NOTTINGHAM BUSINESS SCHOOL
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Biotechnology, life sciences and skills in D2N2:

A report for Learn Direct and the D2N2 Local Enterprise Partnership

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Executive Summary

This research project had a number of objectives:

- Review the growth of the biotech/life science sector in Nottingham and consider the key factors that have led to its expansion;
- Review available mapping evidence on the scale and nature of these sectors in the D2N2 area;
- Review and synthesise available research evidence on the nature of skills requirements in these sector and related barriers to business growth and development;
- Undertake new primary research into the skills requirements of these firms operating in the D2N2 area – this will take the form of a telephone survey of local businesses.
- Make recommendations for future skills provision and related business support for D2N2 and local stakeholders.

The nature of life-sciences and biotech:

- Life sciences are about more than just biotechnology, covering medical technology as well and both bio-pharmaceuticals and medical technology involve ‘core’ and ‘service’ activities;
- The D2N2 area is estimated to have in excess of 400 life science firms. Well over two thirds are located in Nottinghamshire, chiefly in and around the city of Nottingham which is home to a life sciences cluster;
- Nottingham’s life science cluster has a strong presence in the bio-pharmaceutical field centred on the BioCity incubator;
- Evidence from the BioCity incubator, indicates a particular strength in the provision of research services;

Skills and employment in the sector:

- The research literature indicates a shift in demands for skills in these sectors from highly specialized individuals who are experts in a narrow field, to those who have a broader skillset including inter-disciplinary science, commercialisation skills and business acumen.

- There has been a long tern decline in the training of laboratory technicians, one consequence of which may be under-employment of graduates;
- Life sciences firms are often small and can lack the resources to invest in training.

Recommendations:

1. Continued support for the development of specialist business incubation and grow-on facilities suitable for use by life-sciences and biotech companies is important.
2. Inadequate supply of laboratory technicians appears to be an issue that local stakeholders should explore further.
3. Local stakeholders may wish therefore to consider development of a collaborative approach to the training of laboratory technicians, in partnership with local colleges and universities.
4. Business and commercialisation skills for scientists may also represent areas where the feasibility of collaborative local provision could usefully be explored.

1 Introduction

The emerging bioscience cluster that has developed in Nottingham and the D2N2 area, some of which is associated with BioCity's success, has become increasingly recognised by policymakers at local and national levels. This recognition is evidenced through Nottingham's designation in 2006 as one of six science cities in the UK; EMDA's identification in its Regional Economic Strategy published in 2006 of bioscience as one of four key sectors in the East Midlands Economy; the D2N2 Strategic Economic Plan and Nottingham City Council's designation of bioscience as a priority sector.

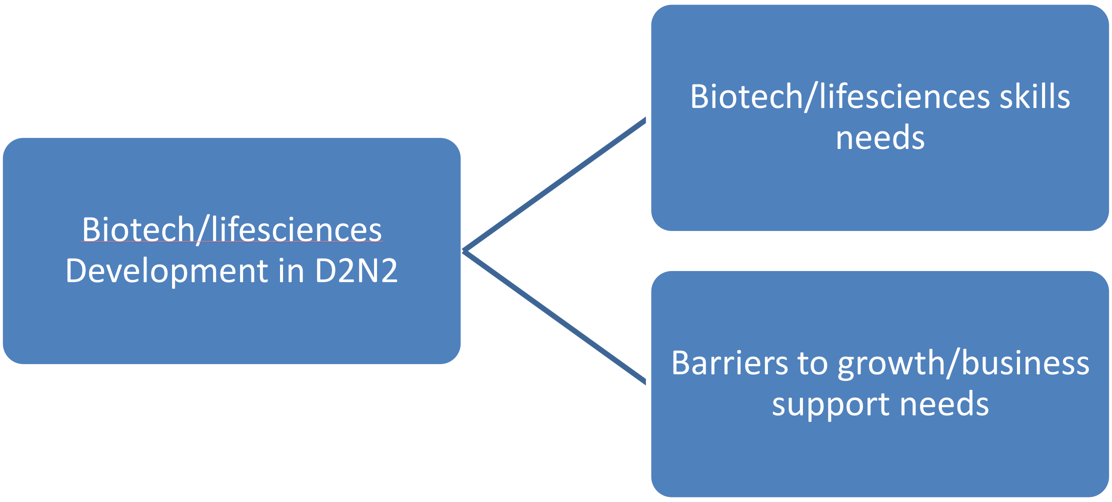
However while Nottingham/D2N2's bioscience cluster has been increasingly recognised, little research has been undertaken on the development of the life science sector in Nottingham or to assess the specific skills needs of the sector or related barriers to growth. Consequently the ESRB welcomes the opportunity to contribute to remedying this situation by undertaking a review of available evidence and new primary research on skills needs within the sector.

The research team assembled by the ESRB was well placed to undertake this project as they have previously undertaken research on the development of the biotechnology sector in this region (Smith & Ehret 2012, Smith, Rossiter and McDonald-Junor 2017), various aspects of economic development in the D2N2 area and a wide range of consultancy assignments including some relating to the biotechnology sector, and skills research to support policy development in the region.

This project had a number of objectives:

- Review the growth of the biotech/life science sector in Nottingham and consider the key factors that have led to its expansion;
- Review available mapping evidence on the scale and nature of these sectors in the D2N2 area;
- Review and synthesise available research evidence on the nature of skills requirements in these sector and related barriers to business growth and development;
- Undertake new primary research into the skills requirements of these firms operating in the D2N2 area – this will take the form of a telephone survey of local businesses.
- Make recommendations for future skills provision and related business support for D2N2 and local stakeholders.

Figure 1 Research Themes



1.1 Approach

The project entailed a 'mixed methods' research process that combined a review of existing research evidence and a survey of local life science and bioscience companies.

The nature and extent of growth of the life science sector in Nottingham was measured by analysing a variety of business databases including those compiled by BEIS/The Office for Life Sciences (Srength and Opportunity dataset), Medilink, FAME and other official sources such as the ABI.

Our desk based research considered a range of documentation that relates to the life sciences and bioscience sector, and innovation activity in the wider D2N2 area and elsewhere. We also reviewed academic and public policy work from elsewhere in order to capture insight that will help us to further develop our conceptual framework.

The key outputs of this task include:

- Review available mapping of growth of the life science sector in Nottingham
- A review of research and policy documents relating to the growth of Bioscience related sectors in the North and Midlands.
- Synthesis of available evidence on sectoral skills needs

These outputs informed the design of the survey research instrument. We also drew on tried and tested question sets that have been used for the National Employer Skills Surveys. This provides the added benefit of allowing comparison of some indicators with other sectors/localities.

A telephone survey of bioscience/life science companies in D2N2 was undertaken. This survey collected quantitative and qualitative data that populate our baseline and fed into the assessment of skills requirements and barriers to business growth.

The sample was drawn from the Strengths and Opportunities (BEIS) database supplemented with membership databases from BioCity and Medilink and our own database of bioscience start-ups since 2004 (a product of previous NBS research relating to this sector) and data collated by Incudata.

Fieldwork was sub-contracted to a specialist agency, QA Research with extensive experience of undertaking surveys of this kind and a strong track record of research involving biotech businesses.

2 What are life sciences and the biotech industry?

The term life sciences is broad. It typically embraces both bio-pharmaceuticals and medical technology. Biotechnology forms a major part of the former and includes the development of new therapies. Bio-pharmaceuticals can be divided into core activities (i.e. drug development) and service activities such as the provision of contract research services. Contract research services have increased in importance with the growth of R & D outsourcing. A similar division applies to medical technologies, although a much smaller proportion of firms are involved in the provision of services.

