

# Future Skills Requirements of the Biopharma-Pharmachem Sector

November 2010



Foreword	3
Executive Summary	5
E.1 Introduction	5
E.2 Scope of Study	5
E.3 Methodology	5
E.4 Sector Profile	6
E.5 Labour Force Profile	7
E.6 Education and Training Provision	9
E.7 International Benchmarks	10
E.8 A Skills Strategy for the Biopharma-Pharmachem Sector	13
E.9 Recommendations	16
Chapter 1 Introduction	20
1.1 Introduction	20
1.2 Objectives	20
1.3 Methodology	21
1.4 Report Structure	21
Chapter 2 Structural Trends and Drivers of Change: Implications for Skills Base	22
2.1 Introduction	22
2.2 Industry Structure	23
2.3 Key Drivers of Change	25
2.4 Conclusion	34
Chapter 3 Profiling the Biopharma-Pharmachem Sector's Labour Force	35
3.1 Introduction	35
3.2 Employment in the Irish Biopharma-Pharmachem Sector	35
3.3 Employment and Occupational Forecasts for the Irish Biopharma-Pharmachem Sector	43
Chapter 4 The Provision of Biopharma-Pharmachem-related Education and Training Programmes in Ireland	46
4.1 Introduction	46
4.2 Second Level	46
4.3 Third Level - Undergraduate	48
4.4 Postgraduate Education	53
4.5 Further Education and Training	58
4.6 Key Chapter Findings	59
Chapter 5 International Approaches: Learnings for Ireland	60
5.1 Introduction	60
5.2 North Carolina (NC)	61
5.3 Switzerland	70
5.4 Singapore	79



5.5	Summary	90
5.6	Conclusions	95
Chapter 6	Future Skills Requirements of the Biopharma-Pharmachem Sector	96
6.1	Introduction	96
6.2	Science and Technology Skills Challenges	97
6.3	Cross-Discipline Areas	101
6.4	Business Skills	104
6.5	Student Work Placements and HEI Staff Placements	110
6.6	Operatives in the Biopharma-Pharmachem Sector	111
6.7	Conclusion	113
Chapter 7	Conclusions and Recommendations	114
7.1	Conclusions	114
7.2	Recommendations	117
Appendices		121
Appendix A:	Steering Group Membership	121
Appendix B:	EGFSN Membership	122
Appendix C:	Sample Company Guide for Singapore Student Internship Program	123
Appendix D:	References to soft skills in course descriptions in North Carolina, Singapore and Switzerland	126
Appendix E:	List of EGFSN Publications 2005 - 2010	129



## Foreword

On behalf of the Expert Group on Future Skills Needs (EGFSN), I am very pleased to introduce this report on future skills requirements of the biopharma-pharmachem sector. The EGFSN has already examined the future skills needs of the biotechnology sector, the food and beverage sector and the medical devices sector. This report completes the EGFSN's analysis of the future skills needs of the life sciences industry.



The biopharma-pharmachem sector, comprising the pharmaceutical and biopharmaceutical industries, has a high economic impact in the Irish economy, providing significant high skilled employment. Ireland has earned a reputation as a world leader in the manufacturing of biopharma-pharmachem products, attracting some of the world's leading pharmaceutical companies and being home to a thriving domestic sector.

The industry is currently facing significant global challenges that are fundamentally altering the structure of the sector. This has particular implications for Ireland, with eight of the top ten global pharmaceutical companies located here. The aim of this report is to examine trends and drivers of change which will have the greatest impact on employment and skills over the 2010-2015 period, and to recommend actions that need to be taken to meet the future skills requirements of the industry. I am confident that the report fully addresses this and that its recommendations, if implemented, will underpin the future development of the industry.

I would like to thank all those who contributed to the production of this report. In particular, all those from industry, academia and expert organisations who participated in interviews and discussions in Ireland, the US, Singapore and Switzerland. Their participation was invaluable in producing this study. I would especially like to express my appreciation to Dr Brendan Murphy who chaired the Steering Group, and to each member of the Group who contributed their time and expertise. I would also like to thank the team in Forfás for leading this project to a successful conclusion.

Finally, I would encourage the prompt implementation of the report's recommendations to help ensure that the biopharma-pharmachem sector is well-placed to succeed in the future.

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Una Halligan  
Chairperson, Expert Group on Future Skills Needs



## Acknowledgements

This study was overseen by a Steering Group, whose membership is set out in Appendix 1. Forfás would like to record its appreciation to Dr Brendan Murphy, Chairperson of the Group, and to each member of the Group for their commitment and contribution.

The Skills and Labour Market Research Unit of FÁS, which forms part of the joint secretariat of the EGFSN, conducted the quantitative research for the report.

Chapter 5 of this study is based on research carried out by the Circa Group Europe Ltd on behalf of the Expert Group on Future Skills Needs. Thanks are due to the industry executives, academics, government officials, and industry organisation executives met during the study visits to North Carolina, Singapore and Switzerland.

Forfás would also like to acknowledge the contribution of many industry executives, academics and staff at expert organisations in Ireland who gave interviews as part of this study.



## Executive Summary

### E.1 Introduction

The Expert Group on Future Skills Needs (EGFSN) recognises the importance of future skills requirements for the health life sciences sector. The EGFSN has already published reports on the supply and demand for skills in the biotechnology sector (2003), the food processing sector (2003, 2009) and the medical devices sector (2008). This report on skills requirements for the biopharma-pharmachem sector completes the Group's analysis of the future skills needs of the life sciences sector.

### E.2 Scope of Study

The overarching aim of this study was to assess the demand for skills in the biopharma-pharmachem sector in the period 2010-2015, and identify what actions needed to be taken to ensure that the supply of these skills is available to drive the future growth of the sector in Ireland. The specific project objectives included:

- Identifying the structural trends and drivers of change in the industry which will have the greatest impact on employment and skills requirements in the period 2010-2015;
- Determining the implications of these trends/drivers of change for employment and the skills requirements of the sector;
- Deducing the implications for education and training suppliers, including curricula and courses in education and training institutes and provision by state agencies, and assessing whether the current skills supply framework can satisfy the industry's future requirements.
- Profiling the sector's labour force in terms of numbers employed by gender, age, educational attainment, nationality, occupation, and forecast employment and occupations to 2015;
- Examining international best practice in education and training provision and applying learnings to the Irish context.
- Assessing the need for upskilling of the current workforce in the sector in order for the industry to develop and compete internationally.
- Proposing future action by public and private sectors to meet the future skills needs of the industry, by recommending concrete steps to be taken and identifying the organisations that will effect implementation.

### E.3 Methodology

The methodology had the following main components:

- Secondary research;
- Analysis of labour market composition;
- Analysis of data on students and higher education courses;
- An extensive stakeholder consultation with enterprise, education and training providers and state agencies in Ireland;
- Study visits to North Carolina, Switzerland and Singapore



## E.4 Sector Profile

The biopharma-pharmachem sector comprises pharmaceutical and biopharmaceutical companies, and has a high economic impact in the Irish economy. The sector employs 25,300 people<sup>1</sup>, with approximately 24,000 employed in support services to the industry, and contributed more than €1 billion in corporation tax in 2008. The industry exported products to the value of €38.2 billion in 2008. Provisional figures for 2009 indicate that exports rose to €42.2 billion, representing 50% of total goods exported<sup>2</sup>.

Ireland is known as a world leader in the manufacturing of biopharma-pharmachem products, attracting some of the world's leading pharmaceutical companies, and is also home to a thriving domestic sector. Eight of the top ten global pharmaceutical companies are located in Ireland, with seven of the top ten pharmaceutical blockbusters produced here. Ireland is also emerging as a leading location for biopharmaceuticals with a mix of start-ups, high growth SMEs and large multinationals located here. Industry leaders including Pfizer, Eli Lilly, Genzyme, Merck, Elan, GeneMedix and Allergan have significant investment in Ireland, which has facilitated rapid growth and development of the biopharma industry. While foreign-owned companies account for 86% of employment in the sector<sup>3</sup>, there has been rapid growth in employment in indigenous companies.

Ireland also provides a world class research landscape, a cluster of pharmaceutical, biopharmaceutical, medical device and diagnostic companies whose reputation is based upon knowledge, flexibility and the ability to deliver.

While the success of the Irish biopharma-pharmachem sector is heartening, the industry is currently facing significant global challenges. Cost pressures, patent expirations, the rise of competition from generic drugs, a shrinking research pipeline and increased consolidation are among the factors that are fundamentally altering the structure of the industry.

The challenge for the industry now is to retain its hard-earned size, scale and reputation by continuing to deliver world-class performance in all aspects of current operations. This will mean developing, embracing and leading the implementation of new concepts of manufacturing and supply-chain excellence. The industry will also need to grow by supporting and nurturing new indigenous biopharma-pharmachem companies while adding greater value within existing companies through a superior offering of new services. This will include on-site innovation such as process and product development, and services such as supply-chain management and corporate services, linking research directly to manufacturing and supply. In addition, the industry must improve its competitive position by reducing its cost base. In this way, the industry can position itself to compete internationally. An appropriately skilled workforce will be an important ingredient to meet that challenge.

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<sup>1</sup> Forfás Employment Survey, 2009

<sup>2</sup> CSO, External Trade Bulletin, September 2009, CSO Database Direct, October 2010

<sup>3</sup> Forfas Employment Survey, 2009

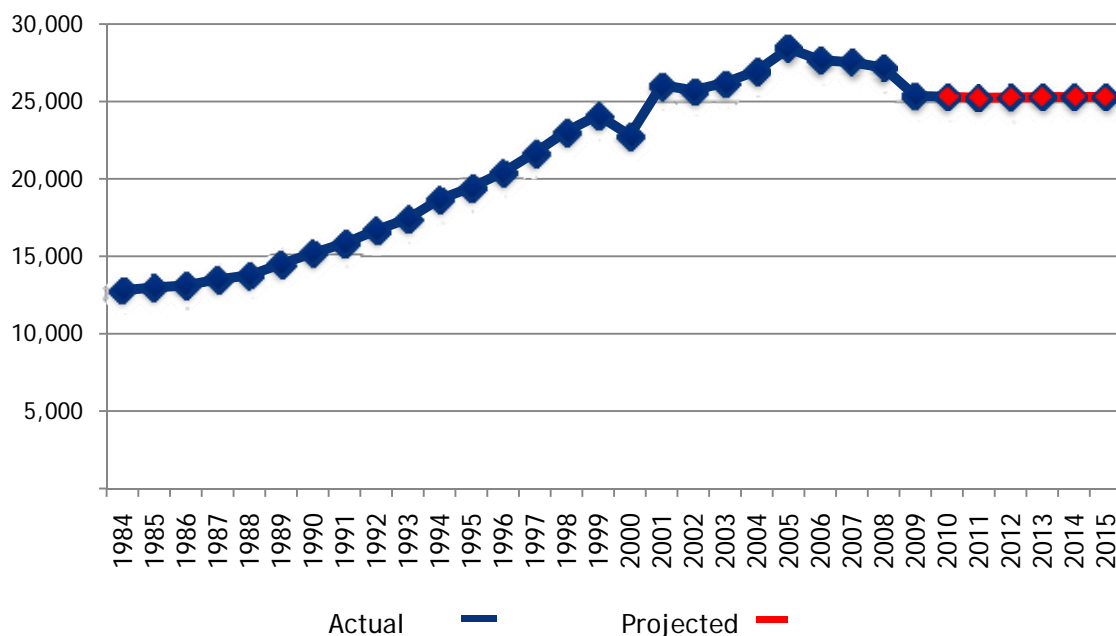


## E.5 Labour Force Profile

Employment in the biopharma-pharmachem sector grew rapidly in the 1980s and 1990s and totalled 25,300 in 2009<sup>4</sup>. The industry has a highly skilled labour force, with educational attainment levels higher than the national average. 46 per cent of the sector's labour force have third level degrees or higher, compared to a national average of 24 per cent. 25 per cent of all PhD researchers employed in Irish industry are employed in the biopharma-pharmachem sector. In 2009, the sector's occupational profile shows that operatives have a 20 per cent share, professional occupations have a 22 per cent share, managers and administrators 18 per cent, and associate professionals (technicians) have a 15 per cent share.

The global biopharma-pharmachem industry is currently undergoing transformation due mainly to patent expiry and consolidation. This change will inevitably result in job losses in Ireland in the 2010-2015 period. These job losses are likely to be balanced by job gains in the biopharma sector, and pharma companies moving to higher value added activities such as process and product development, and services such as supply-chain management and corporate services. If this transformation is achieved, employment in the 2010-2015 period is projected to be static.

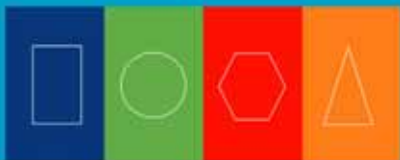
Figure E.1 Biopharma-pharmachem sector employment 2000-2015



Source: EGFSN/industry estimates

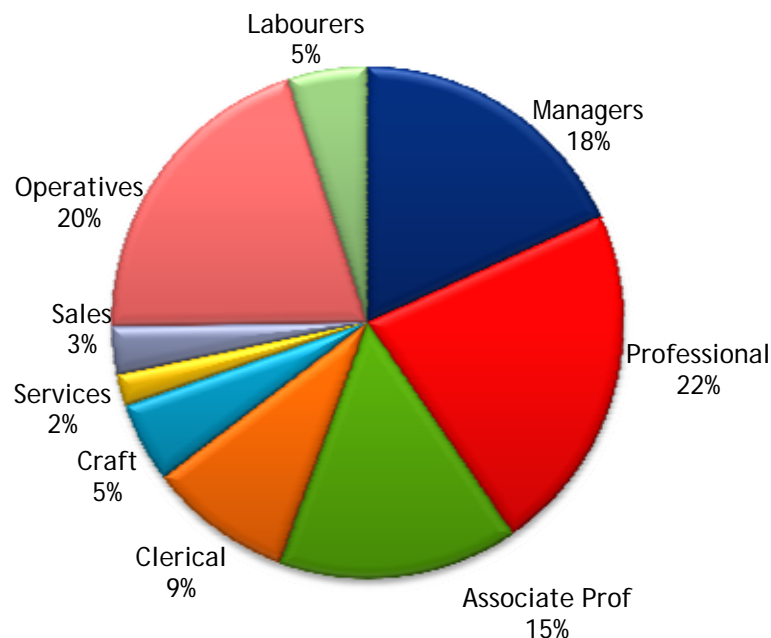
<sup>4</sup> Forfás Employment Survey, 2009





The transformation the industry is undergoing will require a more highly skilled workforce, with the sector's occupational structure reflecting an increased share in professionals and associate professionals, with a significant decline in the number of operatives. It is anticipated that the share of operatives in the biopharma-pharmachem occupational distribution will fall from 20 per cent currently to ten per cent in 2015. This equates to a loss of 2,500 jobs. It is also expected that there will be a decline in the share of crafts persons and clerks and sales persons. If the transformation is achieved, these job losses are anticipated to be balanced by job gains for professionals and associate professionals, particularly chemical, production, mechanical and electronic engineers, biological and other natural scientists, scientific and laboratory technicians and business analysts. The main challenge in the 2010-2015 period therefore will be to retain existing employment levels and position the industry for future growth thereafter.

