The Disposable Academic

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To life science researchers career uncertainties are nothing new. But how did we get into this mess and why has it been continuing for so long? Jeremy Garwood investigates.

"The disposable academic" was the title of a long article in *The Economist* magazine (16/12/2010). Written by a biologist, the sub-title read: "Why doing a PhD is often a waste of time". Amidst talk of treating research students like "slave labour", it spoke of an "oversupply of PhDs" and the lack of stable research jobs for all these highly qualified postdocs.

Doctorates may be designed as training for a job in academia but the number of PhD students graduating each year is completely unrelated to the number of job openings. "The fiercest critics compare research doctorates to Ponzi or pyramid schemes," notes *The Economist*. Strong words indeed from one of the world's most influential news magazines: a "Ponzi scheme" is any scam that pays early investors returns from the investments of later investors, while a pyramid scheme is a non-sustainable business model (fraud) that involves promising participants payment, primarily for enrolling other people into the scheme or training them to take part, rather than supplying any real investment!

How did this situation arise?

The future employment situation for researchers is apparently so bad that it's almost dishonest to encourage students to study for a PhD. Even when senior scientists do admit that future prospects aren't good, they tend to stress the possibility that if you work hard and follow orders, you might be lucky enough to get one of the few jobs that do exist. Who knows, they say, the situation may have improved by the time you've finished your PhD. And besides, they might note, a PhD is a good training in itself: it's an intellectual challenge in the service of humanity. They imply that it's somehow inappropriate for an academic to be talking about money and careers.

According to *The Economist*, as higher education expanded after the Second World War, so did the expectation that all university lecturers should have PhDs. In this respect, US universities led the way: by 1970 they taught almost a third of the world's university students and half of its science and technology PhDs. The annual output of PhDs in the US has since doubled to 64,000, rising 22% between 1998 and 2006.

Meanwhile, the rest of the world has been catching up, with 40% more doctorates awarded in all OECD (Organisation for Economic Co-operation and Development) countries over the same period. PhD production sped up most dramatically in Mexico, Portugal, Italy and Slovakia, but even Japan produced 46% more.

Although some of this growth reflects genuine employment demands by expanding higher education institutions, universities have also discovered that PhD students are cheap, highly motivated labour. With more, relatively low paid PhD students, they can do more research.

In some countries, particularly the US, they can also do more teaching. Graduate students who have completed 'all but their dissertations' (often referred to as 'ABDs') cost less – at Yale university, an ABD earns $20,000 a year for nine months teaching compared to an average $109,000 for a professor.

Cost-effective PhDs

Furthermore, the production of PhDs has far outstripped demand for university lecturers. In the US, more than 100,000 doctoral degrees were awarded between 2005 and 2009 but there were only 16,000 new professorships. It seems that only a few fast-developing countries, such as Brazil and China, are currently short of PhDs.

Not surprisingly, few PhDs pass directly into a stable academic job. Instead there has been an enormous expansion in the numbers of postdoctoral researchers, employed on short-term contracts, who together with the PhD students do most of the research work. *The Economist* described them as "the ugly underbelly of academia". Too many postdocs now compete for relatively few, stable research jobs. In US life sciences, a PhD has about a one in five chance of getting a faculty job.

Even the OECD has recognised that there's a problem. In its 2010 Science, Technology and Industry Outlook, it acknowledged that changes in the international labour market for researchers have "deeply affected" employment conditions and the career paths of researchers. "The growing number of temporary contracts in universities and public research institutes has led to the emergence of a 'secondary' labour market where lack of clear rules on recruitment, employment and promotion may lead to job insecurity and inequity."

Is the PhD itself the problem?

Could the PhD qualification itself be to blame? Some academics consider it to be outdated and have called for radical changes that go as far as total abolition.

In April 2011, *Nature* published its own special issue on "The future of the PhD" (472:259-384). The editorial set the tone: we must "fix the PhD" since it is "no longer a guaranteed ticket to an academic career." One article described "The PhD Factory", asking if it was "time to stop producing more PhDs than ever before"; others called for "rethinking PhDs" or stated that if we couldn't "reform the PhD system" then maybe we should simply "close it down!"