Biotechnology can be defined as the application of advances in biological knowledge relating to cells and genes to the development of marketable *products, processes, or services*. Examples include the development of new therapies, new diagnostic techniques, cloning and genetically modified crops and foods. These advances can be grouped into three broad categories: (1) new modes of synthesis that have expanded the range of potential agents that can be used as drugs, (2) new knowledge about the underlying biological mechanisms of disease and the targets for drug discovery, and (3) new design and screening methodologies that have facilitated the search for new drugs based on biological information (Pisano, 2006b). The application of advances in biological knowledge in this way entails the use of a wide and growing range of laboratory techniques in order to manipulate and alter the nature of the organisms involved for a particular purpose, such as the biological synthesis of pharmaceutical compounds (UN Convention on Biological Diversity, Art. 2). The industrial aspect of biotechnology is inherently based on the commercial exploitation of these techniques and the outcomes produced.

Based on this definition, the biotechnology industry, unlike many others, is defined more by the technologies that are employed (i.e., the systematic manipulation of living systems) and less by the products that are produced. What also marks biotechnology out as a ’novel industry’ (Prevezer, 2001) that differs from most others according to some leading writers (Pisano, 2006b), is the convergence between science and business. Hitherto business has made extensive use of developments in science but the two fields have remained separate. In the biotechnology sector in contrast the two fields increasingly overlap as science businesses are created and engage in seeking scientific advances that can be appropriated through what Pisano (2006b: 9) terms, 'the monetization of intellectual property'. The biotechnology sector isn't only unusual in the manner in which it brings science and business together. Other distinctive features include: the proliferation and prevalence of small science-based firms, the importance of linkages between the private and public sectors, especially public institutions such as medical schools, universities and research institutes (Shohet, 1998) and collaborations with large pharmaceutical companies. While it is important to understand the role that these different features of the industry play, it is equally important to have an understanding of the historical context surrounding the development of the biotechnology industry. Understanding the elements that have led to the growth of the industry will allow us to determine what aspects need to be addressed in order to maintain the growth of the industry and tap into the potential for further advancement in this and other industries.

The advances and outputs that occur within biotechnology have applications in a variety of sectors of which the main ones are pharmaceuticals, healthcare, medical devices, diagnostics, agriculture, food and environment (Bacon, 2003). This has led to biotechnology being labelled as an 'enabling technology' or a general purpose technology (GPT). The advancement of biotechnology is often compared to the impact that the steam engine had on pre-industrial economies (Rosevear & Jones, 2013). But while some claim that economic success in the twenty first century will be defined by the life sciences (Rosevear & Jones, 2013), there are others who are sceptical arguing that the industry has yet to yield the returns anticipated (Pisano, 2006a).

2.1 Origins of the Biotechnology industry

While many of the key scientific advances underpinning the development of biotechnology occurred in the UK (see table 1), it was the US that pioneered the commercialization of these advances, utilizing new fledgling start-up companies in which scientists took a leading role. Commercialization began in the mid-1970s when Nobel prize winning scientist Herbert Boyer, teamed up with Robert Swanson of venture capital firm Kleiner Perkins to establish the first biotechnology company, Gentech, based in San Francisco to synthesize human insulin using recombinant DNA (Ehret, McDonald-Junor and Smith, 2012). They were soon followed by other similar biotechnology start-ups companies like Biogen in 1978 and Amgen in 1980. Between them they served as 'lighthouse' companies (DTI,1999) providing an influential model for biotechnology start-up companies not only in California but in Massachusetts as well. The US's early and very substantial lead in the development of a biotechnology sector comprising small science-based start-up companies was the result of close collaboration between the institutions involved – state and federal research agencies, universities and venture capitalists (Shohet, 1998). However there were also significant 'structural differences' (Shohet, 1998) between the US and Europe. These differences reflected a more supportive environment for such developments in the US and included factors such as: more generous funding of the science base, the availability of funding in the form of venture capitalists, and the willingness of large pharmaceutical companies to support start-ups through strategic alliances (Prevezer, 2001). Another major structural difference was the relative ease with which scientists employed as academics could found biotechnology start-up companies whilst retaining their academic posts. In Europe in contrast it was often difficult for academics to be involved in industry related activities. In Finland for example academics were expressly forbidden to work in private sector organisations providing 'research services' on the grounds that it would compromise academic freedom and independence (Kostiainen and Sotarauta 2003).

Table 1 Key Biotechnology-related scientific discoveries.

Date	Innovation	Scientists	Country
1953	**DNA Structure**	**Watson/Crick**	**UK**
1974	In vitro recombinant DNA	Cohen/Boyer	US
1975	**Monoclonal antibodies**	**Milstein/Kohler**	**UK**
1977	**DNA Sequencing**	**Sanger et al.**	**UK**
1978	Polymerase chain reaction	Mullis	US
1979	**p53 Cancer gene**	**Lane**	**UK**

1982	**Cascade super fusion bioassay**	**Vane**	**UK**
1985	**DNA profiling**	**Jeffreys**	**UK**
1988	**H2 – receptor antagonist**	**Black**	**UK**
1996	**Transgenic sheep**	**Wilmut**	**UK**
1998	**Antibody protein engineering**	**Winter**	**UK**
1998	**Nematode worm sequencing**	**Sulston**	**UK**

Source: Cooke (2001) cited in Smith and Ehret (2013).

Meanwhile in the UK the Spinks Report in 1980 expressed deep concern about the lack of similar developments (Shohet, 1998). Among its recommendations was that the government funded Research Councils should increase their support for biotechnology. The report also advocated direct state funding to establish a dedicated biotechnology firm to exploit developments arising from the UK science base. The result was the setting up of Celltech, the UK's first biotechnology company, established to capitalise on the discovery of monoclonal antibodies (Jones and Wisdon, 2018) with funding from the government's National Enterprise Board and support from the Medical Research Council. Celltech was to have first right of refusal on Biotechnology discoveries emerging from research funded by the MRC. State intervention was deemed necessary to get the UK industry off the ground, in contrast to the US which by then had nearly 100 dedicated biotechnology firms.

The setting up of Celltech acted as a trigger for the development of the UK biotechnology industry. During the course of the 1980s a modest stream of biotechnology start-ups followed. While most were pharmaceutical related covering both therapeutics and diagnostics, other sectors served included biological reagents, plant biotechnology, veterinary products, and to a lesser extent food and drink, energy and environmental services (Shohet, 1998). However their establishment did not always follow the pattern established in the US where scientists working in universities were the prime movers. As Shohet (1998) has observed large firms played an important role in the early stages in the UK, unlike the US. Thus Delta Biotechnology was established in Nottingham in the East Midlands by Bass Brewers to exploit the commercial possibilities of yeast genetics in 1984. The following year when the pharmaceutical company G D Searle was taken over by Monsanto, research activity was quickly transferred to the US, leading to the closure of Searle's research facilities. At this point two scientists from Searle, Brian Richards and Keith McCullagh, then used their redundancy payments to set up British Biotechnology based in Oxford a major centre of biological research (Shohet, 1998). Other biotechnology start-ups followed centred on Oxford and Cambridge, another major centre of biological research. Cantab Pharmaceuticals in Cambridge followed the model more typical of academic spin-outs in the US, being founded by Alan Munro a leading Cambridge academic specialising in immunology.

2.2 Features of the emerging UK biotechnology industry

Although the pattern of biotechnology company formation was cyclical being strongly influenced by the general level of economic activity, by the start of the 1990s there were according to the Sainsbury Report into biotechnology clusters (DTI, 1999) in excess of 100 biotechnology companies in the UK, making the country the second biggest biotechnology centre after the US and much the biggest in Europe. There were however significant structural differences compared to the US. Thus a much smaller proportion of dedicated biotechnology firms in the UK were engaged in drug development for therapeutic applications. Instead UK firms placed greater emphasis on the provision of services, such as the supply of biological reagents.