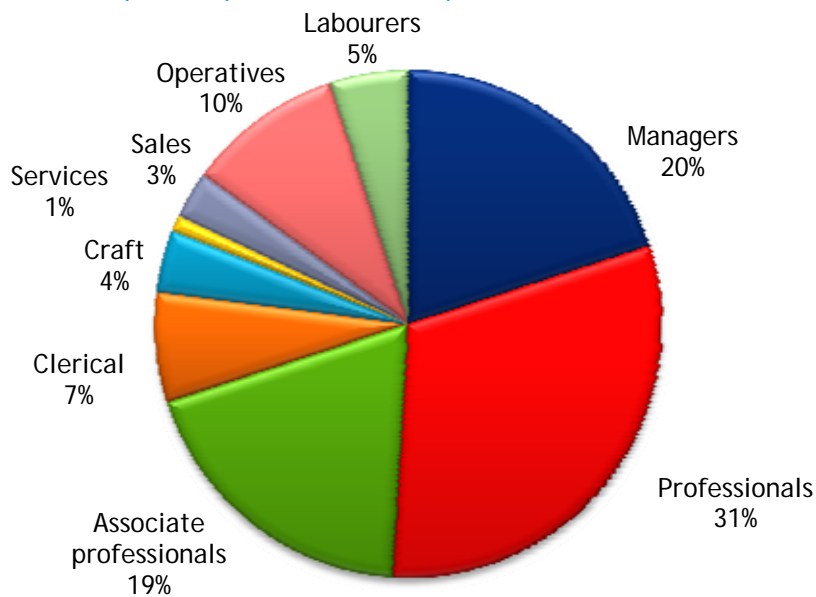
Figure E.2 Biopharma-pharmachem Occupation Profile Q2 2009



Source: Analysis by SLMRU (FÁS) based on CSO data



Figure E.3 Biopharma-pharmachem Occupational Forecast to 2015



Source: Analysis by SLMRU (FÁS)

## E.6 Education and Training Provision

Graduate annual output numbers in biopharma-pharmachem related subjects<sup>5</sup>(approximately 1,100 in 2008) are considered to be sufficient to meet industry demand at technician level (NFQ levels 6/7 and 8). CAO acceptances data suggests that this level will continue for the next three to four years. It is noticeable that high performing students tend to progress to further study before entering the industry.

In 2007 and 2008, there were almost 800 postgraduate awards for biopharma-pharmachem subjects each year. More than half of the awards were for masters degrees, approximately 30 per cent for doctoral degrees, with biology/biochemistry subjects holding the larger share, and less than 15 per cent of awards at certificate/diploma level. There would therefore appear to be sufficient numbers at postgraduate level to meet industry demand.

In 2009, there were 111 major FETAC<sup>6</sup> awards in food science, laboratory techniques and pharmaceutical processing skills, from programmes provided by FÁS and the Vocational Education Committees (VECs). The skills developed by these learners are an important step in developing industry relevant skills and can lead to further progression to other awards on the NFO (e.g. level 7 – Ordinary Bachelors Degree).

<sup>5</sup> Biopharma-pharmachem programmes relate to relevant courses in science but may also include selected courses in other disciplines such as human nutrition and engineering. Chapter 4 provides further detail.

<sup>6</sup> The Further Education and Training Awards Council (FETAC) is the national awarding body for further education and training (FET) in Ireland.



A number of state agencies also provide training and development programmes for the biopharma-pharmachem industry in Ireland. The principal agencies with relevant offerings for this sector are the National Institute for Biotechnology Research and Training (NIBRT), Enterprise Ireland, FÁS and Skillnets. As the industry transforms, this provision will be critical to ensure that the workforce is continually upskilled.

## E.7 International Benchmarks

International best practice in education and training provision was investigated in three locations - North Carolina, Switzerland and Singapore - where skills have played an important role in the success of the biopharma-pharmachem industry. The core objectives of the study visits were to assess views on future skill needs for the biopharma-pharmachem sector through interviews with industry and other relevant organisations, and to review the ways in which skills provision is currently delivered within each region. Of specific interest within the latter objective was to establish the mechanisms by which educational organisations, and development agencies, maintained contact with the industry so as to ensure a continuing supply of appropriately trained expertise.

Industry views on future skill needs were very consistent at all three sites where the main future skills needs were defined as follows:

- **Good basics.** The preference is for graduates that are smart, well equipped with the basics of science, technology and engineering, their core specialisation, and ready to learn. Loading the graduate with a lot of specialisations is widely regarded as a mistake.
- **Understanding of the drug chain.** Graduates need to understand the drug process from discovery to market and the different professional inputs at each stage. Team-working is considered essential, and a cross-disciplinary understanding of other team members' needs and viewpoints. Working in such a system requires a mixture of hard skills and soft skills, including communication, team-building and project management skills.
- **Informatics and Bioinformatics.** There is a widespread view in these three locations that all involved in the drug industry will be increasingly involved in, and often dependent on, analysis and interpretation of large data sets. It is therefore important that industry staff have the ability to understand the basics of data management processes and equipment as a grounding for usage of whatever systems will be used within industry. A good understanding of the statistical principles which underpin the data is also considered an essential requirement.

Other trends and discipline shortages noted during the research included: multi-product facilities, disposable technology and nutrition/medicine interaction.

The processes for education of biopharma-pharmachem staff, and the mechanisms by which educational agencies interact with industry were found to be diverse across the three sites, and are summarised below:



## North Carolina (NC)

- Biotechnology is a priority activity within NC and it has a well-developed biotech sector with 528 companies in a wide range of sectors, including 18 biomanufacturing plants, most of which are multinational corporations (MNCs) with no local allegiance.
- A state agency, the NC Biotechnology Center, has been central to the development of the biotech industry within NC. Among its many initiatives, it has undertaken a process of defining 'model employees' for the biopharma industry and their training needs, through wide consultation with industry.
- A programme - NCBioImpact - to develop and deliver these defined skill needs has been agreed by the State, academia and industry and an \$80m investment has been made in the necessary facilities.
- Relevant education is provided by community colleges (technicians and operatives), and by universities of which there are many of high reputation within the State. However, NCBioImpact has concentrated its programme within two universities, and a selected number of community colleges. These were selected for their expertise in the area, and their extensive contact with industry. The delivery of skills to the sector is therefore concentrated in a small proportion of institutions.
- A high proportion of students seeking training in the community colleges (i.e. technician and operative qualifications) are 'career-changers' who have been made redundant in the furniture and textile sectors. With their experience of manufacturing, and with appropriate basic training, these are highly valued by the pharma industry as entry level staff.

## Switzerland

- The pharma industry is extensive and almost all indigenous, and includes several international players. It has long-standing and traditional mechanisms of operation, and its interests are strongly entrenched in local politics. Because of the importance of the pharma industry to the local economy in Zurich and Basel, industry has significant input to decision-making in the FachHochschulen or Universities of Applied Science (UAS) in these regions.
- The most relevant educational institutions are controlled at local level by the canton (rather than by the Federal Government), and there is a strong imperative within these institutions to ensure training of graduates which are suited for employment by industry. The Universities of Applied Science (UAS) are obliged 'by law' to produce graduates who are '*ready for employment*' and this is reflected in the systems which are in place to ensure that the curriculum addresses industry skill needs.
- Switzerland has a very traditional system of education involving early streaming of children either towards university (about 30 per cent), or to a vocational route involving apprenticeship. A significant strength in terms of training is the excellent practical training which results from the combination of apprenticeship and a UAS degree.



## Singapore

- The biopharma-pharmachem industry is a relatively new sector within Singapore. It is almost entirely foreign direct investment which has been attracted to Singapore primarily by tax incentives, and by its strategic position as an Asian hub with good facilities and living standards.
- Singapore has a very strong central government and agencies. The main economic development agency, EDB, maintains very close contact with industry to assess developing needs and challenges, and the system is highly reactive to any skill or other needs defined by companies.
- The educational system is similar to that in Switzerland in that students are streamed early (age 14) into those who will enter university and those who will pursue a more vocational education route. The educational institutes are also obliged to ensure that economic relevance is a guiding principle of their activities. Consequently, they also involve industry in committees and other advisory groups which define academic services.
- There is an apparently unlimited budget for investment in infrastructure for the sector, and for development of worker expertise through funded training programmes.
- Singapore is not dependent on local graduates for its workforce. It is accepted and encouraged that companies attract staff from all parts of the world to work in Singapore, and a high proportion of staff in industry are foreign nationals.

In summary, the provision of training for the sector is influenced by a wide range of historical, infrastructural and policy issues. In the three locations examined, there are formal processes designed to maintain contacts between the educational institutions and industry. The principal means by which interaction between education institutes and industry is achieved is through industry experienced lecturers in academic institutes, student work placements, and formal consultative groups and processes which are wide-ranging.

In contrast, industry-academia links in Ireland are mainly informal and depend on individuals rather than structures and formal processes. Individual lecturers, departments or institutes may choose to foster links with industry but the current system does not actively support or reward that activity.

The learnings from these international case studies for Ireland's skill provision include:

- Improving industry-academia links through formal processes and incentives
- Embedding business and generic skills in science and technology programmes
- Ensuring that science and technology courses have a practical application
- Structured student work placements that may take place during academic holiday periods
- Including taught components in post-graduate courses

The study visits also revealed that for the companies interviewed in the three locations, there was a unanimous view that the key role in which PhD graduates are required within the industry is for leadership roles within R&D or within process development. This view was consistent at all sites visited. In contrast, PhDs in Ireland are deployed in manufacturing roles as well as R&D. It is likely



that in future the role of PhDs in the Irish biopharma-pharmachem industry will be more in R&D and process development.

## E.8 A Skills Strategy for the Biopharma-Pharmachem Sector

The industry consultation for this study revealed that companies have been broadly satisfied with graduates of the Irish education system. The competencies and expertise of Irish scientists and engineers helped position Ireland as a world-class manufacturing location for the biopharma-pharmachem industry. Now, as the nature and scope of the business changes, so too will the competences required. This will require industry to ensure that its workforce is continually upskilled through continuous professional development (CPD), and keep the education and training sector advised of its changing requirements. Education and training providers will then need to offer appropriate undergraduate, postgraduate and executive education programmes.

It is also considered that there needs to be more collaboration between industry and academia, capitalising on the expertise that exists, wherever that expertise resides. Initiatives will be needed to break down walls between academia and industry, and also within academia and industry themselves, to facilitate collaboration and maximise resources.

A skills strategy for the sector will need to cover the following areas:

### Developing High-level Science and Technology Skills

In overall terms, the biopharma-pharmachem industry's challenges tend to be cross-disciplinary and not confined to a specific scientific discipline. Consequently, graduates should ideally emerge from the education system with their specialism, supported by an overall perspective of how that specialism fits into various scientific and engineering disciplines. The industry requires graduates with good core disciplines and cautions against hybrid degrees which do not provide the level of specialism required.

In order to ensure that Ireland can excel in the skills arena, science and technology programmes will need to better prepare graduates for the industry environment, by strengthening programmes' practical application, encouraging innovation, and better aligning provision with industry's changing requirements. As the industry moves to achieve its strategic objective of engaging in more upstream activities such as process and product development, a specialised skills set is required that has not previously been required of Irish graduates. Higher education institutes (HEI) chemistry programmes will need to cover analytical chemistry, formulation, organic chemistry and crystallisation, while biological science graduates will need competences in cell culture, stem cell research, formulation and vaccine development. Problem-solving, Informatics and bioinformatics are becoming increasingly important for the sector and will also need to be embedded in HEI programmes.



## Strengthening Business Skills

Business skills in the sector are critical and need to be strengthened, as the industry moves to a more service focused business, and engages in downstream activities such as supply-chain management and corporate services. For international companies, this is because traditionally Irish sites have been manufacturing sites, with excellent technical expertise, but have little experience in other functions. In the current environment, these multinational companies now have to manage their sites as a business rather than a manufacturing site, and this will require leadership and business strategy skills. For the indigenous sector, business skills are also a key priority, with most indigenous companies in this sector falling into the SME category. These companies face many of the challenges common to SMEs throughout the economy, including lack of time and resources, and weak management, innovation and entrepreneurship skills.

A changing global market, driven by demographic, socio-economic and consumption trends is having a major impact on markets for biopharma-pharmachem products and services. Ageing populations in developed economies will drive demand for a wide range of treatments to address age related ailments. At the same time, ageing populations and the growth of chronic and lifestyle related conditions are putting significant pressures on healthcare systems globally. The rise of emerging economies as locations of production and markets will also alter the healthcare landscape over the coming decade. The loss of patent protection and the rise of generics is leading to a new business environment, particularly for the pharmachem sector.

Leadership and entrepreneurship, business development and strategy, Information technology, sales and marketing, together with team working, communications, IP management and project management will all be essential skills that need to be strengthened. This should be done at all points of the chain from full-time education programmes to executive education provision.

To help ensure that graduates enter the workforce with some business acumen, it is considered that business modules provided by higher education institutes should be embedded in science and technology programmes. Science and engineering students should learn business skills that apply to the sector in which they intend to pursue careers, so that the skills learned are relevant to the work environment. Student work placements and internships are also considered to be extremely valuable in this regard, giving students practical experience of the workplace environment that complements their academic studies. For those employed in the biopharma-pharmachem sector, mentoring and development programmes for senior management will be required, as will widespread provision to improve the workforce's business skills.

## Achieving Operational Excellence

The Irish biopharma-pharmachem industry needs to continue to deliver world-class performance in all aspects of its business. Companies in the biopharma-pharmachem sector are facing growing pressures to reduce costs and maximise returns on investment in an environment characterised by stringent regulation, loss of patent protection and increasing R&D costs, while maintaining high standards and managing risk. Operational excellence will need to take account of the following:



- Embrace lean technologies, Six Sigma and green technologies to maximise productivity gains and operational efficiencies. This will require training at all levels in organisations and modules in HEI programmes.
- Support manufacturing modernisation through continuous rather than batch manufacturing. This will necessitate modules on engineering processes in science programmes and upskilling of the current workforce.
- Excellence in managing regulatory issues is a key strategic advantage for healthcare companies, and helps bring products to market quickly. The Irish biopharma-pharmachem sector has an excellent track record in this arena and will need to continue this in an increasingly complex environment. This represents an area that could be covered during students work placements or internships, combining theory with practical experience, as well as ongoing professional development for the workforce.
- As the industry changes, operatives will need to be upskilled, capable of working in teams, and skilled in a number of areas, including mechanical changing of equipment, information technology, analytical offline testing, chemical engineering and chemistry. This will enhance productivity and operational efficiencies.

