serious financial cutbacks, nearly every ranking puts it among the five best universities in Germany.

Students are already attracted to the emerging elite universities. A recent online poll (Table 3) of 50,000 German students by the weekly news magazine *Der Spiegel* together with McKinsey and AOL (Friedmann *et al.*, 2004) showed that successful universities actively select their students, have a strong academic tradition, merge research and teaching early on, and have close contacts with other research institutions and industry.

Technical University in Munich, which ranks among the top five in many areas of the poll, now selects many of its students through individual interviews and puts more emphasis on early research in training, which is helped by the 11 Max Planck Institutes in the Munich area. As Wimmer summarized, more autonomy in personnel matters, more competition and strong selection are essential for improving the attractiveness of a university to students and researchers alike. His university in Göttingen is another test case for autonomy. It is now independent of political influence from the Lower Saxony Ministry of Research in personnel matters and is closely cooperating with the Max Planck Institutes in the city, which Wimmer hopes will improve its standing in the long term. Universities and research institutes have also become more aggressive in recruiting good research personnel.

Basing an education system on equality and free access, as in Germany, has its advantages: it produces well-trained students and scientists with a broad knowledge base who are warmly welcomed in research laboratories everywhere. However, the big problem is that this has been

achieved at the expense of the best and brightest scientists in the country. The great challenge now is to reform outdated structures and career paths, to lure domestic and foreign scientists to a research career in Germany. "The individual must be more important—you have to create an environment that offers challenges and you need to help outstanding people," Tuschl summarized, drawing from his own experience at Rockefeller University. It seems that university administrators and science policy makers in Germany are now beginning to realize this too.

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