In terms of geographical location the firms were heavily concentrated in areas with a strong science base, with well over half located in the so called 'golden triangle' of Cambridge, Oxford and London. Other centres included Scotland and the North West of England. Significantly Nottingham and Leicester in the East Midlands region of the UK in contrast, were described by Shohet (1998: 221) as one of the areas,

> *'where relatively few biotechnology start-ups are to be found, despite highly rated bioscience university departments with strong collaborative links with industry'.*

By the end of the decade however, despite a sharp drop in new entrants caused by the recession of the early 1990s, the Sainsbury Report (DTI, 1999) was reporting that the number of dedicated biotechnology firms in the UK had more than doubled to something over 250 (DTI,1999). Although there were exceptions, such as British Biotechnology which employed some 300 staff, most of these firms were still small with total employment in the sector amounting to 12,000 (DTI, 1999). In contrast in the US at this time there were more than 1200 specialist biotechnology firms employing 150,000.

Although the Sainsbury Report of 1999 noted that a lack of incubator facilities was a significant obstacle to new biotechnology start-up company formation, the first biotechnology incubators were established during the 1990s. Cardiff MediCentre, a joint venture between the local authority, Cardiff University and Cardiff & Vale Health Board opened in 1994, followed by Babraham Bioscience in Cambridge in 1998 and the University of Manchester Innovation Centre (UMIC) in 1999. However while the report found that companies sometimes found difficulty finding premises, when it came to skills the picture was more positive. Thus it was reported that,

> *'In most areas we found that biotechnology companies were generally able to recruit scientists and technicians to meet their needs' (DTI, 1999: 6).*

However while, 'training and skills were not considered a major problem in general', it was noted that there were exceptions one being the recruitment of technicians with appropriate training in, 'Laboratory Practice' (DTI, 1999: 27) and while the report commended the provision of some novel training schemes these tended to be in the form of undergraduate courses provided by universities.

2.3 The Bioincubator boom of the 2000-2008

Following the Sainsbury Report there was a big expansion of bioincubator capacity right across the UK (see table 2), reminiscent of the science park boom of the 1980s (Oakey, 2012), though this time without the same level of media attention. By 2010 there were 20 biotechnology incubators in the UK, the vast majority of which were new having been established during the course of a decade. Although they were not all set up on university campuses, nonetheless the active involvement of universities in most of them was an indication of government policy at this time which was keen to encourage academic entrepreneurship, especially the commercialisation of research by academic staff through the formation of spin-off companies (Ehret et al., 2012). This was a function of government policy at national and local levels. Crucially important here were the regional development agencies (RDAs) established by New Labour early in its first term. A key part the RDAs' remit at this time was the implementation of the government's cluster policy. The DTI was particularly keen to see the RDAs develop knowledge based industrial clusters (Swords, 2013) and since the Sainsbury Report specifically focused on biotechnology clusters, the setting up of biotechnology incubators designed to promote the development dedicated biotechnology firms was timely and aligned especially well with government policy. Not only that, there were now significant resources that the RDAs could draw upon. These included a £50 million 'Incubator Fund' made available through the Small Business Service and a £50 million 'Regional Innovation Fund' and in some instances the European Union in the form of the European Regional Development Fund (ERDF) (Wynarczyk and Raine, 2005: 208). The fact that several of the RDAs including EMDA in Nottingham prioritized biotechnology and healthcare as a growth sector as part of their Regional Economic Strategies helps to account for both the number and the distribution of biotechnology incubators established during the 2000s (Ehret al., 2012).

Table 2 Biotechnology incubators in the UK, 2010

	Incubator	Location	Region	Size: firms	Start date	Size: m^2
1	Babraham	Cambridge	East	31	1998	7,000
2	BioCity Nottingham	Nottingham	E..Midlands	67	2003	12,000
3	BioPark Herts	Welwyn	East	25	2006	4,750
4	Bradford Bioincubator	Bradford	Yorks & Humberside	10	n/a	n/a
5	Cardiff MediCentre	Cardiff	Wales	16	1994	1,770
6	CELS Bioincubator	Newcastle	North East	5	n/a	372

7	Colworth Science Park	Bedford	East	16	2004	1,909
8	DiagNox	Oxford	South East	12	2000	300
9	Imperial Incubator	London	London	21	2006	2,230
10	Leeds Bioincubator	Leeds	Yorks & Humberside	10	2007	2,044
11	London BioScience IC	London	London	10	2001	1,800
12	Manchester UMIC	Manchester	North West	29	1999	9,320
13	MerseyBio	Liverpool	North West	23	2004	1,718
14	Norwich Bioincubator	Norwich	East	19	2002	1,860
15	Papworth Cardiothoracic	Cambridge	East	4	2006	1,300
16	Queen Mary BioEnterprises	London	London	n/a	2008	3,683
17	Roslin	Edinburgh	Scotland	18	1999	2,000
18	Sheffield Bioincubator	Sheffield	Yorks & Humberside	4	2005	2,700
19	Tetricus Bioscience	Salisbury	South West	6	2002	2,090
20	York BioCentre	York	Yorks & Humberside	13	2003	3,000

Source: Ehret, McDonald-Junor and Smith (2012)

3 Restructuring, Open Innovation and Outsourcing in the Pharmaceutical Industry

While the incubator boom was increasing the UK's stock of small dedicated biotechnology firms and in the process increasing the demand science graduates and trained laboratory technicians, changes taking place within the pharmaceutical industry were having the opposite effect on labour supply, though this would not manifest itself until the longer term.

Table 3 Mergers and acquisitions in the pharmaceutical industry, 1989-2000

Year	Companies	Countries
1989	Dow/Marion	US/US
	Bristol-Myers/Squibb	US/US
	SmithKline/Beecham	US/UK
1990	Rhône-Poulenc/Rorer	France/US
	Roche/Genentech	Switzerland/US
1994	SmithKline Beecham/Sterling Health	UK/US
	BASF/Boots	Germany/UK
	American Home Products/ American Cynamid	US/US
	El Sanofi/Sterling Drug	France/US
	Roche/Syntex	Switzerland/US
1995	Glaxo/Wellcome	UK/UK
	Hoescht/Marion Merrell Dow	Germany/US
	Pharmacia/Upjohn	Sweden/US
	Rhône-Poulenc/Fisons	France/UK
1996	Ciba-Geigy/Sandoz	Switzerland/Switzerland
1997	Roche/Boehringer	Switzerland/Germany
1999	Hoescht/ Rhône-Poulenc	Germany/France
	Astra/Zeneca	Sweden/UK
2000	Glaxo Wellcome/SmithKline Beecham	UK/UK
	Pfizer/Warner-Lambert	US/US

Source: Owen (1999)

During the 1990s the pharmaceutical industry was subject to a succession of mergers and acquisitions (see table 3). At least two key factors lay behind this, a slowdown in the discovery of new blockbuster drugs (Jones and Wisdon, 2018) and moves by national champions to internationalise so that they could compete on a global scale (Owen 1999). In the UK Beecham merged with SmithKline of the US, Glaxo merged with Wellcome, Zeneca merged with Astra of Sweden and Boots was acquired by BASF of Germany. Finally in 2000 Glaxo Wellcome and SmithKline Beecham. Inevitably this consolidation led to some re-structuring and the closure of some sites. In the case of Glaxo Wellcome the merged group reduced its R & D staff from 11,500 to 9,500 as the latter's long established R & D laboratories in Beckenham, Kent were closed (Owen, 1999). However it was to be the following decade of the 2000s before the full impact of this industry consolidation was felt.

During the course of the 2000s, what has been described as a 'seismic shift' (Crocker, 2011: 6) took place in the pharmaceutical industry, as large incumbent pharmaceutical companies sought to move away from the vertically integrated model of new drug development that had been the dominant model throughout the second half of the twentieth century (Corley, 2002). In pharmaceuticals as in other sectors, many firms had for some time been gradually reducing their reliance on internal R & D (Whittington, 1991). Faced with pressure from the financial markets pharmaceutical companies increasingly sought to curb expenditure on R & D (Jones and Wisdon, 2018). This, together with scope for rationalisation following mergers and acquisitions led to a spate of closures of R & D laboratories (see table 4).