### Developing Blended and Converging Skills

Convergence stretches across pharmaceuticals, biotechnology, medical devices and diagnostics, and has already resulted in the creation of many convergent products. These include products such as drug eluting stents, transdermal patches that transport drugs locally and systematically through the skin, pre-filled, metered dose syringes, injector pens, or inhalers.

Technological convergence requires a skills set that is broader than the traditional skills found in the sector, encompassing mechanical, biomedical and materials engineering, nanotechnology and information technology, as well as the traditional disciplines of chemistry, biological sciences and chemical engineering. Industry requires professionals with a deep knowledge of their core discipline who can work in a multi-disciplinary environment, contributing to a multi-disciplinary team. This will require embedding soft skills such as team-working and communications in undergraduate and postgraduate programmes and postgraduate conversion courses for scientists and engineers.

For process development, blended engineering and chemistry skills are required. Industry needs chemists and engineers with a strong core discipline and a good knowledge of each other's discipline, allowing the development of technologists with both science and engineering skills. Postgraduate conversion courses for full-time students, with modules offered to industry executives, would address this skills challenge.





## E.9 Recommendations

### 1. Strengthen business skills within the sector

This study has identified that business skills in the Irish biopharma-pharmachem industry need to be strengthened. These skills will be essential if the sector is to continue to develop and compete internationally. In particular, the EGFSN recommends the following:

- Business skills should be embedded in science and technology programmes, ensuring that graduates emerge with some business knowledge. For example, this would include innovation, entrepreneurship, IT and lean skills. *(Responsibility: HEA, HEIs)*
- Student work placements should be used to familiarise students with the working environment and to enhance their business acumen *(Responsibility: HEIs, PharmaChemical Ireland, Irish BioIndustry Association)*
- Mentoring and development programmes in business strategy for the industry's senior management will be required to ensure leadership in the sector. *(Responsibility: Enterprise, IDA, Enterprise Ireland)*
- State Agencies should continue to provide programmes that improve the industry's business skills. This will include provision by Enterprise Ireland, including offerings in leadership, lean techniques and sales and marketing. Skillnets will also be a useful vehicle in providing business programmes for indigenous and international companies. *(Responsibility: Enterprise Ireland, Skillnets)*

### 2. Align education and training provision with industry's requirements

The stakeholder consultation for this report revealed that there needs to be a greater alignment of education and training provision with the biopharma-pharmachem industry's requirements. The EGFSN recommends the following in this regard:

- Ensure science and technology programmes are aligned with industry's needs on an ongoing basis. This will include ensuring that course material includes peer review papers as well as textbooks, and reflects current industry practice. Industry will need to ensure that it keeps education and training providers informed of its requirements.
- Informatics, bio-informatics, business and generic skills will need to be embedded into S&T programmes
- Ensure that CPD provision continually meets industry needs and can be delivered in a flexible manner. This will include provision by public and private institutes and state agencies.
- The National Institute for Biotechnology Research and Training (NIBRT) is just beginning to roll out its training programmes. NIBRT will need to ensure that it has access to the best academic research, on an ongoing basis, and that its training programmes are aligned with industry's needs.

*(Responsibility: HEIs, HEA, Enterprise Ireland, FÁS, VECs, Skillnets, NIBRT, PharmaChemical Ireland, Irish BioIndustry Association)*



### 3. Enhance Industry-Academia Collaboration

The research for this study showed that many links between industry and academia in Ireland are informal and rely on individuals rather than structures and formal processes which is not sustainable. The Irish higher education system does not actively support or reward engagement with industry, with performance measures for academic staff focusing on numbers of graduates produced, papers published and funding obtained. In contrast, the study visits conducted in North Carolina, Singapore and Switzerland show that industry-academia collaboration is strong and plays a critical role in ensuring that graduates are equipped with skills required by industry. The EGFSN recommends the following to strengthen industry-academia collaboration:

- Formal structures and processes be put in place to ensure industry involvement in programme design and revision. *(Responsibility: HEA, HEIs, PharmaChemical Ireland, Irish BioIndustry Association)*
- Industry engagement be criteria considered for faculty appointments and promotion. HEI staff could also be encouraged to take sabbaticals to gain industry experience, and measures be taken to ensure that they are not penalised for that in their academic careers. This echoes recommendations of the Innovation Task Force and the Advisory Council for Science Technology and Innovation<sup>7</sup>. *(Responsibility: HEA, HEIs)*
- Industry professionals be used where appropriate in the delivery of course modules where the main expertise is in industry. *(Responsibility: HEA, HEIs)*
- Industry collaboration be a criterion for funding of HEI programmes. *(Responsibility: HEA)*
- Collaboration with research institutes in international locations such as Singapore, North Carolina and Switzerland be explored. *(Responsibility: NIBRT, SFI, HEIs)*

### 4. Develop Structured Postgraduate Programmes

The research for this study indicated that many postgraduate programmes in HEIs are research focused, oriented to the academic profession and do not prepare students for a wider employment market. This corroborates the findings of the Advisory Council for Science Technology and Innovation in 2009<sup>8</sup>, which recommended the development of structured doctoral programmes, moving away from the traditional model of the student-supervisor relationship to a more structured research degree programme including research and generic skills development. The 2009 Forfás report on the health life sciences sector<sup>9</sup> makes a similar recommendation. This is also reflected in cycle 5 of the Programme of Research in Third Level Institutions (PRTLTI) which includes a structured PhD in Life Sciences.


The EGFSN recommends the development of structured research masters and PhD programmes in biopharma-pharmachem disciplines, that would include taught courses as an integral part of the programme, and a student work placement of at least 6 months. Ideally, students would have the option to either complete a masters programme or decide to transfer to a PhD programme after 12-24 months.

*(Responsibility: HEA, HEIs)*

<sup>7</sup> Innovation Ireland, 2010, Report of the Innovation Taskforce; Advisory Council for Science, Technology and Innovation, 2010, Maximising the Environment for Company Research and Development,

<sup>8</sup> Advisory Council for Science Technology and Innovation, 2009, The Role of PhDs in the Smart Economy

<sup>9</sup> Forfás, 2009, Health LifeSciences in Ireland - An Enterprise Outlook



## 5. Develop a standardised student work placement for all HEI biopharma-pharmachem related disciplines

Stakeholders consulted for this study, including industry and HEIs in Ireland and in the three international locations visited, considered student work placements an important part of science and technology programmes, giving students practical experience of the working environment. Yet, large numbers of students taking biopharma-pharmachem related courses in Ireland do not have access to a placement. While most institutes of technology programmes and some university programmes include work placements, it is not commonplace in most university programmes. The research for this study also showed that these placements differ in structure depending on the HEI or individual departments within HEIs. A number of core factors emerged as contributing to effective student work placements and should be progressed:

- Ensure that students taking biopharma-pharmachem related courses have access to a work placement
- Placements should be of 6-9 months duration and incorporate academic holiday periods if necessary.
- A partnership approach between industry, HEIs and students should be encouraged in the provision of work placements
- Placements should be sought in companies in Ireland and abroad
- While every effort should be made to secure placements for students in companies, alternative locations could be explored such as education/research institutes.
- Subject areas where the main expertise is in industry should be covered during the student work placement. This would include areas such as commercial awareness, business development, communication skills and problem-solving. Some technical areas, such as compliance, where industry has the main competence could also be covered.

*(Responsibility: HEA, HEIs, PharmaChemical Ireland, Irish BioIndustry Association)*

## 6. Address the strategic development of the Pharmachem sector by providing dedicated research and training

- (i) The EGFSN recommends that dedicated research and training in areas such as process development, synthesis, process analytical technologies (PAT) and formulation be provided to address the strategic development of the pharmachem sector. This will include horizon scanning of the environment on an ongoing basis to determine research and training needs, and provision of that research and training when demand is identified. While there is a dedicated agency (NIBRT) to address the research and training needs of the biopharma industry, no such facility exists for the pharmachem sector. If the industry is to achieve its strategic goal of increasing on-site innovation such as process and product development, a dedicated research and training resource will be required. This need was also identified by the Advisory Council for Science Technology and Innovation<sup>10</sup>.

The EGFSN recommends that this be done either through institutes that are already in place, such as the National Institute for Biotechnology Research and Training (NIBRT), or developing a separate virtual structure, through existing CSETs for example, drawing from appropriate expertise throughout academic institutions and industry.

*(Responsibility: IDA, SFI).*

<sup>10</sup> Maximising the Environment for Company Research and Development, Advisory Council for Science technology and Innovation, March 2010



## 6. Address the strategic development of the Pharmachem sector by providing dedicated research and training (continued)

- (ii) One such training need in the area of process development was identified in the course of this study and will need to be met in the immediate term. As the industry moves to consolidate its manufacturing expertise by incorporating late stage development, technologists with both engineering and science skills will be required. This calls for engineers and chemists to have strong core disciplines but also a good knowledge of each other's discipline.

The EGFSN recommends that a masters or postgraduate diploma programme in transition skills be developed, with industry driving the course content. These courses, or constituent modules, could also be offered to industry executives to ensure upskilling within the industry.

*(Responsibility: HEIs, HEA, PharmaChemical Ireland)*

## 7. Develop an operative upskilling programme

As the biopharma-pharmachem sector undergoes essential change, the operative role in the sector will also change. Operatives will need to be flexible and skilled in a number of areas, including information technology, analytical offline testing, mechanical changing of equipment, chemical engineering and chemistry. Operatives will also be required to work in teams and will need to develop team-working skills. The EGFSN recommends that:

- An upskilling programme targeted at operatives be developed to include full-time and part-time programmes at NFO levels 6 and 7. Some initial provision at NFO levels 4/5 for those who have been in the workforce for some time, may also be required.
- Funding for this initiative be provided by industry, state agencies, HEA and individuals.
- Provision of these programmes be made available through flexible delivery modes.

*(Responsibility: Skillnets, FÁS, HEIs)*



# Chapter 1 Introduction

## 1.1 Introduction

This study was managed and conducted by Forfás on behalf of the Expert Group on Future Skills Needs (EGFSN). It builds on previous reports published by the EGFSN and Forfás on the health life sciences sector<sup>11</sup>. The overarching objective of the study is to assess the skills requirements of the biopharma-pharmachem sector in Ireland, at all levels from operatives to senior management over the period 2010-2015.

## 1.2 Objectives

The specific objectives of the study were as follows:

- Identify the structural trends and drivers of change in the industry which will have the greatest impact on skills requirements in the period 2010-2015.
- Determine the implications of these trends/drivers of change for the skills requirements of the sector, employment and demand from companies.
- Profile the sector's labour force in terms of numbers employed by gender, age, educational attainment, nationality, occupation, and forecast employment and occupations to 2015.
- Deduce the implications for education and training suppliers, including curricula and courses in further education, at third level institutes, state agencies and private sector institutes.
- Examine international best practice in education and training provision and apply to the Irish context.
- Assess whether the current skills supply framework can satisfy the industry's future requirements.
- Assess the need for upskilling of the current workforce in the sector.
- Propose future action by public and private sectors to meet the current and future skills needs of the industry, by recommending concrete steps to be taken and identifying the organisations that will effect implementation.

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<sup>11</sup> EGFSN The Supply and Demand for Skills in the Biotechnology Sector, 2003; EGFSN The Demand and Supply of Skills in the Food Processing Sector, 2003; EGFSN Future Skills Needs of the Medical Devices Sector, 2008; EGFSN Future Skills Requirements of the Food and Beverage Sector, 2009. Forfás Health LifeSciences in Ireland - An Enterprise Outlook, 2009.



### 1.3 Methodology

The methodology had the following main components:

- Secondary research;
- Analysis of labour market composition;
- Analysis of data on students and higher education courses;
- An extensive stakeholder consultation with relevant stakeholders from enterprise, education and training providers and state agencies in Ireland;
- Study visits to North Carolina, Switzerland and Singapore

### 1.4 Report Structure

**Chapter 2** provides a contextual background to the study, describing the profile of the sector. It examines the key economic indicators for the industry, examines structural trends and drivers of change in the industry and analyses the implications of those trends for the skills base.

**Chapter 3** profiles the sector's labour force in terms of age, gender, educational attainment, nationality and occupational distribution. It also provides employment and occupational forecasts for the sector to 2015.

**Chapter 4** provides an overview of education and training programmes available to the biopharma-pharmachem sector in Ireland as provided by further education providers, third level institutions in the public and private sectors, and state agencies.

**Chapter 5** explores international best practice in education and training provision, examining trends in three international locations (Switzerland, North Carolina and Singapore), where skills have been a key factor in the success of the biopharma-pharmachem sector.

**Chapter 6** outlines the skills requirements of the sector as derived from the stakeholder consultations. It draws from interviews conducted with senior management in industry, key academic institutes and state agencies. This chapter identifies the current and future skills challenges for the sector and highlights any gaps that need to be addressed.

**Chapter 7** outlines the main conclusions and recommendations of the report.



## Chapter 2 Structural Trends and Drivers of Change: Implications for Skills Base

### 2.1 Introduction

The biopharma-pharmachem sector comprises pharmaceutical and biopharmaceutical companies, and has a high economic impact in the Irish economy. The sector employs 25,300 people<sup>12</sup>, and contributed more than €1 billion in corporation tax to the Irish exchequer in 2008. The industry exported products to the value of €38.2 billion in 2008. Provisional figures for 2009 indicate that exports rose to €42.2 billion, representing 50 per cent of total goods exported from Ireland<sup>13</sup>.

The Irish biopharma-pharmachem sector has flourished because of the following intrinsic economic strengths:

- An innovative and resourceful labour force;
- High education standards;
- A proven level of manufacturing and compliance experience;
- An inherent ability to comply with demanding international regulations;
- Competitive corporation tax rates;
- A world class research landscape

Ireland has an enviable history of success in the field, attracting some of the world's leading pharmaceutical companies, and is also home to a thriving domestic sector. Eight of the top ten pharmaceutical companies in the world have Irish facilities, making Ireland one of the premier global locations for the biopharma-pharmachem industry. For example, a significant amount of Allergan's global supply of Botox is made in Westport, while Pfizer's Lipitor, the world's top-selling pharmaceutical, anti-cholesterol medicine is made exclusively in Cork, with revenues of over \$12 billion. The Johnson and Johnson - Centocor investment in Cork also emphasised Ireland's position as a location of choice worldwide for biopharmaceutical activity.

Ireland also provides a world class research landscape, a cluster of pharmaceutical, biopharmaceutical, medical device and diagnostic companies whose reputation is based upon knowledge, flexibility and the ability to deliver.

While the success of the Irish biopharma-pharmachem sector is heartening, the industry is currently facing significant global challenges. Cost pressures, patent expirations, the rise of competition from generic drugs and a shrinking research pipeline are among the factors that are fundamentally

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<sup>12</sup> Forfás Employment Survey, 2009

<sup>13</sup> Central Statistics Office, 2010, External Trade Bulletin, September, Central Statistics Office, 2010, Database Direct, October



altering the structure of the industry. Ireland must now give global companies new reasons to base major facilities here – setting the country apart from competitive economies that are chasing the same investments. Ireland is well placed to do that, building on its reputation for world-class biopharma-pharmachem manufacturing. The challenge now is to embrace the concepts of manufacturing and supply-chain excellence, as well as those of on-site innovation, such as process and product development, thus linking research directly to manufacturing and supply. In addition, the industry must improve its competitive position by reducing its cost base.