Nature questioned whether it was such a good thing for countries to continue to expand their PhD education in science "convinced that higher education and scientific research are the key to economic growth and prosperity". With so few stable jobs currently available for PhDs, it seems inevitable that "exceptionally bright science PhD holders from elite academic institutions are slogging through 5 or 10 years of poorly paid postdoctoral studies, slowly becoming disillusioned by the ruthless and often fruitless fight for a permanent position".

Both *The Economist* and *Nature* note that the relative abundance of students willing to study for PhDs has eroded the quality of their training and supervision. In the US, PhD completion rates for doctoral students are only 57% within ten years of starting. Studies suggest that those who finish are no cleverer than those who do not. Instead, "poor supervision, bad job prospects or lack of money cause them to run out of steam".

In the EU, there has been an attempt to limit PhDs to three years. However, the need to produce original results that can be published within these time limits, often means that students are restricted to a handful of techniques within a pre-defined and fairly predictable experimental plan. Students have less freedom to make their own mistakes. They can no longer learn by trial-and-error how to think independently when conceiving and executing their experimental research.

Ruthless and fruitless fights

Furthermore, by choosing to do a PhD, students are restricting their future career options: too highly specialised, they may be very good at performing certain techniques and analysing certain datasets but how useful are these skills if there are no jobs available in that research area?

Transferring highly specialised skills and knowledge from a PhD to non-research jobs outside academia is not obvious. The latest OECD study on the careers of doctorate holders (2010) reported that five years after receiving their doctorates, 60% of PhDs in Slovakia and more than 45% in Belgium, the Czech Republic, Germany and Spain were still on temporary contracts. Many were postdocs. About one-third of Austria's PhD graduates take jobs unrelated to their degrees. In Germany, 13% of all PhD graduates end up in "lowly occupations" (defined as "occupations other than professional and managerial"). In the Netherlands, the proportion is 21%.

Here, proposed solutions involve teaching PhD students additional, more transferrable 'soft skills', for example, by requiring students in doctoral schools to take courses in computing, management, presentation techniques, etc.

Should we really be blaming the PhD for its popularity and success? Can changes to the PhD solve the general employment problem for scientific researchers? Instead, the real problem might have more to do with the larger structure of scientific research itself.

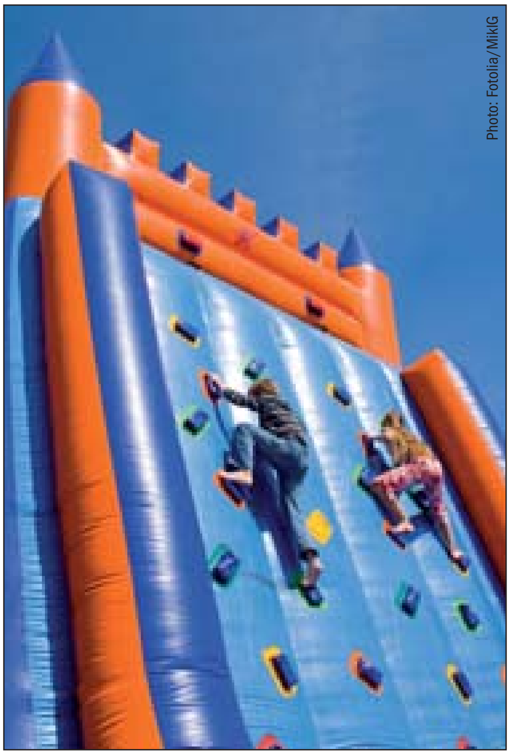
The lack of stable research jobs is not new. It has been developing for some time in both the US and Europe. Already in the 1990s, there were obviously too many PhD graduates for the existing academic job market, especially in life sciences. At that time, the American Society for Cell Biology (ASCB) realised that this employment crisis looked more like an economic than an academic, problem and they turned to an economist for his analysis of the situation.

Economic view on bioscience research

The distinguished labour economist, Richard Freeman, Professor at Harvard University and the London School of Economics, has been studying employment trends in research and higher education for four decades.