Table 4 Pharmaceutical R & D Laboratory Closures in the UK

	Company	**Location**	**Redundancies**	**Date**
1	G D Searle/Monsanto	High Wycombe	250	1986
2	Glaxo Wellcome	Beckenham	1,000	1997
2	Knoll/Abbott	Nottingham	450	2001
3	Roche	Welwyn	700	2005

4	AstraZeneca	Loughborough	1,200	2010
5	Merck	Glasgow	250	2011
6	Pfizer	Sandwich	2,400[a]	2011
7	AstraZeneca	Alderley Park	1,600[b]	2014

[a] includes all staff not just R & D staff; [b] includes staff transferred to Cambridge

This reflected the earlier consolidation together with the imminent expiry of patents on some blockbuster drugs, a squeeze on healthcare budgets worldwide, and a lack of new drugs with good prospects in the pipeline despite the expenditure of billions on research (Hirschler and Kelland, 2010). Another factor was the advances in the life sciences and the increasing number of dedicated biotechnology firms able to capitalise on these advances both in terms of drug discoveries and what Mittra (2007: 281) describes as 'economies of scale and scope in early stage R & D ….as industrialised automation technologies began to complement traditional craft-based experimentation'. The emergence of new life science technologies for drug discovery, coupled with the revolutionary potential of a new biomedical paradigm, prompted many pharmaceutical companies to re-configure internal R & D processes and exploit creative strategic relationships with small biotechnology firms taking the role of external innovators (Mittra, 2007). Hence pharmaceutical companies increasingly made use of outsourcing using open models of innovation (Chesbrough, 2006), because it offered the prospect of buying promising new drugs from biotechnology start-up companies established to commercialise discoveries originating in universities, as well as providing scope for buying in specialist research services.

Evidence of this trend is highlighted in the proportion of research carried out externally for pharmaceutical companies. Historically this had been low. However as Jones (2000) points out, what he describes as 'extramural R & D' by UK pharmaceutical companies increased from 5.04% in 1989 to 15.40% in 1995. It then levelled off before rising again at the end of the decade to reach 25.76% in 2003 (Howells et al., 2007). This trend to greatly increased external R & D duly fed through to fuel the growth of the biotechnology sector in the first decade of the twenty-first century.

However another manifestation of this trend increased reliance on outsourcing of R & D by pharmaceutical companies was a wave of laboratory closures during the 2000s as pharmaceutical companies cut back on in-house R & D (see table 4). As table 4 indicates this resulted in substantial redundancies for science-trained laboratory staff. The redundant buildings fared somewhat better as a number were converted into biotechnology incubators. The leading example of this was in Nottingham where the former Boots laboratories in Pennyfoot Street were gifted to Nottingham Trent University which, in collaboration with the University of Nottingham and the East Midlands Development Agency (EMDA) established the BioCity incubator (see table 2). Hence laboratory closures actually helped to stimulate the growth of the biotechnology sector in some parts of the country and specifically in Nottingham.

4 The Decline in Laboratory Technician training

As the large pharmaceutical cutback on the scale of their internal R & D so they also cutback on training. Historically pharmaceutical companies operating large R & D laboratories could justify training substantial numbers of technicians. Typically this training took the form of attendance on day release and evening courses run by science departments in locally based colleges and polytechnics. Laboratory closures and staff redundancies brought this to an end. In the short term this had little impact on the supply of staff, as there was scope for redeployment. But in the longer term it led to a decline in the supply of laboratory technicians. Small biotechnology start-up companies lacked the scale and the resources to undertake technician training. As one such firm in a recent survey of biotechnology in the North East region graphically explained, '*we do not train our own technicians, we do not have the time or the resources*' (Macdonald-Junor, 2018). The interviewee went on to explain that his company instead had a policy of 'buying-in' suitably qualified technicians, and there is every reason to believe that this typical of small biotechnology firms.

At the same time as pharmaceutical companies were cutting back on the numbers of technicians they trained so changes in the higher education system were cutting back on the opportunities for training. For many years higher education in the UK operated as a binary system which divided/differentiated the universities offering exclusively undergraduate and postgraduate degrees that they devised and controlled on one hand from the polytechnics and colleges, who offered a much broader range of programmes in a wide variety of different modes of study including part time day release and evening courses. The 1991 Further & Higher Education Act abolished the binary divide as polytechnics & colleges become universities. Now able to award their own degrees many, like Nottingham Trent University, began to phase out sub-degree/BTEC work or transfer it to the FE sector, preferring instead to focus on full time degree provision for national and international markets at the expense of provision for local markets. As table 5 indicates, the result was a significant decline in part time sub-degree/BTEC/professional courses (e.g. HNC) – exactly the sort of courses that trained technicians.

Table 5 Decline in part time courses in higher education

Courses	**2006/07 – 2015/16** **(% change)**
1st degree	-12.6%
Other undergraduate	-65.0%
Postgraduate	-14.3%
Total	

Source: Patterns and Trends in UK higher education 2017, Universities UK

5 Life Sciences sector in the UK: current picture

Post 2010, there were significant national policy changes that impacted the biotechnology sector. The RDAs which had hitherto had both the remit and the resources to support the growth of the biotechnology sector were abolished. They were replaced by Local Enterprise Partnerships (LEPs) covering a more limited geographical area and with a more limited mandate. At the same time the Coalition government's austerity programme resulted in a big decline in public funding to support biotechnology. These policy changes combined with the onset of recession following the 2008 financial crisis led to a fall in the formation of new biotechnology start-ups (Crocker, 2011). A total of 290 new life science companies were formed in the five years 2006-10 compared with 315 in the period 2005-9 (Crocker, 2011). Although the fall was relatively small, it was felt most keenly in the peripheral regions of Scotland, the North-West and Yorkshire & Humberside.

Despite this blip by 2012 the total number of biotechnology companies in the UK comprised 1036 firms, employing 26,941 staff and generating £4.1 billion in turnover (McDonald-Junor, 2015). This compares with just 207 biotechnology companies in the mid/late 1990s according to a study by Cooke (2001).

After 2012 the formation of biotech companies returned to levels seen in the early 2000s (Crocker, 2017) with a further 332 new start biotech firms formed 2012-16. As in the past the golden triangle of Cambridge-London-Oxford attracted the greatest number of start-ups with 54% of the total in this region (Crocker 2017). This growth in part reflected a switch as private sector funding replaced the relatively high levels of public funding available in the past.

The UK Government's Office for Life Sciences currently divides the life sciences sector into two main segments: bio-pharma and medical technology (see table 6), where the former comprises the development and production of human therapeutics (i.e. biotechnology narrowly defined), while the latter embraces the development and production of medical devices. Each of these segments in turn comprises core and service elements, where the core activities in each case are supported by large specialist UK based service sectors (i.e. contract research organisations). Table 6 shows that currently of the two segments, bio-pharmaceutical is much the more valuable generating more than two thirds of the turnover

(68.5%) while employment is almost equally divided with bio-pharma having 49.4% and medical technology having 50.6%. In both segments the core element is much more significant in terms of turnover than the service element. However when it comes to employment in the bio-pharma segment employment in the service element is very substantial at 54,900 and on a similar scale to the core element with 64,100 employed. This almost certainly reflects the growth of external (i.e. so called 'extra-mural') research provided by contract research organisations. In the medical technology segment the division between core and service activities is much clearer with the former being much bigger both in terms of turnover and employment.