The following sections describe how the industry is structured, the key drivers of change for the sector, and the consequent implications for the skills base.

## 2.2 Industry Structure

The biopharma-pharmachem industry forms part of the health life sciences sector which has experienced rapid growth over the past decade. The life sciences sector is a collective term used to describe the pharmaceutical, biotechnology, medical devices and diagnostics sectors.

The life sciences sector is currently estimated to be worth approximately US\$1.2 trillion globally and is expected to grow at rates between three and nine per cent (depending on the sub-segment) to reach more than \$1.5 trillion in 2013<sup>14</sup>.

The life sciences industry has contributed significantly to Ireland's economic development over the past decades and will continue to be vital in driving export led growth in the future. Today the health life sciences sector employs in excess of 50,000 people in over 350 enterprises, with exports reaching approximately €48.9 billion in 2009<sup>15</sup>.

### Pharmaceuticals

Ireland is known as a world leader in the manufacturing of pharmaceuticals and chemicals. Eight of the top ten global pharmaceutical companies are located here, with seven of the top ten pharmaceutical blockbusters produced in Ireland. While the sector is primarily made up of multinational companies, there are also a number of Irish owned pharmaceutical companies, such as Eirgen, TopChem and Merrion Pharmaceuticals.

Traditionally, foreign owned companies have been involved in the production of active pharmaceutical ingredients (API) and/or formulation. More recently, a number of companies have widened their activities to include such areas as supply chain management, international financial management, shared services and headquarter activities. Supported by the development agencies, there has been increased investment in in-company R&D, and in process development in particular. A number of firms are also linked into R&D initiatives being undertaken by research institutes supported by SFI.

<sup>14</sup> Global Pharmaceuticals, Biotechnology & Life Sciences: Industry Profile; and Global Health Care Equipment & Supplies: Industry Profile, Datamonitor, 2009

<sup>15</sup> Central Statistics Office, 2010, External Trade Bulletin, September, Central Statistics Office, 2010, Database Direct, October, Forfás 2010, Annual Business Survey of Economic Impact, October





The past five to six years has also seen the emergence of an indigenous drug development segment from a growing base. It is principally comprised of early stage start-up and growth stage enterprises focused on developing therapies in niche areas such as the treatment of autoimmune disorders. The success of companies such as Élan has encouraged the establishment of a number of start-ups, that include speciality pharma companies such as Azur Pharma, Circ Pharma, and AGI Therapeutics. The concentration of pharmaceutical companies, their length of experience (typically 20-30 years) and the successful regulatory track record within Ireland, combine to create a highly reputable and trusted global supply centre for the industry.

There is a view that the emerging drug development indigenous companies are unlikely to become large scale entities, mainly because of the extent of M&A activity in the sector. Many are likely to develop high value IP licensing and/or partnering models, whereby they license technologies to larger pharmaceutical or biopharma enterprises, or partner with them to bring products to market. In these cases, Ireland's IP, fiscal and legislative structures are particularly important. There may also be potential for these indigenous companies to undertake pilot manufacturing in Ireland, particularly in the context of expanded capabilities in the area of process development.

## Biopharmaceuticals

Biopharmaceuticals are medical drugs produced using biotechnology<sup>16</sup>. Ireland is emerging as a leading location for biopharmaceuticals with a mix of start-ups, high growth SMEs and large multinationals located here. Industry leaders including Pfizer, Eli Lilly, Genzyme, Merck, Elan, GeneMedix and Allergan have significant investment in Ireland which has facilitated rapid growth and development of the industry.

It is estimated that there are 60 biopharmaceutical companies in Ireland, employing approximately 4,000 people<sup>17</sup>. The industry is supported by SFI, EI and IDA investments, industry associations such as the IBIA and BIOConnect, and the National Institute for Bioprocessing Research and Technology (NIBRT), which focuses on process R&D and the skills and training needs of the sector.

The industry has a strong presence in manufacturing and development with companies such as Pfizer establishing globally strategic plants and Eli Lilly building from their pharmaceutical heritage to establish a biopharmaceutical plant in Ireland. The new Wyeth development in Grangecastle, Dublin, now part of the Pfizer Group, is one of the largest integrated biopharmaceutical campuses in the world and is the only facility in Europe to manufacture biopharmaceuticals, pharmaceuticals and vaccines within the same facility. There is also a growing cohort of established indigenous biopharmaceutical companies, including Sigmoid Pharma and Opsona.

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<sup>16</sup> Biotechnology can be defined as the application of biological knowledge relating to living cells and genetic material in order to develop products, processes or services for commercial or medical purposes.

<sup>17</sup> This figure is based on data from the Forfás Annual Employment Survey, the Central Statistics Office (CSO) and the Irish Business and Employers Confederation (IBEC). It is difficult to determine the exact number of companies and employees within the biopharmaceutical industry as the sector has not been assigned an individual NACE (European Classification of Economic Activity) code.



## 2.3 Key Drivers of Change

Nine key drivers of change were identified during the research phase of this study. These were selected based on consultation with international and indigenous companies in the sector, industry representative bodies, state agencies, and extensive secondary research<sup>18</sup>. The following section examines these drivers of change in terms of their implications for employment and skills in the Irish biopharma-pharmachem industry.



### 2.3.1 Cost Competitiveness

Companies in the biopharma-pharmachem sector are facing growing pressures on reducing costs and maximising returns on investment in an environment characterised by stringent regulation, loss of patent protection and increasing R&D costs, while maintaining high standards and managing risk. In Ireland, biopharma-pharmachem companies are especially concerned about high labour and utility costs which impact on the sector's competitiveness. Increased competition from other locations

<sup>18</sup> This section draws from the Forfás report: *Health LifeSciences in Ireland - An Enterprise Outlook, 2009*



with a lower cost base and the cost containment strategies of health services globally, highlight the importance of addressing competitiveness.

The extended period of economic growth over recent years led to significant increases in the costs of doing business in Ireland - particularly in relation to key business inputs such as rents, pay and incomes, utilities and business services. This situation was exacerbated by the over reliance on domestic consumption as the primary source of economic growth. These factors undermined Irish cost competitiveness, making Ireland one of the most expensive locations in the Eurozone to do business. While Irish competitiveness has improved somewhat during 2009-10, particularly with regard to construction costs, there remain significant challenges.

### 2.3.1 a Labour costs

Analysis conducted by the National Competitiveness Council has found that growth in labour costs in Ireland exceeded the EU-15 average between 2004 and 2007. However, growth rates in Irish labour costs slowed significantly in 2008 and the first half of 2009, and were lower than the EU-27 and euro area-16 average<sup>19</sup>. The ESRI have already highlighted the need for wage costs in Ireland to be reduced in order to restore international competitiveness.

In the biopharma-pharmachem sector, total payroll costs in the industry in Ireland amounted to €1.6 billion in 2009, according to the Forfás Annual Business Survey of Economic Impact<sup>20</sup>. This shows a per annum increase of 5.3 per cent in the 2000-2009 period, compared to a per annum increase of 3.2 per cent over the same period for all economic sectors in Ireland. The survey also analyses total payroll costs per employee, and that analysis shows that total annual payroll costs per employee in the biopharma-pharmachem sector amounted to €68,300 in 2009, compared to €53,500 in terms of all sectors. In the 2000-2009 period, this represented a 5.9 per cent per annum change, broadly in line with the total economy which shows a 5.7 per cent per annum change over the same period.

More recent CSO earnings data show a downward adjustment in weekly earnings (including irregular benefits) in most sectors. Average weekly earnings in the economy fell to €682.91 in quarter 1, 2010, down from €709.55 a year earlier, representing a fall of 3.8% over the year. On a quarterly basis, weekly earnings decreased by 4.9% between quarter 4 2009 and quarter 1, 2010. In contrast, in the professional, scientific and technical sector, which is most closely related to the biopharma-pharmachem sector, an annual increase of 0.8% was recorded in weekly earnings, and a 7.2% quarterly increase between quarter 4 2009 and quarter 1, 2010<sup>21</sup>. While it is not yet clear whether this is an ongoing trend, if wages in the sector do not fall, labour costs will continue to adversely affect the competitiveness of the Irish biopharma-pharmachem sector.

<sup>19</sup> National Competitiveness Council, 2010, Annual Competitiveness Report 2010, Volume 1: Benchmarking Ireland's Performance, Forfás, Dublin

<sup>20</sup> Forfás, 2010, The Annual Business Survey of Economic Impact, Dublin

<sup>21</sup> CSO, 2010, Earnings & Labour Costs Survey, Dublin



### 2.3.1 b Non-pay costs

Non-pay costs also represent an area of competitiveness concern for the Irish biopharma-pharmachem sector. These have been the subject of extensive analysis to date, notably, by the National Competitiveness Council (NCC) which concludes that non-pay costs in Ireland compare poorly with other countries across a range of business inputs. The biopharma-pharmachem sector has particular concerns about the high level of energy, waste and local authority charges which also adversely impact the sector's competitiveness.

### 2.3.1 c Increasing Pressures from Public and Private Payers

A 2006 OECD report found that public spending on health and long-term care amounted to an average of 6.7 per cent of GDP in 2005<sup>22</sup>; in the US, healthcare expenditure came to 16 per cent of GDP in 2005<sup>23</sup>. Total healthcare expenditure in OECD countries could rise to as much as 13 per cent of GDP by 2050. Set against this trend of rising healthcare costs, governments and other payers are looking to contain the costs of drug and diagnostic spending. These cost containment strategies generally take the form of price cuts on pharmaceutical, biotechnological and medical device products, reductions in public investment in R&D, and greater efforts to tie medical decision making to scientific evidence of successful impacts on patients. This in turn impacts on cost structures in companies, and emphasises the importance of cost competitiveness in the biopharma-pharmachem sector.

From an employment perspective, these competitiveness issues will continue to put pressure on employment levels as companies struggle to compete. From a skills perspective, these cost pressures emphasise the need for business acumen and productivity skills, particularly in areas such as lean manufacturing and Six Sigma.

## 2.3.2 Loss of Patent Protection and the Rise of Generics

It is estimated that US\$115 billion of branded drugs from the top 50 pharmaceutical companies will lose patent protection by 2012 and will be open to competition from generics<sup>24</sup>. This is a particularly important issue for Ireland where seven of the top ten blockbusters are manufactured. It presents a real challenge for manufacturing companies based in Ireland to reposition themselves within the context of their parent company strategies, and for Ireland to provide the supportive business environment to enable them to do so effectively. Generic drug production now comprises over half of all prescriptions currently written<sup>25</sup>.

The main challenge facing companies is the fact that products come off patent at a relatively early stage, which demands ongoing investment in innovation and successful delivery of new higher value products to market within a relatively short time frame.

<sup>22</sup> OECD, 2006, Projecting OECD health and long-term care expenditures: what are the main drivers?

<sup>23</sup> CBS News, 2007, Health Care Costs Approach \$2 Trillion, January, available from <http://www.cbsnews.com/stories/2007/01/09/health/webmd/main2342455.shtml>

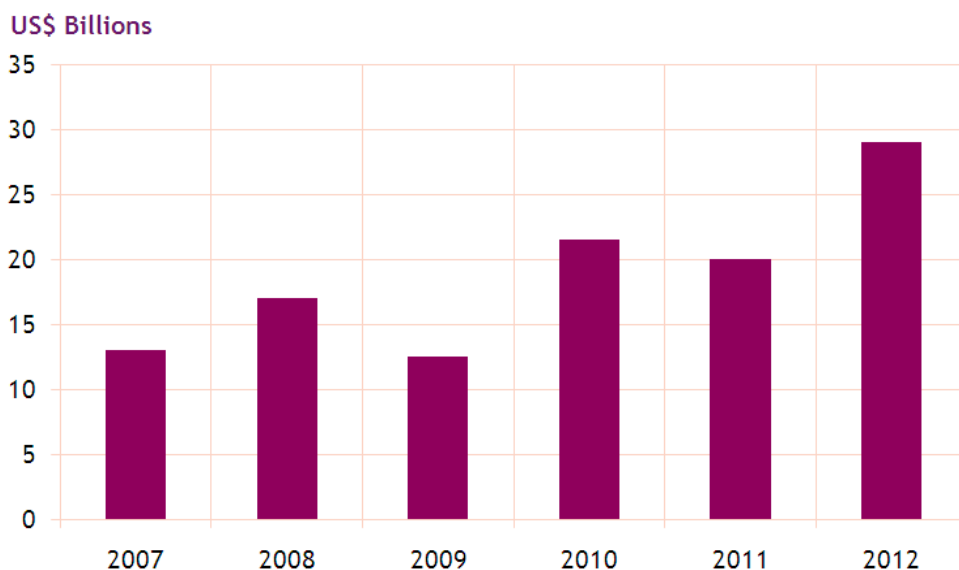
<sup>24</sup> Datamonitor, 2008, Current & Future Trends and Strategic Issues facing Pharma

<sup>25</sup> Ibid.



From a skills perspective, this will require an increased emphasis on innovation, entrepreneurship and specialised technical skills.

Figure 2.1: Value of Drugs Going Off Patent Worldwide, 2007 - 2012



Source: Datamonitor, 2008, Current & Future Trends and Strategic Issues facing Pharma

### 2.3.3 Shrinking Research Pipelines

The costs of drug development are increasing while at the same time the drug pipeline, particularly in the pharmaceuticals sector, is thinning. The typical net cost of bringing a drug to market is US\$800 million<sup>26</sup>. R&D makes up a major portion of this cost with approximately 25 per cent of all R&D expenditure going on clinical trials. The average time to market for a new pharmaceutical product can be anywhere between 5 to 15 years depending on the type of drug and its status<sup>27</sup>.

Only one in twenty drugs entering clinical testing successfully completes the clinical trial process and the FDA approved only 19 new drugs in 2007, the fewest in 24 years<sup>28</sup>. In many cases the failure of a drug to gain approval does not happen until late in the process at which time considerable investment has been committed to large scale clinical trials.

<sup>26</sup> Tufts Centre for the Study of Drug Development, November, Forum on Drug R&D, available from <http://csdd.tufts.edu/NewsEvents/RecentNews.asp?newsid=21>

<sup>27</sup> Datamonitor, 2008, Current & Future Trends and Strategic Issues facing Pharma, March and consultation process

<sup>28</sup> Datamonitor, 2008, Current & Future Trends and Strategic Issues facing Pharma, March



Skills that help increase efficiency and speed to market, along with innovation and business acumen to identify alternative products and markets, will be necessary to address this phenomenon.

### 2.3.4 Biotechnology

Developments in biotechnology are enabling the creation of new biopharmaceuticals, improvements in manufacturing processes and in the greater application of the predictive sciences.