In 2001, in association with the ASCB, he published "Competition and Careers in Biosciences" (*Science* 294:2293-4), a short and penetrating insight into the economic particularities of US bioscience research.

Freeman started with the basics: economic supply and demand. Most of the 150,000 PhD life scientists in the US work at colleges and universities. The US government is the major source of biomedical research funding. Through its funding policies, the government affects the supply of researchers, for example, with its postdoctoral fellowships, research assistantships and admission of students and scientists from abroad. At the same time, by awarding research grants, the government influences demand for the research activity that actually employs these researchers.



The Tournament Model: the first to the top will rake in scientific renown, awards or tenure.

When Freeman looked more closely at university bioscience laboratories, he found that they resembled "small family businesses". In these "businesses", research students and postdocs depend on the laboratory for their education, career development and income. Then he looked at the dynamic forces driving the research within.

The Tournament Model

Freeman observed that research activity in bioscience actually corresponds to a defined economic structure – the Tournament Model. This tournament is like a competitive sports contest, in which participants have the chance of winning a big prize. In this case, the prizes on offer might include an independent research career, tenure, professorship, scientific renown, awards, etc.

But the tournament also encourages particularly intense competition by "amplifying small differences in productivity into large differences in recognition and reward". After all, victory may result from being only "marginally better than competitors, e.g. by completing a key experiment a week earlier". But because the differences in rewards (you either do or don't get the job) are far bigger than the differences in output, it results in a "disproportionate incentive to win".

In the "ideal" economic model, such tournament job markets are "socially efficient" because they "induce" high productivity from all participants. Everyone will tend to optimise their effort, if they believe that they have a reasonable chance of winning.

Bioscience research fits this model quite nicely, "Many researchers have sufficiently similar scientific talent and equipment to make a big discovery. When a new technology or idea appears, many scientists with similar research experience can grab the 'low-hanging fruit'. If the chance of being first to make an extraordinary finding rises with increased effort, researchers have a strong incentive to invest in that effort."

Stress...

Except that "this configuration puts enormous competitive pressure on principal investigators (i.e. research group leaders), because the slightest edge can make the difference between success and failure". Freeman found that many principal investigators (PIs) responded to the possibility of being "scooped" by working long hours.

But it's not just the PIs who feel under pressure as they try to win the tournament, "Nearly one-third of PhD biological scientists work 60 or more hours per week." And it's hardly surprising that under these conditions, researchers have difficulties outside the lab, for example, establishing or maintaining families. Some senior scientists recognised that they, their students and postdocs should take more time for their personal lives. But instead they have adapted their daily lives to the clear incentives of the tournament.

Freeman realised that the pressures of the tournament model could also explain some of the other practices that have arisen in bioscience research: for example, the incentive to publish as quickly as possible and in quantity. Already ten years ago, biosciences had the shortest citation half-life among all sciences, "making it difficult to pause from or reduce work and return to the same career trajectory as before".

Between 1990 and 1995, bioscientists published 6.7 papers per year compared with 4.7 papers for scientists in other fields. Correlating work time to paper output, it seems five hours of extra work per week over a year equated to one additional publication. Furthermore, each publication corresponded to an approximately 0.9% higher salary. In the US, "bioscientists who work more hours publish more, and those who publish more, earn more".

...and "perverse outcomes"

But the Tournament model also directly affects the employment situation within the laboratories because it encourages PIs to recruit as many postdoctoral fellows and research students as possible, "irrespective of the personal value of their training".

One PI said, "If I have three postdocs and we work all the time, I have a bigger chance of getting my results out first than if I have two postdocs and take weekends off." As Freeman notes, the small businessman might have said, "If I keep the store open late and on weekends, I will attract customers from my competitor who doesn't."

As long as cheap postdoc or graduate student labour is available, PIs will use them as their primary labour input. "If encouraging graduate students and postdocs to specialise narrowly helps PIs win the research tournament, this will occur even if alternative forms of training, or leaving the lab sooner, might better serve the students and postdocs."