Table 6 UK Life Sciences sector 2017

	Bio-pharmaceutical		**Medical technology**		Total
	Core	Service	Core	Service	
No. of Firms	673 (11.9%)	1,393 (24.7%)	2,604 (46.1%)	979 (17.3%)	5,649
Employment	64,100 (26.6%)	54,900 (22.8%)	97,300 (40.4%)	24,600 (10.2%)	240,900
Turnover	£33.3bn (47.3%)	£14.9bn (21.2%)	£17.8bn (25.3%)	£4.4bn (6.2%)	£70.3bn

Source: Office of Life Sciences (2017)

In terms of geographic distribution, the bio-pharma core is heavily concentrated in the South of England and the North West, with the South East, East and London regions together with the North West being home to 82% of the employment in this sector (Office for Life Sciences, 2018). Medical Technology in contrast is less concentrated and much more geographically dispersed with the four most prominent regions, the South East, East, Scotland and the North West having 57% of employment.

6 Nottingham's life sciences and biotechnology cluster

Despite being home to one of the UK's first biotechnology companies, Delta Biotechnology, set up in 1984 and based in Nottingham, the East Midlands region was not identified in the Sainsbury Report of 1999, which looked at the distribution across the UK of biotechnology clusters comprising agglomerations of small biotechnology firms, as being home to a significant number of such firms. Similarly Shohet (1998: 221) noted that, 'despite highly rated bioscience university departments with strong collaborative links with industry' Nottingham, along with its East Midland neighbour Leicester, had relatively few biotechnology start-ups. However despite this, when the German chemical giant BASF sold its Knoll Pharmaceuticals division in 2001 and decided to close the former Boots research laboratories on Pennyfoot Street in Nottingham in 2001, the company gifted the facility to Nottingham Trent University for the express purpose of converting it into an incubator for biotechnology start-ups.

Developed as a joint venture between Nottingham Trent University, the University of Nottingham and EMDA, the first phase opened as the BioCity Biotechnology incubator in 2003 (Smith and Ehret, 2013). By the time the third phase opened in 2009 following an extensive programme of refurbishment, there were some 50 tenants and total employment on the site had risen to just under 400 (Smith and Ehret, 2013). Of these firms around 39 were life science companies, the remainder being service organisations such as patent attorneys and consultancies. The 39 life science companies were themselves divided into two fairly distinct groups. 15 were engaged in drug discovery, that is to say in Pisano's (2006a) terminology, their main function was 'the monetization of intellectual property'. The remaining 24 in contrast were contract research organizations (CROs) supplying a range of specialist services to facilitate R & D for pharmaceutical companies. By the time plans for the fourth phase of the incubator's development were announced in 2014 there were some 75 companies on site at BioCity and overall employment at the site had risen to 650 staff (Brown, 2014).

The plans for the new extension to the BioCity incubator involved the construction of a new £30million purpose-built facility that would provide an additional 50,000 sq. feet of laboratory and office space. Funded by Nottingham City Council and the D2N2 local enterprise partnership (LEP), the Discovery building as the new facility was named was designed to provide grow-on space for existing BioCity tenants that had developed to the point where they needed more space. Among the first such companies to occupy space in the Discovery building was Sygnature, a highly successful contract research organisation (CRO). It was one of the incubator's first tenants, but had grown to the point where it was employing 150 staff. The opening of the Discovery building in 2017 resulted in a significant boost to employment at the BioCity incubator which by 2020 is expected to reach 1,000 personnel.

The success of the BioCity bioscience incubator led to the development of another similar project in Nottingham. This was MediCity a medical technology, health and well-being incubator based in a former Boots manufacturing facility on the outskirts of the city. Located in Nottingham's newly designated Enterprise Zone and opened in 2013 as part of a collaboration between Boots and BioCity. MediCity currently houses some 16 tenants drawn chiefly from the medical technology and related sectors.

A measure of the success of the BioCity incubator and the extent to which a biotechnology cluster has begun to form in and around the city of Nottingham, albeit not on the scale of Cambridge or Oxford, is the way in which policymakers in the city now see the life sciences sector as an important feature of the local economy and one of its best prospects for expansion and growth. As early as 2006 EMDA's regional economic strategy identified bioscience and health as one of four priority sectors to make the greatest contribution to the region's growth (EMDA, 2006). Similarly in 2012 Nottingham City Council in its growth plan again explicitly identified bioscience as one of the city's leading sectors in terms of its potential for growth (Nottingham City Council, 2012).

7 Life Science activity in the D2N2 LEP area

Just how big is the life science sector within the jurisdiction of the D2N2 LEP?

The previous discussion outlines key events in the development of life sciences in a one part of the D2N2 area, namely the city of Nottingham. The standard industrial classification (SIC) provides scope for building up a limited picture of life science activity over a wider area covering Nottinghamshire and Derbyshire. However as the annual report of the Office of Life Sciences (OLS, 2018: 43) makes clear, “the SIC system does not allow identification of the full range of health life sciences businesses”. In particular it is in the identification of businesses engaged in the provision of services (for example research services provided by contract research organisations) where the SIC system is lacking. Hence trying to identify life science firms in the geographic area covered by D2N2 from the FAME database on the basis of their SIC, permits the identification of core Bio-pharma and Medical Technology firms but not ones providing services. This potentially significantly under-estimates the level of life science activity in the D2N2 area. However despite this it is possible to gain a limited picture of life science activity using the FAME database (see table 7), that at least indicates the geographical distribution of such activity.

According to FAME there are currently a total of 281 firms in the East Midlands region who can be classified as life science firms on the basis that they are engaged in either core bio-pharmaceuticals (SIC 2100 and SIC7211) or core medical technology (SIC 2660 or SIC 3250).

Table 7 Number of firms in the Life Science sector by SIC in 2018

(core Bio-pharmaceutical and Medical technology firms only)

	Bio-pharmaceutical Core firms (SIC 2100 & 7211)	**Medical technology Core firms (SIC2660 & 3250)**	**Life Science (i.e. total)**
Nottinghamshire	94	27	121
Derbyshire	28	22	50
D2N2 LEP	122	49	171

Source: FAME database

In the D2N2 area in contrast there are 171 such firms (see table 7). A number of features of life science activity emerge from table 7. Firstly of the two counties it is very clearly Nottinghamshire that has much the highest level of life science activity (121 firms). Not only that, a high proportion of this activity is in bio-pharmaceuticals with 94 firms[1] in this category compared to just 28 in Derbyshire. Of the 94 bio-pharmaceutical firms, a large proportion comprising some 74 firms, are engaged in 'research and experimental development of biotechnology' (SIC 7211). This undoubtedly reflects Nottingham's knowledge base in particular the presence of a university with a strong record of life science research, a major teaching hospital and one of the largest biotech incubators in the country. In Derbyshire in contrast there are just 16 such firms.

When it comes to medical technology in contrast the two counties are much more evenly matched with 27 medical technology firms in Nottinghamshire and 22 in Derbyshire. Overall however it is Nottinghamshire and Nottingham in particular that has a much higher level of life science activity. It should be noted that these figures significantly understate the level of life science activity in the D2N2 area, as they do not include firms providing services in either bio-pharmaceuticals or medical technology, since such firms are very difficult to identify using

[1] Cambridgeshire has 294 bio-pharmaceutical firms and Oxfordshire 187.

SICs. Given that table 7 shows there to be a total 171 life science firms in the D2N2 area, then taking the data in table 6 as a guide it would not be unreasonable to assume that life sciences in the D2N2 area amount to at least double this number of firms i.e. 350 or more firms. Of these the overwhelming majority are located in and around the Nottingham area.

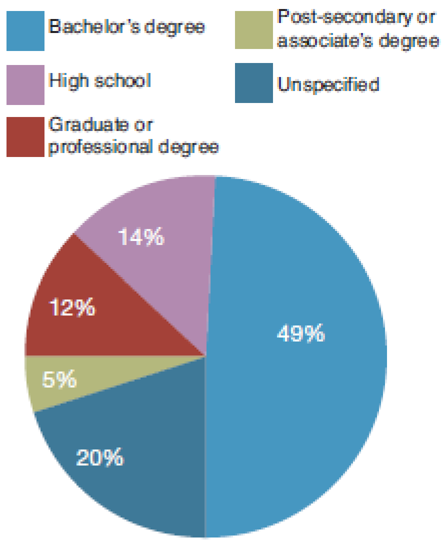
8 Skills in life-sciences

Over the past decade the life sciences industry has performed better than many sectors, adding new jobs at a faster rate (Nugent & Kulkarni, 2013). As the biotechnology industry continues to grow, it "demands a talent pool with a strong knowledge base, with all of the components necessary to translate scientific discovery effectively and efficiently into commercial products" (Nugent & Kulkarni, 2013, p. 853). The follow sections provide an overview of the current skill distribution within the biotechnology industry, as well as how the demand for certain skills is changing.

