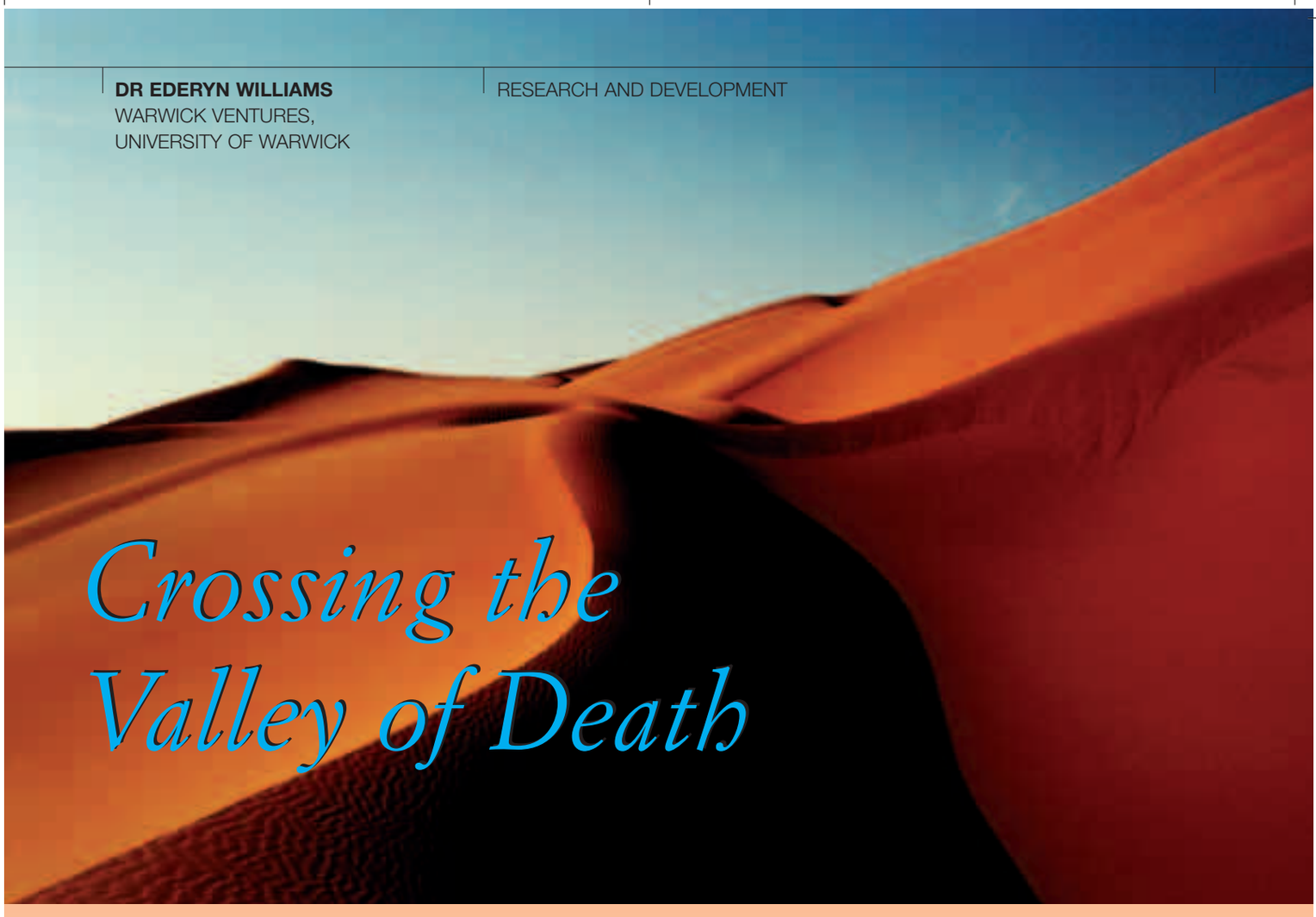
DR EDERYN WILLIAMS
WARWICK VENTURES,
UNIVERSITY OF WARWICK



Crossing the Valley of Death

What have gas-powered air conditioning, an optical concentrator for infra-red data and a new design for cochlear implants got in common?
The answer: absolutely nothing, except that all these ideas came from the fertile minds of the engineers at Warwick University. And we at Warwick Ventures, the technology transfer office of the university, have the task of helping these innovations through the 'Valley of Death'.

Death Valley in California is the desert that finished off many of the early pioneers heading for the West Coast in their horse-drawn wagons. Today, the 'Valley of Death' is the name given to the gap between the great plains of research funding and the orange groves of manufacturing. The mission of research funders, such as the Engineering and Physical Sciences Research Council, is to fund innovative work that proves new principles in engineering and science. Once a new principle has been proven, the research funder sees its job as complete. Manufacturers, on the other hand, would prefer to see a manufacturing prototype, fully working with materials specified. A scientific paper plus a crude laboratory lash-up seem to them to be an inadequate basis for investing great amounts of time and effort. Both parties are happy to spend money on their stage of the innovation process, but both shy away from the gap between them – promising projects starve and die in the Valley of Death.