According to classical economic theory, changes in the supply of labour are linked to changes in the wage level, i.e. how much workers are paid for their work. Basically, if the demand for workers in a particular profession is high but the labour supply (number of available workers) is low, then wages will go up because competing employers need to pay more to attract qualified workers.

Chronic lack of stable jobs

However, when wages are high enough, new workers will want to train to do this job rather than another, lower-paying profession. Consequently, the labour supply will rise, employers will have abundant choice and they can now pay lower wages. This, in turn, swings the equation back since, as wages decrease, fewer workers will want to enter the profession and others will leave it. Finally, an equilibrium point is reached where the labour supply matches the demand for their work as expressed in the wage level that employers will pay.

Obviously, in the 'real world', matters are more complicated. Instead of just wages, we have a whole range of additional factors to consider, like job security, health cover, pension contributions, a safe and pleasant working environment, etc. Nevertheless, what economists like Freeman expect is that an awareness of poor future career opportunities in research ("the large discrepancy between scientific promise and career prospects") should result in a fall in supply, as students choose alternatives to PhD training until such time as they become convinced that conditions in the research profession have improved.

'Rational workers' shouldn't even be starting their PhDs! Aware of the chronic lack of stable research jobs, they should be choosing career paths with a more promising future. In effect, you'd be crazy (i.e. not economically rational) if you chose to do years of poorly-paid graduate studies (more than five years in the US) followed by two or more years as a trainee postdoc, before you philosophically accept that perhaps this wasn't the best life choice you could have made.

Photo: photocase.com/table

As a 'rational worker' you might want to start thinking about alternative uses for your latex gloves

Foreigners fill the gaps

So why are there still too many PhD students? On the one hand, Freeman found that admission standards to study at US graduate schools had been lowered to bring in more US students but, on the other hand, he discovered that the major reason was the availability of foreign students and researchers who provided a cheaper, more productive alternative.

In effect, the increased recruitment of non-US citizens to meet the labour requirements of research laboratories has "profound implications for the potential of market forces to improve bioscience careers". This is because labs can enrol foreign graduate students and hire foreign postdocs if they have a shortage of US researchers, which means that the natural reduction in supply predicted by classical economic theory does not occur when job prospects get worse.

Freeman estimated that in 1966, only 23% of science and engineering PhDs in America were awarded to students born outside the country. By 2006, that proportion had increased to 48%, of whom more than half were of Asian origin (China, India and South Korea), while 27% were European-born. Furthermore, unlike traditional influxes of unskilled foreign labour, these capable and highly-motivated foreign students tended to outcompete US-born students in getting into the elite US academic institutions and better ("higher quality") PhD programmes.

However, this supply of foreign researchers has not only upset the balance in the classical labour market for US bioscientists, it has also contributed to maintaining lower pay and working conditions. This is because foreign PhD students and postdocs tend to tolerate poorer working conditions and lower wages than US citizens.

Possible solutions for students?

For PhD students, Freeman and the ASCB called for an increase in their pay and relative independence by providing more fellowships. The reaction to these proposals reveals some of the resistance to change in the US research system. This is where it starts to sound suspiciously like a Pyramid scheme, as vested interests reveal their annual need for large numbers of new PhD students to keep the system functioning.

For example, most US graduate students are paid indirectly from grants awarded to faculty members. *Science* reported reactions when Freeman and the chemistry Nobel Prize winner, Roald Hoffmann, suggested that PhD students should receive more fellowships to give them greater independence during their studies (2009; 325:528-30). "Any radical shift away from what we do now would jeopardize a strong innovation system," said the president of the Council of Graduate Schools. The president of the Association of American Universities thought it would be unwise because it would take the selection of graduate students out of the hands of investigators. Others explained how they needed enough graduate students to do their research and teach the undergraduate courses.

When Shirley Tilghman, president of Princeton University, suggested that a typical ten-member lab might symbolically shed one graduate student as a way to reduce the overproduction of PhDs and improve the quality of their training, horrified PIs told her it would lead to a big fall in their lab productivity.