8.1 Skills distribution

Due to the heavy focus of research and development within the biotechnology industry, it is not surprising to find that a majority of the employees within this industry are educated to a high level, including undergraduate, masters and PhD degrees. Indeed, as Figure 1 below illustrates, just under half of all job postings for biotechnology jobs in the US require at least a Bachelor's degree.

Figure 2 Degree required (% of US life-sciences job postings). Nugent & Kulkarni (2013)



Taking into account the more regulated skills development and education curriculum that exists in the State-level of the USA, it is likely that the job-requirements within the UK biotechnology industry are even more skewed to focus on recruiting University graduates. Indeed, it has been reported that 97% of vacancies within the biotechnology sector are filled by individuals with a minimum qualification of a Bachelor of Science, while 20% of these hold Master's degrees in Science, and 33% hold PhDs (Sector Skills & Competitiveness Statement, Biotechnology). While the current proportion of STEM and Life Science graduates recruited into the biotechnology sector too low to support a claim that supply is insufficient for demand, these graduates are also well sought after in other areas of the economy, which may in the future lead to the supply becoming thinly stretched and the need for other avenues of recruitment to be adopted (Cogent, 2011).

It is expected that a large proportion of the workforce in the industry would need the theoretical and conceptual knowledge gained through a university education to develop new biotechnology processes and applications, however, as the companies expand, the needs of the workforce need to adapt. One of the primary concerns that has been raised is that highly qualified individuals are often recruited for intermediate-level roles, which may not necessarily match their competences and career aspirations.

8.2 Change in demand for skills

It is predicted that skills gaps will continue to emerge across all occupations that are primarily driven by technology, regulation and compliance. The most critical part of the workforce in the industry are the occupations related to science and technology, which are predominantly found in the occupations of managers, professionals, associated professionals, process operatives, and skilled trades. Cogent (2011) projected that the priority occupations for 2017 were:

- Managers – 39,000
- Professionals – 20,000
- Associated professionals – 24,000
- Machine operatives – 24,000
- Skilled trades – 13,000

This projection reflects a continued demand for a highly educated workforce, but indicates a slight disparity of the education level needed for certain occupations (such as machine operative and skilled trade occupations) compared to the percentage of employees recruited with graduate degrees. Nugent and Kulkarni (2013) highlight four distinct requirements for knowledge workers within the biotechnology industry:

- A substantial need for employees with baccalaureate and advanced degrees;
- A significant need for high-school only graduates who can receive industry-specific training from their employers;
- A continued demand for employees with industry-based work experience and industry-specific job skills
- Candidates with advanced or specialized degrees, such as biostatisticians.

While the context of this report must be taken into account – it was developed with the more developed US biotechnology industry in mind – many of the points are still applicable to the sector in the UK. While school leavers are currently not in great demand within the industry, as will be discussed below, the role of technicians and the different skill-set that these workers bring may lead to a change to the skills-distribution currently seen.

Several themes emerged among hiring managers and industry leaders from all sectors of biotechnology (Albo, Dayon, & Conicella, 2015), including:

- Individuals with strong science skills combined with multidisciplinary academic training and experience (commonly referred to as “professional hybrids”);
- Regulatory professionals who can help bridge the gap between regulatory functions and business activities;
- Scientists, engineers, and clinicians who possess cross functional skills that promote strong communication and the ability to interface well with both internal as well as external partners;
- Strong and informed partnerships between academia and industry to provide tailored and relevant training to effectively meet the changing industry needs;
- Marketing, entrepreneurial, and technology transfer skills;
- Foreign language knowledge.

Despite the large proportion of highly qualified and specialised recruitments, there does appear to be a shift in the industry away from senior scientist positions that are narrow in focus. There is now a stronger focus on recruiting individuals who have interdisciplinary academic training, so that they are able to work across multiple areas and in project teams where not all members have to be an expert in all relevant fields (Nugent & Kulkarni, 2013). Similarly, Cogent (2009) have consistently highlighted the importance of combining business acumen and commercialisation skills with scientific knowledge for workers in the life-sciences industry.

It is felt that possession of these wider skills sets will allow employees to work in a wider range of roles and not be limited to one area of the industry; additionally, by promoting increased understanding of different facets of the biotechnology industry, such as services and commercialisation, employees would be able to offer greater insights and have increased levels of understanding of the whole process, from development of a product to selling the product. There is a particular focus on enhancing the skillset which allows for effective translation of scientific outcomes to stakeholders, a commercial market-based mind-set compared to a purely academic mind-set, and the ability to apply the theoretical and practical knowledge to tackle real-world problems (Nugent & Kulkarni, 2013). Thus, while it has been forecast that future employment and overall employment levels will remain relatively static (Holt, Sawicki, & Sloan, 2010), the skills required for these employees is expected to change from narrow and specialized to more diverse.

9 Need for and importance of technical skills/intermediate roles

Technicians are highly productive individuals who are involved in the application of proven techniques and procedures to the solution of practical problems. Generally, technicians have supervisory or technical responsibility and deliver their skillset in the STEM fields (Lewis, 2017). As the term ‘technician’ is currently used in the UK, it denotes individuals occupying technical roles that require either Level 3 or Level 4/5 skills – i.e., intermediate-level skills (Lewis, 2017). As such, technicians include both those people who are involved in skilled trades as well as associate professional and technical roles.

It has been found (see Lewis, 2017) that the overall share of technician roles in the biotechnology workforce is smallest in organisations that are primarily involved with research and development, amounting to approximately five percent of the workforce. The areas of the industry which attracts the largest percentage of technician roles, approximately twenty percent, are those which have a focus on process development and manufacturing. A possible reason for this discrepancy in workforce distribution is that research and development orientated organisations are heavily focused on science-related roles, requiring employees to have at least a Bachelor’s degree. In contrast, organisations which have a focus on processes and manufacturing require dedicated manufacturing technicians to manage the equipment in their pilot plants and development laboratories. Hence as the biotechnology industry matures and the scope of operations moves from being focused on research and development to manufacturing and commercialising the products, the proportion of work carried out by specialist technicians will in all probability increase. This outcome seems to be highly likely with the increased focus of the industry on commercialisation and is particularly relevant to Nottingham which has a high proportion of service-based biotechnology firms; approximately 68% of new jobs created between 2003-2008 were service-based, while only 32% were product based (Smith & Ehret, 2013).

Some biotechnology organisations do not have dedicated technician roles, particularly those organisations focused on research and development, but also those that are more process-focused. As many of the organisations in the industry are still emerging, the volume of work required to justify hiring dedicated technicians does not exist. Others that have a substantial volume of work merely outsource the responsibility. However, there is a third group, that, while large enough to warrant dedicated technicians roles, still have research scientists perform these duties (Lewis, 2017). Some companies that previously would have fallen into this third group have begun to initiate more elaborate divisions of labour within their organisations. As technician roles generally focus on routine tasks, employing dedicated technicians to handle these tasks frees up the more highly qualified specialists to focus on the more intellectual and problem solving work, which has been thought to increase both the efficiency of the work done as well as graduate employees' work satisfaction.

The concept of graduate work satisfaction and the impact it has on the biotechnology industry, among others, is of importance. Even when genuine laboratory technician roles exist in different organisations that could be filled by individuals with Level 3, 4 and 5 qualifications – i.e., intermediate-role qualifications – they are in practice, more often than not, filled by graduates (Lewis, 2017). This often leads to employees performing roles that their qualifications exceed, a phenomenon known as 'over-qualification'. This is common in countries where there is a large supply of graduates, such as the UK, and is often done so that the organisations can skip the costs incurred by training technicians themselves.