Industrial R&D

Extracts from the *Science and Innovation Investment Framework 2004–2014* (Treasury, DTI and DES, July 2004, paras 4.4–4.10) illustrate Government thinking on the issue:

> Research clearly shows that investment in Business R&D generates substantial returns … When one takes into account that benefits from the R&D also accrue to other firms or industries, then rates of return can reach 100% … The UK faces a major challenge in trying to increase its R&D intensity towards the level in other major developed economies in Europe and beyond … To underpin the required increase in the output of the UK's knowledge-intensive economy, the Government it is now right to set out a target for the UK to increase R&D intensity from the current level of 1.9% to 2.4% of GDP by 2014 … To achieve this target requires substantial growth in business R&D in the UK.

International	UK-Owned
1. Ford (£4.8bn) (2)	1. GlaxoSmithKline (£2.9bn) (1)
2. DaimlerChrysler (8)	2. AstraZeneca (3)
3. Siemens (3)	3. BAE Systems (9)
4. General Motors (1)	4. Unilever (4)
5. Pfizer (31)	5. BT (10)
6. Toyota Motor (6)	6. Marconi (5 as GEC)
7. IBM (4)	7. Rolls-Royce (13)
8. GlaxoSmithKline (34)	8. Shell (6)
9. Matsushita Electric (7)	9. BP (17)
10. Volkswagen (20)	10. Invensys (14 as Siebe)
11. Microsoft (32)	11. Reuters (11)
12. Intel (£2.5bn) (21)	12. Amersham (£184m) (34)

Note: figures in brackets denote a company's position in the 1998 scoreboard

Table 1 The top 12 R&D investors 2003

In other words, the Valley of Death is worse in the UK than in many other economies, and, although the Government has ambitious plans, including increasing the science budget to over 5% per year, in real terms the targets will only be met if business R&D spending increases substantially. The scenario in the framework is for business R&D spending to increase by £12.6 billion per year by 2014 – an ambitious objective indeed!

Businesses that are more active in R&D find it easier to pick up part-developed technologies from universities and complete the development process, creating a new line of business for themselves. Some do this well, but most do it badly.

The DTI publishes an annual R&D scoreboard, showing the companies that invest the most in R&D. The 2003 Top 12 are shown in Table 1.

These are the companies with deep pockets and a strong commitment to carrying technologies across the Valley of Death. Universities find it easy to interface with these companies, and most of the companies have superior growth rates and dominant positions in their industries.

But we must take note of how concentrated they are in a few industrial sectors. Pharmaceuticals are strongly represented, as are electronics, IT and automotives. Outside these sectors, it is hard to find a big spender. The consequences for exploitation of university research are inevitable.

Licensing works ... sometimes

Many universities are working very hard to identify innovations arising from their research, patenting them and then seeking a business which will take a licence to exploit them. With over £3 billion spent on research each year in UK universities, there is no shortage of exciting innovations. The latest national survey conducted by the the Office of Science and Technology, the Higher Education Funding Council of England and others (Higher education–business interaction survey 2001–2, January 2004) showed that there were 2478 invention disclosures in UK universities in 2001–2 (up 15% on the previous year). On the basis of these inventions, the universities filed 967 new patents (up 8% on the previous year).

This is very positive progress. Evidence is accumulating that the universities are becoming more effective in identifying valuable innovations arising from research, and in filing patents to protect them, though it is slightly worrying that the proportion of the innovations that were patented had dropped from 42 to 39% in 2001–2. But how many of these inventions were

then licensed to industry? Here the figures become more worrying. The number of licences[1] had fallen from 433 to 415 in the year. So, only approximately 17% of innovations were licensed to industry (or less, since there is sometimes more than one licence per invention), and the rest died in the Valley of Death.

Contrasting this with the US situation is interesting. US universities have been very active in technology licensing, in some cases for over 20 years. In the latest survey conducted by the Association of University Technology Managers (AUTM Licensing Survey, FY 2002), US universities and research institutes reported 15 573 invention disclosures. This is six times the number in the UK, which is roughly in proportion to the relative research expenditure in the two countries. However, the US was more clearly ahead on patent filings, with 7741 in total, equivalent to 50% of the invention disclosures. This 'patenting rate' has been climbing steadily in the US, up from only 27% ten years ago, which is probably due to greater availability of funds for patenting.

On licensing, the US was even further ahead, with 4673 new licences or options signed. This number is almost a third of the invention disclosure total, well ahead of the UK proportion (30% in the US versus 17% in the UK). The death rate of innovations in the UK is still higher than in the US despite all our efforts to catch up.

So why is this? Referring back to the R&D scoreboard, we can see that half of the really big spenders are located in the US, while only one is headquartered in the UK. Clearly we have a geographical disadvantage. But there is a more subtle reason. A more detailed analysis of the US data has shown that over 85% of the licence income coming into universities is from biomedical innovations. Clearly in that sector the Valley of Death is particularly narrow and US technology offices are concentrating on biomedical innovations and on building relations with major pharmaceutical and biotechnology companies.