A recent OECD report envisages that biotechnological knowledge will play a role in the development of all therapies by 2015, both small molecule pharmaceuticals and large molecule biopharmaceuticals, and that advances in biotechnologies will be instrumental for realising the potential for personalised healthcare<sup>29</sup>.

There are considerable challenges if the potential is to be fully realised, however, not least the enormity of the logistical demands in undertaking large-scale population genotyping and the design of the genotyping diagnostics tests, intellectual property (IP) considerations, computing infrastructures and ethical issues.

Bioinformatics<sup>30</sup> advances the understanding of disease states and optimal treatments. The application of bioinformatics in drug discovery and development is expected to reduce the annual cost of developing a new drug by 33 per cent, and the time taken for drug discovery by 30 per cent. It is expected that the global bioinformatics market will be worth nearly US\$3 billion in 2010; more than triple what it was in 2000<sup>31</sup>.

From a skills perspective, The National Institute for Bioprocessing Research and Training (NIBRT) provides training and research solutions for the bioprocessing industry in Ireland. NIBRT is based on an innovative collaboration between University College Dublin, Trinity College Dublin, Dublin City University and Institute of Technology Sligo, and is part funded by IDA Ireland.

In order to create a centre of bioprocessing excellence, NIBRT is currently developing state of the art facilities. These include a pilot plant to support scale up operations and to enable students to get real time experience in an industrial environment.

### 2.3.5 Changing Global Market

Global demographic, socio-economic and consumption trends are having a major impact on the markets for biopharma-pharmachem products and services. The United Nations projects that the world's population will increase from 6.6 billion in 2005 to 7.7 billion by 2020. Ageing populations in developed economies will drive demand for a wide range of treatments to address age related ailments. At the same time, ageing populations and the growth of chronic and lifestyle related conditions are putting significant pressures on healthcare systems globally.

<sup>29</sup> OECD, 2009, The Bioeconomy to 2030, Designing a Policy Agenda

<sup>30</sup> The science of developing computer databases and algorithms to enhance biological research

<sup>31</sup> BCC Research, 2005, Bioinformatics: Technical Status and Market Prospects, August



The rise of emerging economies as locations of production and markets will also alter the life sciences landscape over the coming decade. Enterprises now invest in emerging economies to undertake a range of activities, including R&D and clinical trials. That said, for now, many senior executives cite infrastructural deficiencies, shortages of relevant PhDs and regulatory bureaucracy, as potential risks to such investments.

In the developed world, for many people, increased wealth and free time has resulted in a focus on a healthier lifestyle. This increased focus on overall 'wellness'<sup>32</sup> has led to a growing demand for lifestyle related treatments and products.

Patients are increasingly well-informed, both because of the fact that health issues are reported on in the media to a greater extent and the fact that the Internet has played a significant role in expanding health awareness and providing extensive information on health related issues. This trend has seen consumers taking a more active role in managing their health; demanding choices for treatment options and alternatives.

From a skills perspective, these trends emphasise the need for excellent business skills, particularly, business development, sales, marketing and health economics, for a continually upskilled, flexible workforce, capable of reacting to and anticipating consumer demand.

### 2.3.6 Advances in Technology and Science

The pace and degree of technological advances have unfolded a series of new, predictive sciences which are opening the possibility of new approaches to drug development, more effective diagnosis, therapeutics, and patient care.

These predictive sciences include genomics, pharmacogenomics, and proteomics, which effectively enable the development of drugs and treatments that are tailored to an individuals' genetic makeup, and enable early 'signalling' of an individuals' propensity to a specific disease. In this context, molecular diagnostics is now the fastest growing field in diagnostics and coupled with advances in laboratory equipment will play an increasing role in early diagnosis, monitoring and targeted pharmaceutical intervention. This takes on particular relevance given the reduced product pipelines in pharmaceuticals, such that existing compounds can be modified and/or targeted for sub-populations to increase overall efficacy.

Other technological advances, such as those in wireless, sensors, nanotechnologies, microelectronics and 'wearable' technologies that collect and transmit data from patient to clinician will have an impact on future healthcare diagnostics and delivery.

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<sup>32</sup> Wellness is generally used to mean a healthy balance of the mind, body and spirit that results in an overall feeling of well-being i.e. wellness means being much more than just being disease free



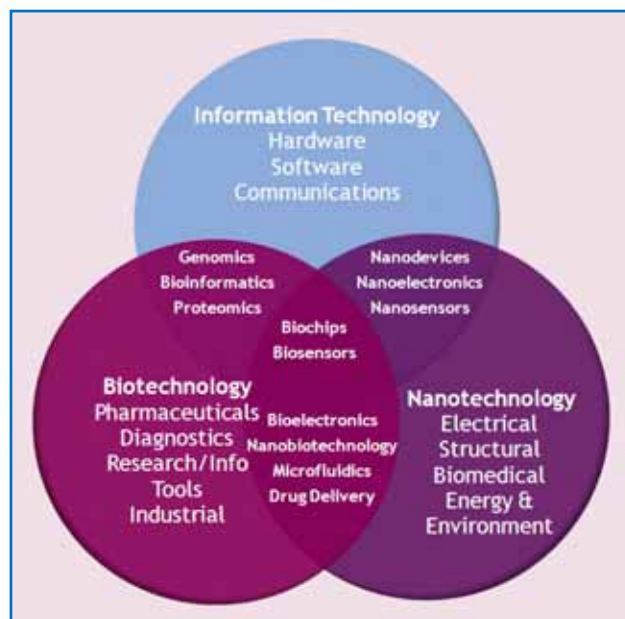
Optoelectronic or photonic technologies have enabled advances particularly in relation to the evolution of 'labs-on-a-chip,' which are devices that integrate one or several laboratory functions on a single chip of only millimetres to a few square centimetres in size.

These technological advances will require a highly-skilled labour force in new and emerging processes across a variety of disciplines, including nanotechnology, engineering, information technology and others.

### 2.3.7 Convergence

Convergence is defined as the intersection and combination of more than one technology platform, for example, nanotechnology, biotechnology, ICT, & cognitive sciences<sup>33</sup>. Although the concept of convergence is not new, the pace at which it is enabling the development of leading-edge innovative new products and solutions has accelerated. Convergence stretches across pharmaceuticals, biotechnology, medical devices and diagnostics, and has already resulted in the creation of many convergent products.

The impact on industry has resulted in a blurring of the lines between formerly discrete sectors. Product development and marketing now, more often than not, involves alliances or M&As between companies from different sectors and the development of new revenue sharing and business models.



Source: Forfás (2009) Health Lifesciences in Ireland - An Enterprise Outlook

<sup>33</sup> The National Science Foundation understands the phrase 'convergent technologies' to mean "the synergistic combination of four major 'NBIC' (nano-bio-info-cogno) provinces of science and technology." National Science Foundation, 2003, Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science, Roco, M.C. and Bainbridge, W.S.(Eds.), Kluwer Academic Publishers





For example, the introduction of drug eluting stents (DEs) - the most successful combination product so far with a market size of US\$5.5 billion worldwide - stimulated both of the sectors to collaborate and create a whole new line of products.

According to PRTM Management Consultants, the market for convergent products is currently estimated to be around US\$40-50 billion and growing at 14% annually. However, this area is still in its early stages, and several challenges need to be addressed. These include risks associated with the technological components and interfaces needed for integration, the challenges of partnering with other firms, often from other industry sectors, and uncertainties about the size and receptiveness of prospective markets.

From an investor perspective, convergent technologies combine the risks of drug development with the quite different risks of device development, without decreasing overall risk. There is also a matter of regulatory issues - as products get smaller in size and are implanted in the patient's body to reach the targeted area, their safety will be of utmost importance. That said, there are many successful convergent products already in the market, with the number of applications for convergent products with the US Food and Drug Administration (FDA) increased from less than 100 in 2003 to 333 by 2007.

Although these advances in science and technologies are enabling the realisation of personalised healthcare, there are many different views as to when and to what extent it will become a reality. Factors such as the economic viability of production, costs and infrastructures, individual risk and insurance and data protection need to be taken into consideration. Having said that, evidence points to products and solutions being developed that are tailored for groupings of patients with similar genetic dispositions (as opposed to being tailored specifically to the individual) and given the importance of the sector to Ireland's future, it is a trend that cannot be ignored.

Convergent products in the market today include:

- Drug-eluting stent that opens and inhibits restenosis in coronary and peripheral arteries
- Bone grafting scaffold/sponge coated with a growth protein that promotes bone regeneration
- Implantable, programmable pump that delivers a drug or biologic in small, timely doses
- Implantable polymer wafer that releases a chemotherapy agent to a specific site
- Implantable neuromodulator that enables the targeted, regulated delivery of a drug or electrical stimulation
- Transdermal patch that transports drugs locally and systematically through the skin
- Pre-filled, metered dose syringe, injector pen, or inhaler
- Screening test for the presence of a specific gene or protein coupled with targeted drug therapy
- Use of passive pharmaceuticals and radiopharmaceutical tracers as contrast agents for positron emission tomography (PET) scanner.



From a skills perspective, technological convergence will impact on skills requirements in a number of ways:

- It will broaden the range of disciplines that are core to the biopharma-pharmachem sector to include not only chemistry, the biological sciences and chemical engineering but also encompass mechanical, biomedical and materials engineering, nanotechnology and information technology.
- While the main requirement will be for people with a deep knowledge of their core discipline who can work in a multi-disciplinary environment, there will also be requirement for people with blended skills or skills that span different disciplines.
- There will be a requirement for skills in business acumen, risk analysis and management, intellectual property management, legal, tax and finance skills.

### 2.3.8 Regulation

In an environment where biopharma-pharmachem companies are facing pressures to reduce costs and time to market, they must also comply with regulatory processes and requirements for sufficient clinical data to illustrate a product's safety and effectiveness for approval.

The blurring of the distinction between medical devices and medicinal products creates a challenge for regulators (and industry) to identify an appropriate regulatory approach to handling products based on convergent technologies. Regulation is being coordinated across the globe by the International Conference for Harmonisation (ICH). Ireland is represented in the negotiations at the ICH through the European Commission (DG Enterprise) and through the European Federation of Pharmaceutical Industries and Associations (EFPIA). Key guidance notes have been prepared by the Irish Medicines Board (IMB) to assist industry on the use of relevant Directives and Regulations.

In a skills context, companies must ensure that their employees are fully conversant with the regulatory environment. Developments such as the use of Process Analytical Technology (PAT) and Quality by Design (QBD) require the development of specialised technical skills in this area.

### 2.3.9 Increased M&A Activity

Large biopharma-pharmachem companies are increasingly looking to start-ups and biotechnology companies as a source of new IP acquired through licensing, collaboration or M&A to bolster their product pipeline and future revenue growth. 15-20 per cent of sales revenue of the top 20 pharmaceutical companies now comes from licensed products and about 40 per cent of their pipelines are composed of externally sourced compounds<sup>34</sup>.

It has long been recognised that the 'go it alone' approach to innovation and development is no longer viable. Today the complexity of problems and the need for multidisciplinary approaches

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<sup>34</sup> Forfás, 2009, Health LifeSciences in Ireland - An Enterprise Outlook, Dublin



requires the flow of ideas and knowledge exchange. Collaborating and partnering enables innovation and new industry creation<sup>35</sup>.

In Ireland, there is a substantial technical skills base in small indigenous companies, particularly in the biopharmaceutical sector which also attracts investment from large multinational companies. In turn, M&A activity requires skills in areas such as intellectual property management, legal, tax and investment skills.

## 2.4 Conclusion

The challenges facing the Irish biopharma-pharmachem sector are significant, but the industry is well placed to meet them, building on its reputation for world-class manufacturing. Cost pressures, patent expirations, a shrinking research pipeline, consolidation, and competition from other international locations are among the factors that have the potential to erode the country's manufacturing base. Yet, if the industry embraces the concepts of manufacturing and supply-chain excellence, on-site innovation such as process and product development, and reduces its cost base, Ireland can become a global centre of excellence for development, manufacturing and supply.

For indigenous companies, there will also be opportunities in areas such as high-end synthesis, biotechnology, contract research and manufacturing. An embedded, integrated and sustainable sector will then develop. Building on our world-class manufacturing base, the industry can move to a more service focused business, working in partnership with health services to address health outcomes.

The availability of a highly-skilled workforce has been a key factor in attracting the international biopharma-pharmachem sector to Ireland and in allowing the indigenous sector to develop. As the industry changes, so too will its skills requirements. Ireland must take action now to ensure that the education and training sectors can provide the industry with flexible, highly-skilled people capable of driving the business forward and creating an industry that is a centre of excellence and innovation.

Chapter 3 analyses the labour force of the biopharma-pharmachem sector in Ireland.

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<sup>35</sup> Burnside, B. and Witkins, L., 2008, Forging successful university-industry collaborations, Industrial Research Institute, March/April



## Chapter 3 Profiling the Biopharma-Pharmachem Sector's Labour Force

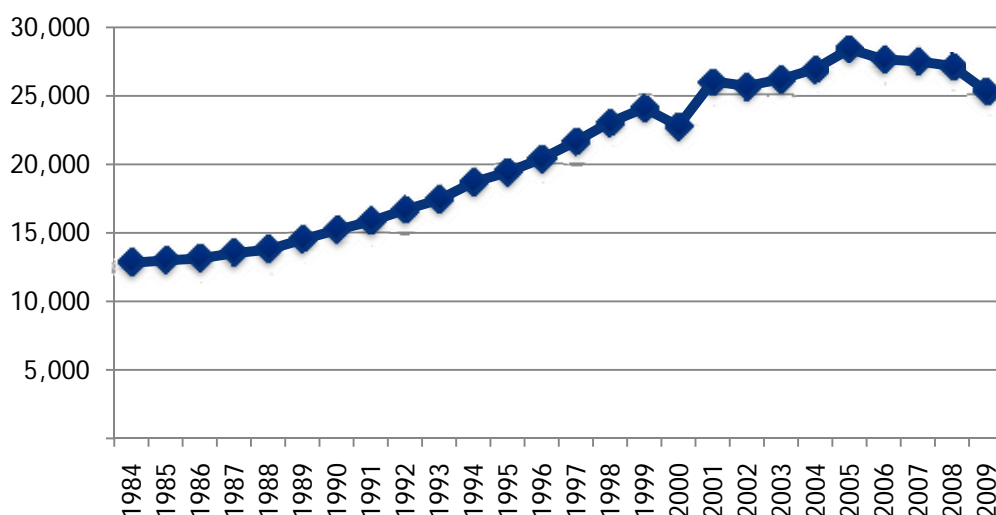
### 3.1 Introduction

The Irish biopharma-pharmachem sector's labour force reached 25,300 in 2009<sup>36</sup>. An estimated 21,300 people are employed in the pharmachem sector with approximately 4,000 employed in the biopharmaceutical sector<sup>37</sup>. In addition, it is estimated that a further 24,000 people are employed in support services to the industry.