Graduates are often willing to begin working at relatively low wages, and thus act as a source of cheap but well-educated labour. However, there are drawbacks. This strategy may bring short-term benefits to the organisation, but, while graduates possess considerable theoretical knowledge, it is often the case that they do not have the practical experience necessarily to apply their skills effectively. Indeed, it has been a source of concern that education students receive, especially in the STEM fields, do not adequately equip them with 'work-ready' skills (Cogent, 2009). Additionally, graduates hired to perform technician-level duties, which are often mundane and repetitive, often become dissatisfied due to this and the low pay compared to other graduate roles. A consequence of this is that these graduates often end up leaving their employer relatively quickly which requires the recruitment, and thus retraining, of new staff.

An important factor to acknowledge when discussing technical roles, is the social and professional status with which they are viewed. It has been argued that that the current status of technicians working in the UK has deteriorated over time and compares unfavourably to the status of technicians in other countries (Lewis, 2017). Additionally, as the role of the technician is one of supporting the work of more prestigious employees, such as scientists, their role tends to remain invisible, exacerbating the aforementioned perspective and incommensurate with the true importance of their work (Shapin, 1989).

9.1 Types of technician roles

There are a variety of different roles that technicians can fill. Lewis (2017) lists three primary types of technicians that exist in the industrial biotechnology sector. These are the laboratory/quality control technicians, the maintenance technicians, and the manufacturing technicians. The qualification requirements and duties of these roles differ, but all can be considered an intermediate-role and essential to the organisations that they work for.

- Laboratory and quality control technician roles require level 3-5 skills and generally fall under two categories. The first category involves the preparation of equipment and materials used for the practical scientific work undertaken by scientists. The second category entails the technicians carrying out various kinds of experiments and tests (such as assays and pH testing). Thus, while a considerable amount of training is needed to fulfil these duties, the tasks themselves are quite repetitive. Lewis (2017) found that these technician roles were most commonly found in organisations who were established manufacturers. In contrast, research and development organisations asserted that the work that is undertaken requires the employees to have at least degree-level skills and knowledge, while the low-level work is either outsourced or undertaken by highly qualified scientists.

- Maintenance technicians can be further divided into mechanical, electrical, and control and instrumentation technicians. While the skills and training needed for these different sub-categories of maintenance technicians is task-dependent, these technicians in established manufacturing facilities typically possess level 3 skills. However, maintenance technicians working in process development facilities may require a higher level of qualification, primarily because the work is involved is not routine maintenance and repair of standard tools and machinery, but rather pilot facilities which will be unfamiliar is some aspects.

- Manufacturing technicians are the most highly qualified intermediate-level employees, requiring Level 4-5 qualifications (i.e., possessing an HNC, HND, or Foundation Degree). This is due to the fact that manufacturing technicians generally do not simply carry out a single, routine production process. They are often required to put in practice a variety of novel, and at times experimental, processes depending on the particular process that is being developed or the kind of product that is being made (Lewis, 2017). Out of the three primary categories of biotechnology technicians, manufacturing technicians are the most difficult to recruit without any additional training. The reason behind this is that as biotechnology is a relatively new industry, a pool of workers who have learned their trade in it has not yet had time to develop (Lewis, 2017).

10 D2N2 Life Science and Skills Survey

In order to go beyond the existing research and policy literature reviewed above, it was decided to undertake a survey of local life science/biotechnology firms in order to explore the extent to which local firms in this sector may have distinctive skills needs or other barriers to their growth and development. This was an ambitious undertaking given the relatively small number of firms known to be operating in this sub-region (see section 7 above).

10.1 Survey Approach

A telephone survey of bioscience/life science companies in D2N2 was undertaken during May and June 2018. This survey collected quantitative and qualitative data that populate our baseline and fed into the assessment of skills requirements and barriers to business growth. The survey design drew on tried and tested question sets that have been used for the National Employer Skills Surveys. This provided the added benefit of allowing us to compare some indicators with other sectors/localities.

The sampling frame was drawn from the Strengths and Opportunities (BEIS) database supplemented with membership databases from BioCity and Medilink and our own NTU/Incudata database of bioscience start-ups since 2004 (a product of previous NBS research relating to this sector). This generated a database of some 430 firms in Derbyshire and Nottinghamshire. It is noteworthy that this compilation data base exceeds the number of firms identified in section 7 on the basis of company data held in the FAME database. It is likely that this is a consequence of our databases including firms that are engaged in biotechnology and medical technology, but for whom this may not be their only or indeed main area of activity. It may also reflect the inclusive nature of the Medilink membership database, coupled with inconsistent definitions of the sector(s) in the different databases used for this study.

Fieldwork was sub-contracted to a specialist agency, QA Research with extensive experience of undertaking surveys of this kind and a strong track record of research involving biotech businesses. The survey was undertaken using a CATI system. The telephone survey achieved a sample of 74 – a 17% response rate. Although this is a respectable response rate for a telephone survey of business, the relatively small achieved sample of 74 firms has limited the extent to which it is practicable or appropriate to drill down/disaggregate within this sample. It is for this reason that findings from this survey should be regarded as indicative. Nevertheless, the survey results are useful in confirming the local relevance of many of the findings that we draw from our review of the wider research and policy literature reported above.

Feedback from interviewers involved in the telephone survey indicated that a common reason given for firms not wishing to participate in the survey was that they did not recognise the terms 'biotechnology' and 'life sciences' as relevant to them. This may be not unrelated to the definitional issues noted previously in this report.

10.2 Survey Results

10.2.1 Location and nature of business

31% were located in Derbyshire and 69% in Nottinghamshire. These findings broadly reflect the spatial distribution of firms reported in section 7 based on our analysis of FAME data. 19 (26%) of the 74 respondents were located at BioCity, Nottingham. This should be no surprise given that this facility in the UK's largest life-science focused business incubation facility. This is also reflected in the wider spatial distribution of the sample. 55 respondents were single site businesses, while 19 declared themselves part of wider, multi-site operations.

When viewed in terms of SIC Sections, those sectors most prominent in our sample were those involved in Professional, Scientific or Technical Activities (SIC Section M), Manufacturing (SIC Section C) and Human Health and Social Work (Section Q). Although these categories are broad, the distribution that they reveal is broadly consistent with the estimates relating to the composition of the sector reported in section 7.

When the nature of firms' activity were probed further, the most common response (32%) was that the firm was engaged in provision of professional support services. Development of intellectual property and provision of research services (19%) were the next most common response, with manufacturing identified as the main business activity by 15% of respondents. We can say that this broad distribution is in line with our expectations of a region outside 'the golden triangle' of Oxford-Cambridge-London where service based business models make up a higher proportion of firms within these sectors.

10.2.2 Company origins

In light of the historic origins of many life-sciences and biotech companies, particularly in the US, it is interesting to note that within our sample the founder's main source of prior experience was typically industrial (70%) rather than academic (14%). We can speculate that this may not be unrelated to the importance of industrial chemistry at Boots and the Pennyfoot Street laboratory in particular in the genesis of the Nottingham life-sciences cluster. This may also be related to the prominence of firms engaged in provision of research services rather than more traditional models of IP exploitation based on new product development.

10.2.3 Location choice

When asked about the nature of their present premises, 19% of respondents identified themselves as located in a life sciences business incubator (such as BioCity); 27% indicated that they were located on an industrial estate; 18% were located at home. For 49% of respondents, this was the company's original location. For 23%, this was a grow-on facility.

Factors cited as reasons for their current location were: availability of space (32%); proximity to customers (23%); working from or proximity to home (21%); and availability of labour (19%).