Box 1

The most lucrative university licence in the world

Florida State is reputed to have the most lucrative technology licence in the world, which earned them US$66 million in royalties in 2002. The licence is with the pharmaceutical company Bristol Myers Squibb, and concerns a method for synthesising Taxol, the anti-cancer drug. Most university licences, even in the US, struggle to earn US$100 000 in their lifetime.

So, it seems that university innovations can achieve licensing, but only if the innovation is of a particular type (for example, biomedical) and if the university has good relationships with major R&D spenders. Our experience at Warwick fits this model. Although we carry out a very wide range of research across the university, the only area where we have had repeated success in licensing is plant biotechnology. Elsewhere, licensing successes have been intermittent at best.

Finding venture capital

If a direct approach to commercial companies proves unsuccessful, venture capital can offer an alternative route across the Valley of Death. Venture capitalists invest in companies, including many technology start-ups and university spin-offs, in order to get them through the development stage and, of course, make a substantial profit from the increase in value of their shares in the company.

The UK venture capital sector is well developed, with almost £6.4 billion of new money invested in 1493 companies in 2003.[2] This is almost half the US level, where the latest statistics from the National Venture Capital Association for Q2 2004 show the annual equivalent of £13 billion invested in just over 3000 companies. If we just look at investments in early stage companies, then in the UK a third of the companies funded (427) fall into this category, though they only received 4% of the total money (£263m), an average of just £600k. On the US side, again about a third of the companies backed (over 900) were early stage, though they got substantially more per company (US$5.1 million or £2.9 million each, five times the amount for UK companies).

UK universities are using this route across the Valley of Death. In the latest survey (Higher education–business interaction survey 2001–2), universities reported 248 spin-off companies being formed in that year (a high figure compared with the US, which is five times as big as the UK on most measures, but generated less than twice as many university spin-offs (450 in total)). The survey did not reveal how many of the companies raised venture capital, but more anecdotal evidence suggests that many do (see Box 2 below).

Box 2

Spin-offs from Warwick University raise venture capital

Warwick Ventures, the university's technology transfer arm, has created 30 spin-off companies in the last five years. The innovations on which the companies were founded arise from many departments of the university: Engineering, Chemistry, Physics, Medicine, Biology, Computing and even Psychology. Some of the more promising ones have succeeded in raising venture capital, mostly in the range of £200 000 to £2 million each, with the total raised to date being almost £6 million. As they mature, some companies are considering a stock market flotation, while others will sell out to a bigger competitor.

So, creating a spin-off company and raising venture capital to complete development is an alternative route. In industry sectors where large companies

are not investing heavily in R&D, this can be a superior alternative to licensing.

Running an R&D partnership with companies

Licensing and spin-off companies can create cash returns for universities (through royalties or sales of shares), but an alternative is to build an R&D partnership with major companies. This is common in Germany, where the Fraunhofer such as the Max Planck Institute, are widely recognised as ideal environments for applied R&D, bridging the gap between academia and industry. Such organisations are less common in the UK, though we have an internationally recognised example in the Warwick Manufacturing Group (see Box 3).

Box 3

Warwick Manufacturing Group: Working with industry

WMG works across a broad range of industrial sectors – from the technological frontiers of the aerospace industry and pharmaceuticals, through the mass production of automotive manufacture, into food processing. It has long-term relationships with many of Britain's most successful companies, from Land Rover to BAE Systems, from AstraZeneca to Rolls-Royce. WMG also has close relations with many business support organisations, and with government agencies at local, regional, national and European level. Founded by Professor Lord Bhattacharyya, WMG now has about 320 staff.

In this model, industry provides much of the funding of the R&D institute, as do regional and national government, and the majority of the innovations created go directly to the participating companies. The companies get leading-edge R&D, partly supported by government, while the university and its staff have the satisfaction of knowing that their innovations are quickly and efficiently transferred to industry. WMG focuses especially on manufacturing industry, and has strong links with the automotive sector, but the same model can work in other sectors. This can help narrow the Valley of Death, and in some cases create an almost seamless connection between university research and industrial application.

The future

Despite all these promising methods of transferring technology, crossing the Valley of Death is still very hazardous, and many wonderful innovations starve and die, or get lost for years in the wilderness. We have established a few 'pioneering trails' that can sometimes allow a successful crossing, and we feel somewhat proud of what we have achieved at Warwick. But in reality, we know that the 'superhighways' across the Valley of Death have yet to be built, and we all hope that the future will allow technology transfer to be much faster, easier and less hazardous than it is today. ■

Notes

1 Figures exclude software licences, which are sufficiently different that inclusion would distort the results.
2 *BVCA Report on Investment Activity 2003*, British Venture Capital Association.

Dr Ederyn Williams is Director of Warwick Ventures, University of Warwick. After a DPhil at Oxford, and seven years as a researcher at UCL, Cambridge and Johns Hopkins, he spent 13 years at BT managing new technology businesses. For the last 14 years, he has been involved in technology transfer at the Universities of Leeds and now Warwick, helping to found over 40 spin-off companies.