### 3.2 Employment in the Irish Biopharma-Pharmachem Sector

Total employment in the Irish biopharma-pharmachem sector grew rapidly during the 1980s and 1990s, and totalled 25,300 in 2009. A number of new plants were developed in the sector in the mid 2000s, providing additional temporary employment during the start-up phase, as indicated in Figure 3.1. In 2009, two major global mergers took place that had a particular relevance for Ireland: Pfizer and Wyeth and Merck and Schering Plough. While it is yet unclear the extent to which there may now be over-capacity in these companies, some further downward movement in employment is anticipated.

Figure 3.1 Employment in the Biopharma-pharmachem sector 2000-2009

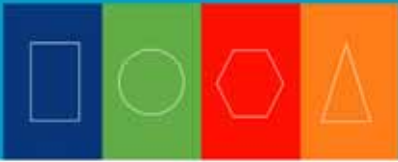


Source: Based on analysis of Forfás Employment Database, 2009

Figure 3.2 examines employment by firm ownership which shows a concentration in foreign-owned firms. In 2000, 84% of those employed in the sector were located in foreign-owned companies. By

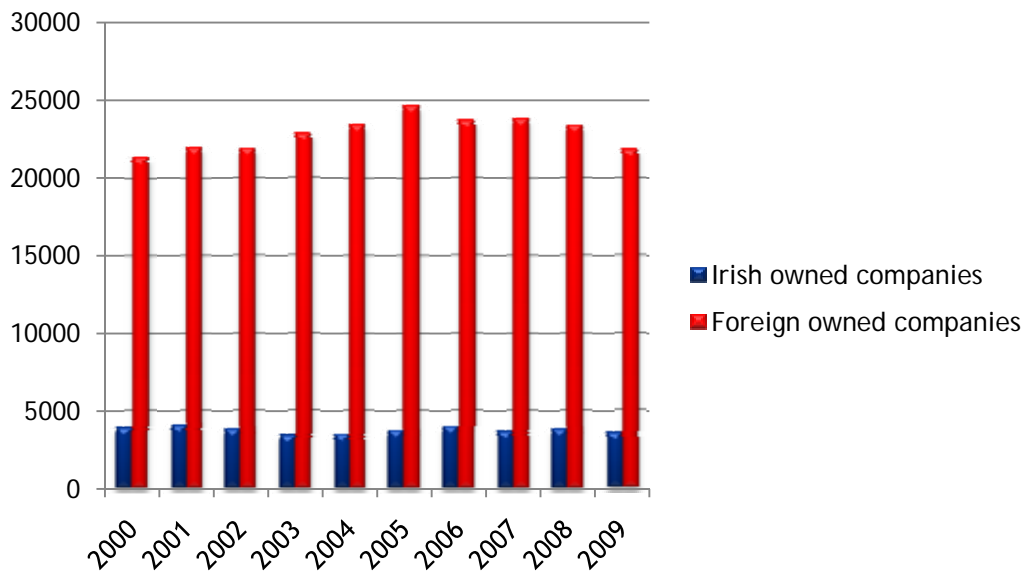
<sup>36</sup> Based on analysis of Forfás Employment Survey, 2009.

<sup>37</sup> This figure is based on data from the Forfás Annual Employment Survey, the Central Statistics Office (CSO) and the Irish Business and Employers Confederation (IBEC). It is difficult to determine the exact number of companies and employees within the biopharmaceutical industry as the sector has not been assigned an individual NACE (European Classification of Economic Activity) code.



2009, this had risen to 86%, with the remaining 14% employed in indigenous firms. Given the extent of M&A activity in the sector, this trend is likely to continue.

Figure 3.2 Employment by Firm Ownership Biopharma-pharmachem Sector 2000-2009



Source: Based on analysis of Forfás Employment Database, 2009

The following sub-sections provide an in-depth analysis of the labour force in the biopharma-pharmachem sector, providing a profile in terms of:

- Gender
- Age
- Educational attainment
- Nationality
- Occupation

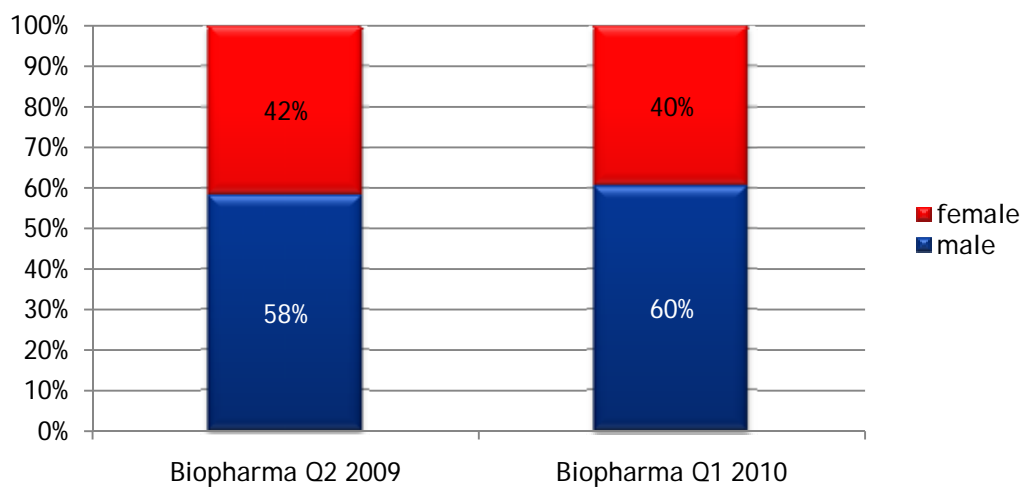


### 3.2.1 Gender Profile

The Quarterly National Household Survey (QNHS)<sup>38</sup> shows that in 1999 the biopharma-pharmachem sector attracted a greater proportion of males than females to its workforce, with 58 per cent males and 42 per cent females. Figure 3.3 indicates that the proportion of males increased in 2010 to 60 per cent, while female numbers decreased to a level of 40 per cent.

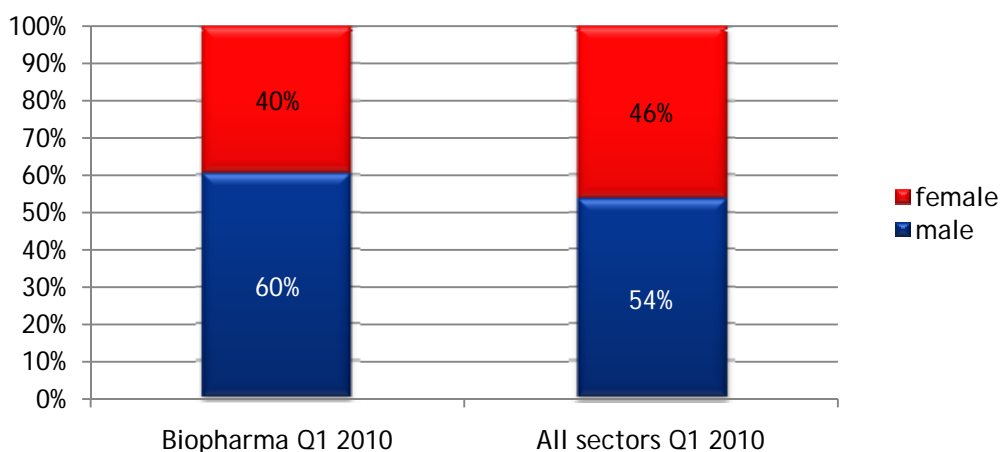
When compared to the national average, Figure 3.4 indicates that the proportion of males in the biopharma-pharmachem sector is slightly higher than the national average where the proportion of males in the national labour force reached 54 per cent in 2010, compared to 46 per cent of females.

Figure 3.3 Biopharma-pharmachem Sector by Gender 1999-2010



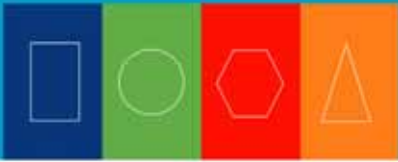
Source: Analysis by SLMRU (FÁS) based on CSO data

Figure 3.4 Biopharma-pharmachem Sector by Gender versus Total Employment by Gender 2010



Source: Analysis by SLMRU (FÁS) based on CSO data

<sup>38</sup> The QNHS is a large-scale nationwide survey of households in Ireland conducted by the CSO. The survey began in September 1997, replacing the annual Labour Force Survey (LFS). 12 field co-ordinators and 152 field interviewers interview 39,000 households each quarter. The survey meets the requirements of Council Regulation (EC) No 577/98 adopted in March 1998, which requires the introduction of labour force surveys in EU member states.

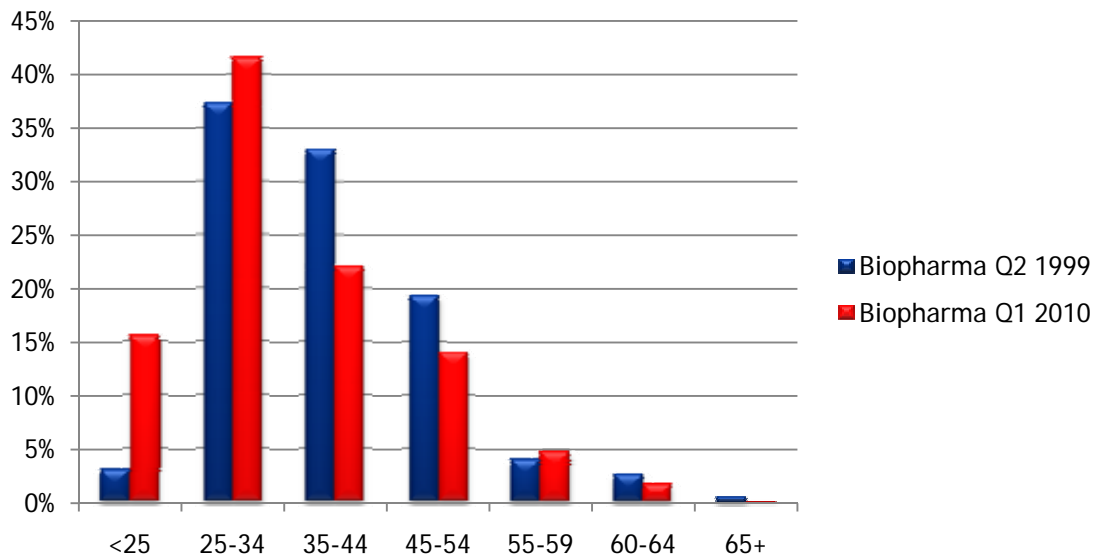


### 3.2.2 Age Profile

The QNHS indicates that the biopharma-pharmachem sector's workforce is concentrated in the 25-44 age group. Figure 3.5 shows that in 1999 less than 5 per cent of the labour force was under 25, compared to 16 per cent in 2010.

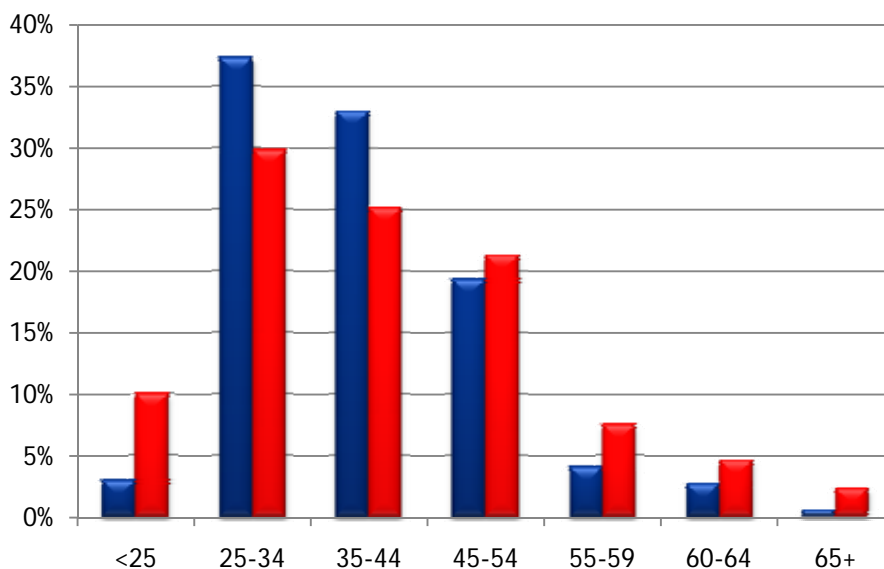
When compared to the national average, Figure 3.6 shows that the sector has a higher concentration of the labour force in the 25-44 age bracket, with a lesser concentration in the under 25, 45-54 and 55-64 age groups.

Figure 3.5 Biopharma-pharmachem Sector by Age Group 1999-2010



Source: Analysis by SLMRU (FÁS) based on CSO data

Figure 3.6 Biopharma-pharmachem Sector by Age Group versus National Employment by Age Group 2010



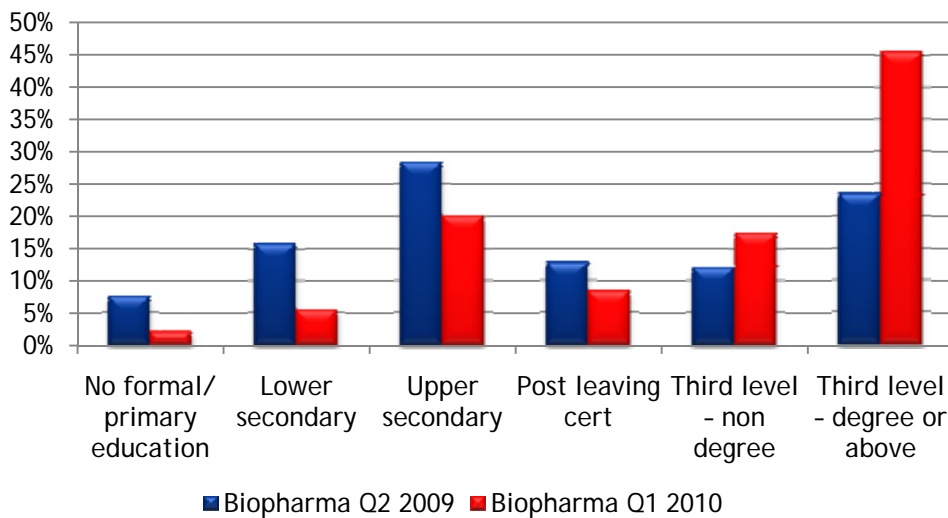
Source: Analysis by SLMRU (FÁS) based on CSO data



### 3.2.3 Education Profile

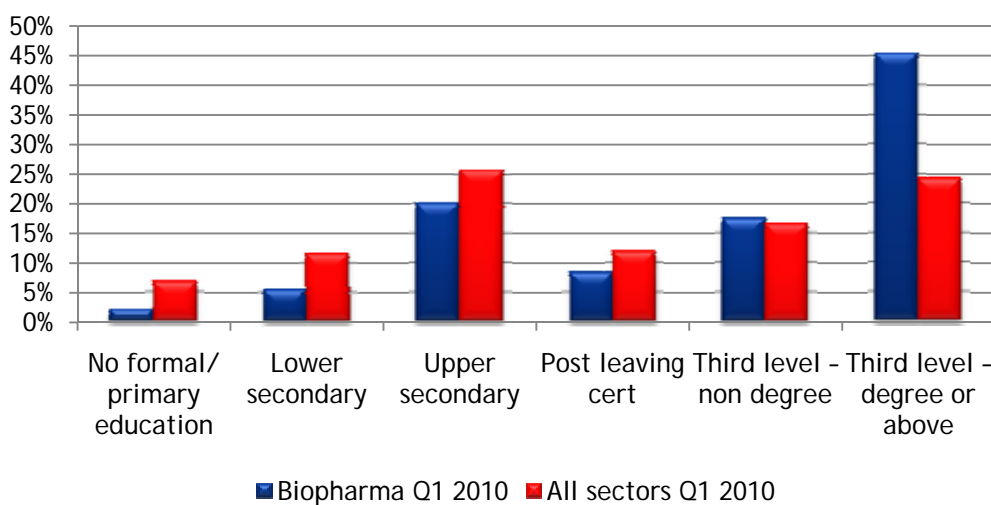
This section examines the sector in terms of educational attainment levels, and shows that the biopharma-pharmachem sector has a highly skilled labour force, with educational attainment levels higher than the national average. The proportion of employees with secondary level education as the highest educational attainment level has declined since 1999 with those attaining third and fourth level qualifications increasing, as Figures 3.7 and 3.8 illustrate.