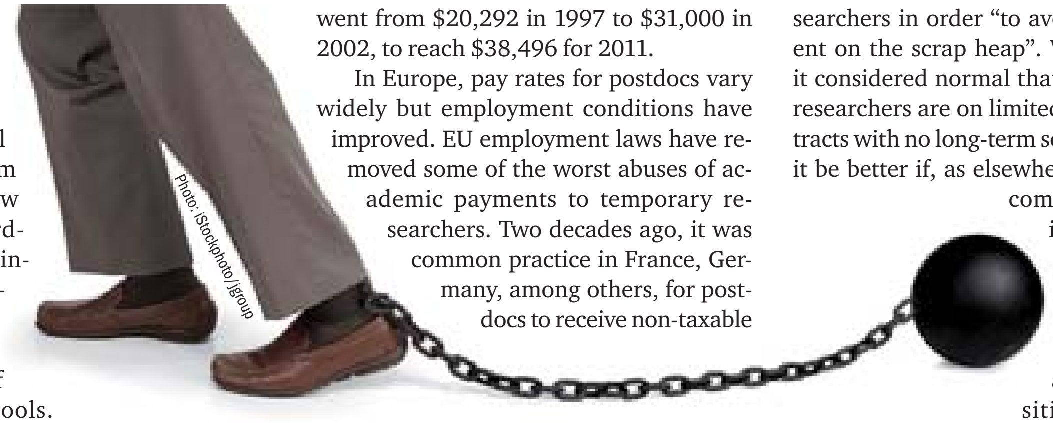
Possible solutions for postdocs?

The PhD may still be the highest academic qualification but what reward does it bring? A few more years as a badly-paid postdoc on a short-term employment contract? Retrospectively, the huge US medical funding agency, the National Institutes of Health (NIH) has been blamed for contributing to the US post-doctoral ghetto.

In "Cheap labor is key to US research productivity" (*Science* 1999, 285:1519-21), Jeffrey Mervis explained how the NIH had been setting the minimum wage for US bioscience. The salary standard for academic postdocs was what the NIH paid recipients of its National Research Service Award (NRSA) traineeships. Furthermore, the NIH had been prominent in maintaining the status of postdocs as trainees, meaning they were not considered as employees. This meant their pay was not considered a salary, was not subject to cost-of-living increases and did not include benefits (like health insurance).

In 2001, Freeman was optimistic that the NIH was one of the big organisations that could make changes to improve the bioscience job market. It had already promised to increase post-doctoral and research student stipends. Indeed, the NIH NRSA went from $20,292 in 1997 to $31,000 in 2002, to reach $38,496 for 2011.

In Europe, pay rates for postdocs vary widely but employment conditions have improved. EU employment laws have removed some of the worst abuses of academic payments to temporary researchers. Two decades ago, it was common practice in France, Germany, among others, for postdocs to receive non-taxable monthly payments without any social security, unemployment insurance or pension rights. Today, postdocs are still on short-term employment contracts but at least they now receive monthly salary slips like 'normal' employees, with the addition of those previously absent items and the extra money that their employers are now obliged to contribute to their pensions, health cover, etc.



Or maybe you fancy continuing "slave labour"?

Give postdocs 'normal' jobs

Nevertheless, postdocs are still stuck with a short-term 'trainee' status and no job security.

A decade ago, the NIH had also endorsed "the concept that post-doctoral trainees should be converted to non-training staff or faculty positions at the earliest practical opportunity". But progress has been slow.

In April 2011, *Nature* reported that the NIH was still asking "tough questions about US science workforce". NIH director Francis Collins has called on an external advisory panel to answer questions like "What is the right size of the future biomedical research workforce?" and "What are the appropriate types of positions that should be supported to allow people to have successful careers and to continue to advance biomedical and behavioral sciences?" This latest report may even be ready "possibly as early as next summer (2012)".

Another suggestion for the NIH in 2001 was that it could support scientists who wished to continue to do research without being obliged to become PIs, "thus directly addressing structural flaws in the training system". A decade later, not only has the US not addressed this problem, in the meantime, it's gotten worse elsewhere.