Taking these two findings together, we may conclude that the availability of suitable premises is likely to be a key attractor of new life science companies to Nottinghamshire and Derbyshire. This does point to the importance of facilities like BioCity and MediCity to the continued development of these sectors locally.

10.2.4 Workforce and retention

Compared to 12 months ago, 62% of respondents indicated that their workforce had remained the same size; 27% that their workforce had increased; and 11% had seen their workforce contract.

15% (11) of respondents said that they have particular jobs in which they have difficulty in retaining staff. Of these, the most commonly cited roles were receptionists/customer facing roles, quality control roles, and care or medical roles. It is important to emphasise the low volume of responses here – hence these figures should be treated with due caution.

Reasons cited for this retention difficulty were: not enough people interested in the type of work; competition from other employers; lack of career progression and geographic location of site.

10.2.5 Recruitment, vacancies and hard-to-fill vacancies

Almost exactly half of our respondents had recruited staff at their site within the last 12 months. 28% of our sample reported current vacancies – the volume of current vacancies ranged from 1 to 10 positions. Half of those reporting vacancies said that they had vacancies that were proving hard to fill.

When asked why these vacancies were hard to fill, respondents cited: a low number of applicants with the required skills; lack of work experience; poor terms and conditions; too much competition from other employers and not enough people interested in the type of work. Again it is important not to regard these responses as no more than indicative given the low cell sizes for these question responses.

When asked about skills that were difficult to obtain from job applicants, the most common response was 'technical, practical or job related skills' (11 of the 16 firms responding to this question).

When asked about specific technical or job specific skills required, the most common responses were: operating quality systems; preparing/maintaining or operating laboratory equipment; and data handling or analysis. These are clearly skills that are often (though not exclusively) associated with technician type roles. Again it was technical, practical and job specific skills that were cited as most important for performing vacant roles in respondent's establishments.

The most commonly cited consequences of hard-to-fill vacancies were increased workloads for other staff; difficulties introducing new working practices; outsourcing work; withdrawal from offering certain products or services; loss of business/orders; difficulties in meeting customer service objectives; and difficulties introducing technological change.

The most common response to these difficulties was said to be use of new recruitment methods or channels.

10.2.6 Workforce qualifications

54% of respondents indicated that more than 80% of their staff were qualified to level 4 or 5 or higher (a degree, HND, HNC or Foundation Degree). 65% indicated that Doctorally qualified staff represent fewer than 20% of the workforce; 50-80% of the workforce in 11% of cases; and more than 80% of the workforce in 15% of respondents. Relatively few employees were qualified to NVQ level 1-2. While the relatively small sample size must caution against over-generalizing from these results, this does confirm the character of the workforce as being relatively well qualified compared to other industry sectors – as one would expect in light of the nature of the work.

10.2.7 HR Practice and training

31 of the 74 respondents (42%) indicated that their establishment has a training plan. 38% indicated that their establishment had a budget for training expenditure. However 58% had funded off-the-job training within the last 12 months. A similar proportion of respondents indicated that they had arranged informal or on-the-job training within the last 12 months.

The most common types of training provision were job specific training (83%), training in new technology (63%), health and safety/first aid (63%), basic induction training (60%), more extensive induction training for new staff (54%) and management training (44%). These percentages are calculated from a base of 48 responses to this question.

10.2.8 Business models and barriers to development.

49% of respondents indicate that there is 'substantial customisation of the offering provided to their customers; 22% report 'significant customisation' and 18% 'some customisation' (question base 74).

Few respondents indicate they are involved in the competing in a market for standard or basic quality products or services. Indeed 90% or respondents indicated that their products or services 'were well above standard', 'very good quality', or 'premium quality'.

73% of respondents indicate that they have a business plan that specifies objectives for the coming year.

When asked to identify barriers to their future development, 41% of respondents cited regulation, 36% access to markets, 36% access to people with the right skills and 34% cited access to finance.

11 Conclusions and recommendations

11.1 The life-sciences and biotech sectors

- Life sciences are about more than just biotechnology, covering medical technology as well and both bio-pharmaceuticals and medical technology involve 'core' and 'service' activities. This can make it hard to identify companies in these sectors – not least because the firms themselves may not identify themselves in these categories;
- The global and national contexts within which the life-science industry exists and operates has changed significantly in the past 20-years. Especially important in the national context is the change in policies enacted by the New Labour government pre-2010 compared to those enacted by post-2010 governments.
- Despite the shifting national and global climate and the challenges (such as the global recession, changes in government and governmental policy, and the subsequent decrease in funding for cluster policy) that have surfaced with these changes, over the past decade the life sciences industry has outpaced many sectors, adding new jobs at a faster rate.
- The importance of the partnership between higher education institutions and industry (as well as government) is highlighted under the Triple Helix theory.
- The D2N2 area is estimated to have in excess of 400 life science firms. Well over two thirds are located in Nottinghamshire, chiefly in and around the city of Nottingham which is home to a life sciences cluster;
- Nottingham's life science cluster has a strong presence in the bio-pharmaceutical field centred on the BioCity incubator;
- The BioCity experience, wider experience of the sector during 2000-2008 and our survey of local companies confirm the importance of suitable premises, if the sector is to continue its growth locally; and
- Although there are a significant number of core bio-pharmaceutical firms in Nottinghamshire evidence from the BioCity incubator, indicates a particular strength in the provision of research services. Typical of these is the contract research organisation Sygnature based at BioCity;

11.2 Employment and skills in life-sciences and biotech

- The research literature indicates a shift in demands for skills in these sectors from highly specialized individuals who are experts in a narrow field, to those who have a broader skillset including both inter-disciplinary science and business acumen.
- Graduates are often recruited to roles that are more suitable to technicians, which has been suggested to result in lower levels of retention and greater turnover of staff.
- Despite cyclical setbacks the life science sector has grown steadily in recent years and currently comprises more than 5,000 firms and 200,000 employees in the UK;
- Increased use of R & D outsourcing has led to growth opportunities for small specialist life science companies offering research services, but has led to a decline in the training of technicians as large pharmaceuticals companies have reduced the size of their in house R&D establishment;
- There has been a decline in part time vocational courses (e.g. HNC) which have in the past been important for training technicians. This reflects both reduced demand from pharmaceutical companies and reduced supply from universities/colleges;
- Life science companies are overwhelmingly small often employing fewer than 10 staff , consequently they lack the resources to train technicians;

11.3 Recommendations

Future development of the life-sciences and biotech sectors will continue to be influenced by developments within the global pharmaceuticals industry, Government policy and funding and cyclical factors. Nevertheless, a number of areas of activity stand out as being amenable to intervention at the sub-regional or city-regional scale (i.e. the level of D2N2) with the object of continuing to develop local strengths in these sectors:

1. Continued support for the development of specialist business incubation and grow-on facilities suitable for use by life-sciences and biotech companies is important. The development of facilities of this kind, alongside other strengths linked to life-sciences,

have clearly been significant in the emergence of a notable life-sciences cluster in and around Nottingham.

2. The supply of graduates in life-science and doctorally qualified scientists appears adequate to meet the foreseeable need of the sector, but inadequate supply of laboratory technicians appears to be an issue that local stakeholders should explore further. Not least because one consequence of this phenomenon may be under-employment of graduates.
3. Anecdotal evidence suggests that many small firms involved in the sector are unlikely to have the scale of demand or the resources necessary to invest in training of technicians themselves. Local stakeholders may wish therefore to consider development of a collaborative approach to the training of laboratory technicians, in partnership with local colleges and universities.
4. This research has also identified further areas of skills need relevant to the future development of the sector. These are firstly the need for scientists working in a sector characterised by a preponderance of small firms, to have significant business expertise alongside their scientific knowledge. Secondly the importance of commercialisation expertise and thirdly the importance of a positive orientation towards interdisciplinary scientific working. While the last of these may be best addressed in Higher Education, business and commercialisation skills for scientists may also represent areas where the feasibility of collaborative local provision could usefully be explored.

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