Figure 3.7 Biopharma-pharmachem Sector Educational Profile 1999-2010



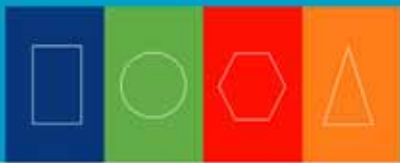
Source: Analysis by SLMRU (FÁS) based on CSO data

Figure 3.8 Biopharma-pharmachem Sector Educational Profile versus National Educational Profile 2010



Source: Analysis by SLMRU (FÁS) based on CSO data

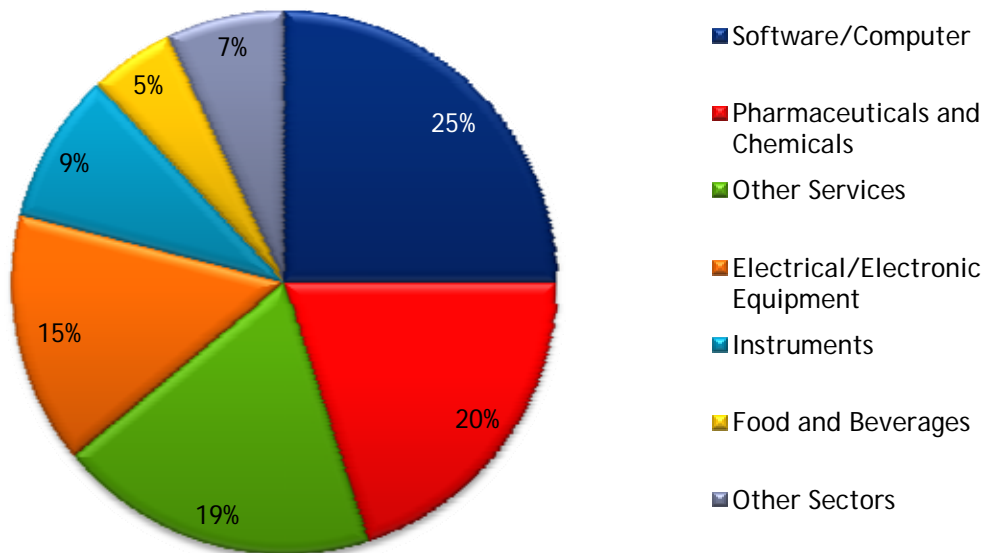




In terms of third and fourth level qualifications, 46 per cent of the biopharma-pharmachem sector's labour force have third level degrees or higher, compared to a national average of 24 per cent. As a sector, the biopharma-pharmachem industry employs the second highest number of PhD researchers in Ireland, with 25 per cent of all PhD researchers employed in Irish industry<sup>39</sup>.

The Business Expenditure on Research and Development (BERD) survey<sup>40</sup> shows that there are four dominant research sectors both in terms of research spend and number of researchers employed. Software and computer-related activities, other services, electrical and electronic equipment and pharmaceuticals and chemicals together account for 79 per cent of BERD and 80 per cent of all researchers employed in the business sector.

Figure 3.9 Business Expenditure on Research and Development by Sector



Source: BERD Survey, 2007/08

The highest proportions of PhD-qualified researchers to other researchers are in the pharmaceuticals and chemicals sector, and food and beverage sector which represent 33 per cent and 20 per cent respectively of all researchers employed in 2007. These proportions are significantly greater than those found in software and computer related activities (5 per cent), electrical/electronic equipment (15 per cent) and 'other sectors' (12 per cent).

<sup>39</sup> Forfás, 2009, 'The Role of PhDs in the Smart Economy', Dublin

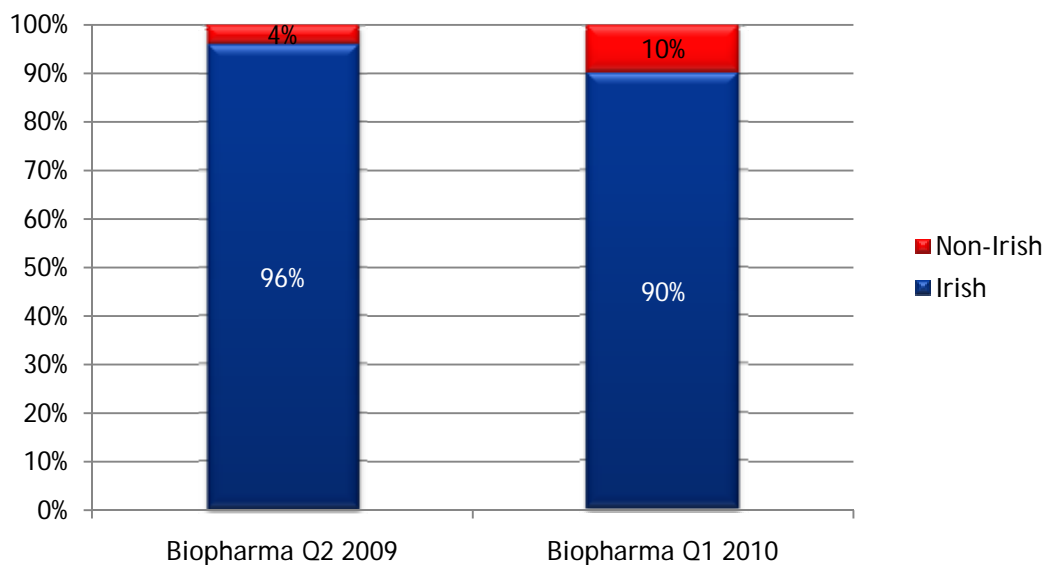
<sup>40</sup> The BERD survey collects information about research and development activities of enterprises and is produced jointly by the CSO and Forfás.



### 3.2.4 Nationality Profile

In terms of nationality, the biopharma-pharmachem sector's labour force is predominantly made up of Irish nationals, with 90 per cent of the labour force in that category in 2010. While there has been an increase in non-Irish nationals in the past ten years, rising from 4 per cent in 1999 to 10 per cent in 2010, it is not a dominant trend.

Figure 3.10 Nationality Profile of Biopharma-pharmachem Sector



Source: Analysis by SLMRU (FÁS) based on CSO data

### 3.2.5 Occupational profile

Figure 3.11 shows the occupational profile of the biopharma-pharmachem sector in Ireland. In 2009, professionals and associate professionals<sup>41</sup> accounted for 38 per cent of the labour force, with managers accounting for 18 per cent and operatives 20 per cent.

<sup>41</sup> The associate professional category covers occupations whose main tasks require experience and knowledge of principles and practices necessary to assume operational responsibility and to give technical support to professionals in the natural sciences, engineering, life sciences and social sciences. In the context of biopharma -pharmachem sector this primarily relates to laboratory technicians, medical laboratory technicians, engineering technicians and other scientific technicians.

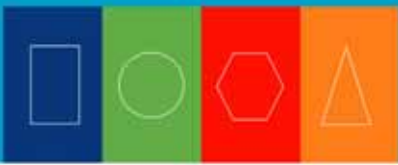
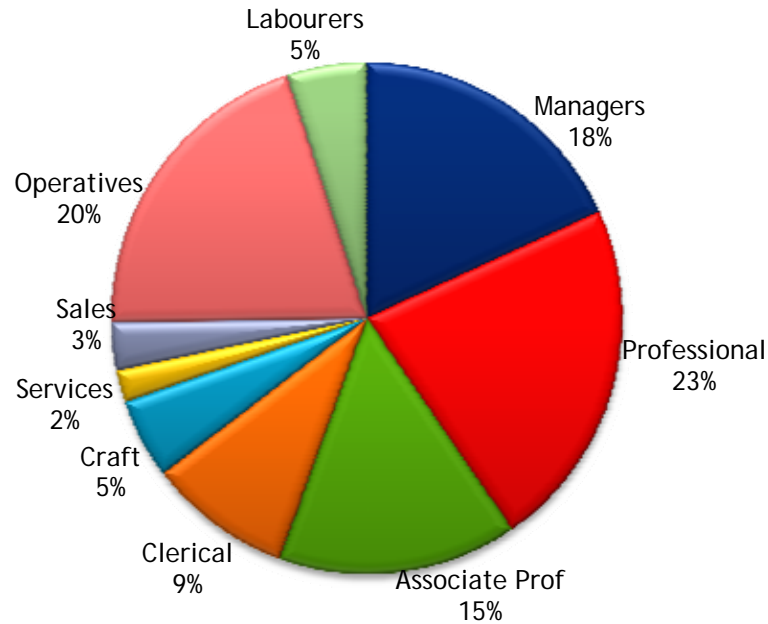


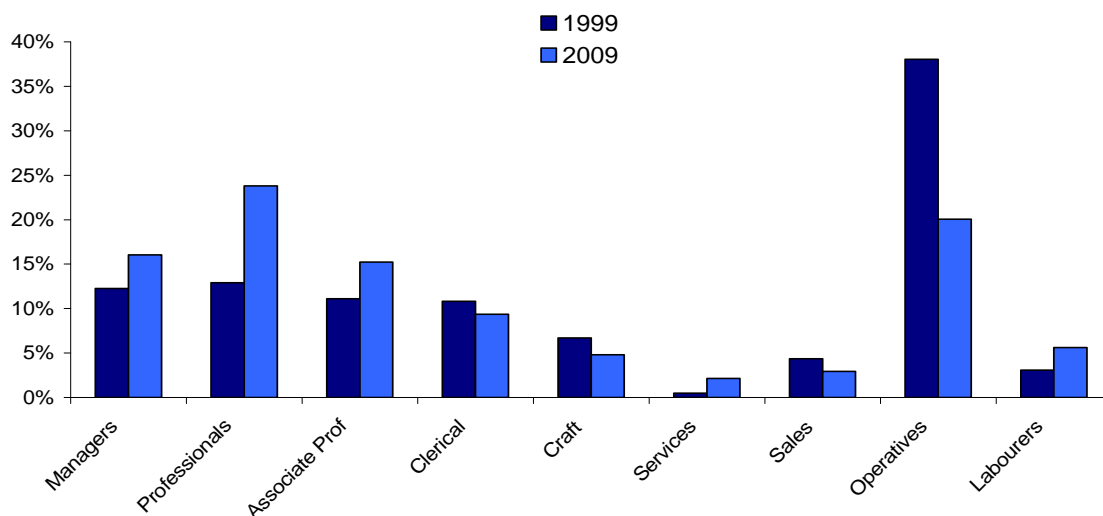
Figure 3.11 Biopharma-pharmachem Occupation Profile Q2 2009



Source: Analysis by SLMRU (FÁS) based on CSO data

When compared to the occupational profile in 1999 (Figure 3.12), it is evident that over a 10 year period, the number of operatives has significantly declined, with managers, professionals and associate professionals increasing.

Figure 3.12 Biopharma-pharmachem sector by broad occupation 1999-2009



Source: Analysis by SLMRU (FÁS) based on CSO data



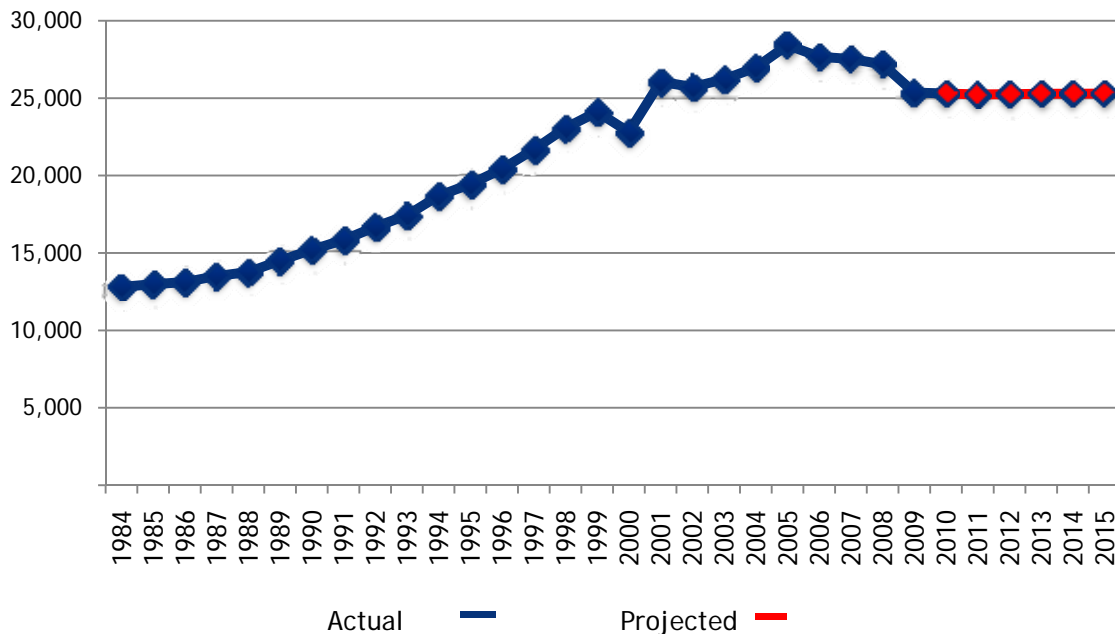
### 3.3 Employment and Occupational Forecasts for the Irish Biopharma-Pharmachem Sector

#### 3.3.1 Employment forecast to 2015

Chapter 2 set out the structural trends and drivers of change in the biopharma-pharmachem sector, and showed that the global industry is undergoing transformation, particularly due to patent expiry and consolidation. Such transformation will inevitably result in job losses in the 2010-2015 period, as the industry itself and roles within the industry change. These job losses are likely to be balanced by job gains in the biopharma sector and pharma companies moving to higher value added activities such as process and product development, and services such as supply-chain management and corporate services. This in turn will require a more highly skilled workforce, with the sector's occupational structure reflecting an increased share in professionals (scientists, engineers, business analysts) and associate professionals (technicians) with a significant decline in the number of operatives.