For example, in the UK, "Give postdocs a career, not empty promises" wrote Jennifer Rohn in *Nature* (vol. 471:7). It's time to create a new type of scientific job for researchers in order "to avoid throwing talent on the scrap heap". Why, she asks, is it considered normal that highly qualified researchers are on limited short-term contracts with no long-term security? Wouldn't it be better if, as elsewhere, their jobs become "professionalized" as careers in themselves rather than simply stepping stones to a few stable positions? (Jennifer Rohn outlined her position in more detail in ***Lab Times*** 04/2010).

Fraudulent US forecasting

Another point addressed by Freeman was why the US government had chosen to fund this oversupply of PhDs in the first place. In effect, such funding decisions are based on economic forecasts, i.e. predictions about the future needs of the US economy.

But Freeman's analysis came on the back of a big statistical lie! In 1987, the US National Science Foundation (NSF) had made an alarming forecast. It predicted a "shortfall" of 692,000 scientists and engineers in the US by 2010 and called for a big increase in the numbers of US science and engineering PhDs to reverse this dramatic situation. Politically influential articles appeared calling for more government funding of science, notably, "supply and demand for scientists and engineers: a national crisis in the making" by the President of the American Academy for the Advancement of Science (AAAS) (*Science* 1990, 248:425-32).

But how accurate was the NSF forecast? Already, in 1990, critics claimed that the figures were far too high and that if the government funded such training, it would result in an oversupply of scientists and engineers. They succeeded in getting a hearing at the US Congress where scientists testified that the study was intentionally misleading and had been used as "leverage" to increase NSF budget requests ("NSF shortage study called bad science", *Science* 1992; 356:553). The conclusion was that the NSF had made an alarming forecast simply to get more money.

In 1995, the NSF director finally admitted the error and repudiated the study. Unfortunately, the damage was already done. The government had increased funding of graduate schools, postdocs, etc. and, sure enough, it had boosted the oversupply of academically disposable PhDs!

Are forecasts made by individual European governments and the EU any more reliable than those in the US? This is particularly problematic when one of the factors incorporated into much of this forecasting is the need, verging on obsession, to emulate the example of US research activity.

Accuracy of EU forecasts

This is not entirely surprising since the US remains the world's largest single contributor to scientific research. By its very size and success, the US research system has served as the model for other nations. In 2006, the US awarded 28% of PhDs in the OECD area and employed 1.4 million researchers; in 2008, US expenditure on R&D increased to 2.8% GDP; it published 277,446 scientific articles; and recorded 49 patents per million population (OECD 2010).

Witness yet another recent report urging European governments to imitate this American success. The first EU Innovation Competitiveness Report (June 2011) warns us that Europe is in a state of "innovation emergency" and is peppered with phrases like:

- "Europe is increasing its international cooperation in science and technology, while striving to catch up with the United States."
- "The United States are still performing one third better than Europe in terms of R&D excellence, with 15.3% of US publications among the world's 10 % most cited."
- "Education expenditure per graduate or PhD student in Europe is a fraction of what it is in the US, sacrificing quality for quantity at the risk of not meeting the expectations of the business sector."

Unfortunately, calls by European economists and policy makers to copy the US research model rarely look beyond the positive points of their plan.

Europe has also had its "urgent" calls to expand the supply of scientists and engineers to meet perceived shortages. In the 'Lisbon Strategy' (2000), European countries agreed to embark upon an enormous expansion in research funding to attain 3% of GDP by 2010. When this faltered, it was replaced by 'Europe 2020', which now aims to achieve the political demands for a 'Knowledge Economy' by 2020.

Apparently unaware of the ongoing economic crisis, the EU Innovation Competitiveness Report (765 glossy pages) still noted Europe's lack of scientists. In 2008, there were *only* 1.5 million full time equivalent researchers in the EU, compared to 1.4 million in the United States, 0.71 million in Japan and 1.6 million researchers "in absolute terms" found in China (the new world leader).

One million more

All of which leads the bureaucrats to the simple conclusion that Europe needs more researchers. And how many? Lots!!

"The EU will need to create *at least* 1 million new research jobs if it is to reach an R&D intensity of 3 %. This net increase by two thirds of the number of European researchers by 2020 should primarily benefit the business sector, where there is a large gap with the United States."

Jeremy Garwood