If this transformation is achieved, employment in the 2010-2015 period is projected to be static, as illustrated in Figure 3.13. The challenge in the next five years will be to retain existing employment levels and position the industry for future growth thereafter.

Figure 3.13 Biopharma-pharmachem sector employment 2000-2015



Source: EGFSN/industry estimates



### 3.3.1 Occupational forecast to 2015

Within the overall employment figure of 25,300, there is likely to be a changed occupational distribution, reflecting a significant move to higher value added activities. It is anticipated that as the industry moves further into upstream activities such as process and product development and downstream activities such as supply chain management and corporate services, there will be a changed occupational mix.

Figure 3.14 contrasts the current occupational spectrum with that perceived for 2015. The data used to project the future sectoral skill mix was drawn from the CSO Quarterly National Household Survey (QNHS), generating occupational distributions for the period 1998-2009, and then generating shares for 2015, using linear trend extrapolation<sup>42</sup>.

A significant decline in the number of operatives is projected, particularly for chemical process plant operatives and packers. The current operator role is considered too restrictive for Ireland's future needs. In overall terms, it is anticipated that the share of operatives in the biopharma-pharmachem occupational distribution will fall from 20 per cent currently to 10 per cent in 2015. In absolute terms, this equates to a loss of 2,500 jobs - from 5,000 currently to 2,500 in 2015.

Figure 3.14 shows an increase in the share of professionals rising from 22 per cent currently to 31 per cent in 2015, with the greatest job gains for chemical engineers, biological and other natural scientists, technologists, production, mechanical and electronic engineers, and business analysts. There is also likely to be growth in the share of associate professionals, predicted to rise to 19 per cent from 15 per cent currently with the greatest job gains projected for scientific technicians and laboratory technicians. In absolute terms, it is estimated that there will be an additional 3,100 jobs for professionals and associate professionals in the sector by 2015, if the industry transformation is achieved.

Smaller changes in the share of other occupations are likely, with a decline in the share of crafts persons, clerks and sales persons, with a possible increase in the share of production managers. In absolute terms, the net job loss for operatives is estimated at 2,500 by 2015, while net job gain for professionals is estimated at 2,100.

<sup>42</sup> A linear trend line was fitted through the historical time series data using ordinary least squares (OLS) method and extended into the future. Occupational distributions from NACE 24 (manufacturing of chemicals and chemical products) and NACE 73 (research and development) were used for the period 1998-2008. For 2009, given the changes in sectoral classification introduced by the CSO, NACE Rev 2 20 (manufacturing of chemicals and chemical products), NACE Rev 2 21 (manufacturing of pharmaceutical products) and NACE Rev 2 72 (scientific research and development), which broadly correspond to the previous NACE 24 and NACE 73.



Figure 3.14 Employment Share by Occupation

Occupational group	Employment			Employment share		
	2009	2015	diff	2009	2015	Percentage point diff
Managers	4,600	5,000	400	18%	20%	2
Professionals	5,700	7,800	2,100	22%	31%	8
Associate professionals	3,900	4,900	1,000	15%	19%	4
Clerical	2,300	1,800	-500	9%	7%	-2
Craft	1,300	1,000	-300	5%	4%	-1
Services	<1,000	<1,000	-200	2%	1%	-1
Sales	<1,000	<1,000	0	3%	3%	0
Operatives	5,000	2,500	-2,500	20%	10%	-10
Labourers	1,200	1,300	100	5%	5%	0
Total	25,400	25,300	-100	100%	100%	0

Source: SLMRU, FÁS

### 3.3.2 Key Chapter Findings

- Total employment in the Irish biopharma-pharmachem sector grew rapidly during the 1980s and 1990s, and totalled 25,300 in 2009. Employment is concentrated in foreign-owned companies, with 86 per cent of total employment in 2009, with the remaining 14 per cent employed in indigenous firms.
- In 2010, the sector attracted a greater proportion of males than females to its workforce, with 60 per cent males and 40 per cent females. When compared to the national average, the sector has a higher concentration of the workforce in the 25-44 age group, with a lesser concentration in the under 25, 45-54 and 55-64 age groups.
- The biopharma-pharmachem sector has a highly skilled labour force, with educational attainment levels higher than the national average. 46 per cent of the labour force have third level degrees or higher, compared to a national average of 24 per cent. 25 per cent of all PhD researchers in Irish industry are employed in the biopharma-pharmachem sector.
- In 2009, the sector's occupational profile shows that operatives have a 20 per cent share, professional occupations have a 22 per cent share, managers and administrators 18 per cent, and associate professionals (technicians) have a 15 per cent share.
- The global biopharma-pharmachem industry is currently undergoing transformation due mainly to patent expiry and consolidation. This change will inevitably result in job losses in Ireland in the 2010-2015 period. These job losses are likely to be balanced by job gains in the biopharma sector and pharma companies moving to higher value added activities such as process and product development, and services such as supply-chain management and corporate services. If this transformation is achieved, employment in the 2010-2015 period is projected to be static.
- The transformation the industry is undergoing will require a more highly skilled workforce, with the sector's occupational structure reflecting an increased share in professionals and associate professionals, with a significant decline in the number of operatives.



## Chapter 4 The Provision of Biopharma-Pharmachem-related Education and Training Programmes in Ireland

### 4.1 Introduction

Ireland is making several strategic changes to science education at primary and secondary level, recognising the importance of human capital development in developing an innovative science and technology sector. Science was re-introduced into the primary curriculum in 2003 and corresponding training for teachers has been taking place both in the colleges of education and via in-service training. At secondary level, a revised syllabus was introduced to the Junior Certificate Science in 2003 with a greater emphasis on investigative work. Revised curricula for physics, chemistry and biology at Leaving Certificate and for mathematics at Junior Certificate and Leaving Certificate are currently being developed.

### 4.2 Second Level

#### 4.2.1 Second Level Science and Mathematics - Junior Cycle

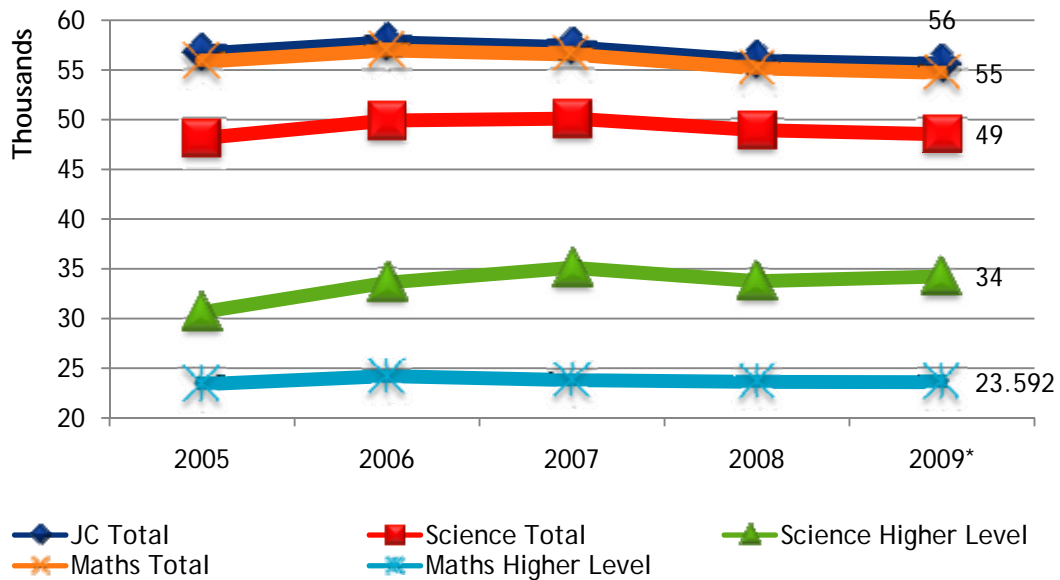
Figure 1 compares the total number of Junior Certificate candidates with the numbers who sat science and mathematics over the period 2005-2009; the number of students taking these subjects at higher level is also provided.

While the number of students sitting science and mathematics in the Junior Certificate examination fluctuated over the five year period 2005-2009, these fluctuations have been broadly in line with changes in the number of Junior Certificate candidates overall. **The share of science students as a proportion of all Junior Certificate candidates grew each year between 2005 and 2008, reaching 88 per cent in 2008, although there was a small decline to 87 per cent in 2009. At 97 per cent in 2009, the vast majority of students sat Junior Certificate mathematics over the same period.**

**Junior Certificate candidates in science are increasingly opting to sit the higher level paper; 64 per cent sat the higher level paper in 2005 but by 2009 this had increased to 71 per cent. The number of higher level science students in 2009 was 12% greater than in 2005 - an absolute increase of almost 3,600. While the share of higher level sits in Junior Certificate mathematics increased (by one percentage point) in 2009, at 43 per cent, mathematics had one of the smallest higher level participation rates of all Junior Certificate subjects.**



Figure 4.1 Junior Certificate 2005-09: Total & Higher Level Sits for Maths, Science



\*Provisional figure only

Note: Science numbers include the 1989 *and* Revised Syllabi

Source: State Examinations Commission

#### 4.2.2 Second Level Science and Mathematics - Senior Cycle

Figure 4.2 shows Leaving Certificate numbers for the key science areas of mathematics, biology, physics and chemistry. The numbers sitting the Leaving Certificate have been increasing since 2007 and at almost 57,500 in 2009, reached their highest level in five years.

**Almost all candidates sat mathematics** in the Leaving Certificate examination each year between 2005 and 2009 (Figure 4.2). The number of mathematics sits has been increasing since 2007, with the increases broadly in line with the rises in the number of Leaving Certificate sits. There was, however, a slight decline in the take-up rate for mathematics between 2005 and 2009 (97 per cent compared to 96 per cent). The **share of students sitting higher level mathematics declined from 19 per cent to 16 per cent** over the same period. Provisional data for 2010 shows a 96 per cent pass rate for higher level maths, with a 90 per cent pass rate at ordinary level.

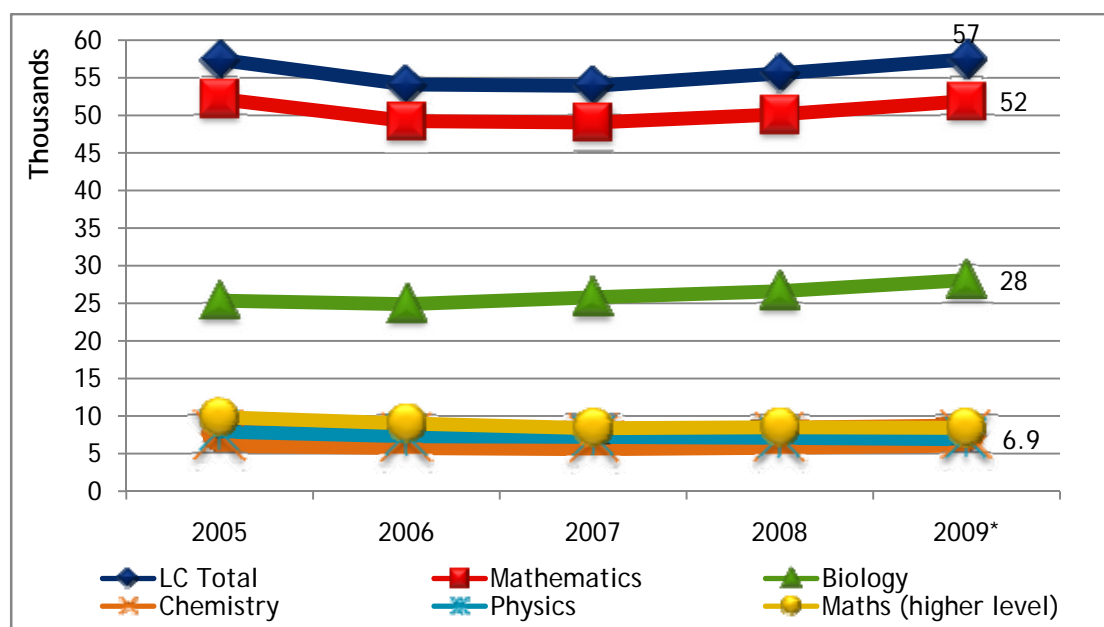
The EGFSN has consistently raised concerns regarding Ireland’s level of mathematical achievement, and proposed a number of complementary policy proposals to improve our mathematical achievement. These include providing professional development and recognition to maths teachers, developing a more interactive, imaginative approach to teaching mathematics, developing a more coherent progression of mathematics learning, incentivising students to take maths at higher level



for Leaving Certificate, providing support for parents' role in their children's maths education, and benchmarking and evaluating our national maths education performance.<sup>43</sup>

**Biology has become an increasingly popular science subject:** the take-up rate rose from 47 per cent in 2005 to 52 per cent in 2009 with numbers growing from approximately 25,000 to just over 28,000 over the five year period. At approximately 7,000 each in 2009, similar numbers of students sat physics and chemistry. While the take-up rate for chemistry has remained unchanged, it declined from 15 per cent to 13 per cent between 2005 and 2009. Many of these students are not destined for the biopharma-pharmachem sector, and go on to study healthcare disciplines, such as medicine.

Figure 4.2 Leaving Certificate 2005-09: Total Sits for Maths and Selected Science Subjects



\*Provisional figure only

Source: State Examinations Commission

### 4.3 Third Level - Undergraduate

The focus of sections 4.3 and 4.4 is on courses in higher education that are specifically related to the biopharma-pharmachem industry. However, there are other subjects offered in higher education which, although not directly related to the biopharma-pharmachem sector, may also provide learners with the skills and competencies for further study and/or employment in this sector. Therefore, in addition to biopharma-pharmachem related programmes, data on student flows for other related science subjects (e.g. medical physics, geology, physics, unspecified science

<sup>43</sup> EGFSN, 2008: Statement on Raising National Mathematics Achievement



and computing programmes, etc.) has been included in a second category - 'related science'<sup>44</sup>. For comparison purposes, we include the combined data on the remaining disciplines<sup>45</sup>.

Biopharma-pharmachem programmes relate to relevant courses in science but may also include selected courses in other disciplines such as health & welfare (e.g. human nutrition) or agriculture (e.g. agriculture and environmental science). The 'other related science' category may also include disciplines such as engineering (e.g. a BSc programme in electronic engineering & computing)<sup>46</sup>.

For the purposes of this study, the biopharma-pharmachem programmes are further categorised into:

- Biology and biochemistry: also includes bioengineering and biochemical engineering
- Chemistry: including chemistry, pharmaceuticals, food science, pharmacy, chemical engineering
- Environmental science.

Details of undergraduate biopharma-pharmachem related courses are available on [www.qualifax.ie](http://www.qualifax.ie) and [www.bluebrick.ie](http://www.bluebrick.ie).

### 4.3.1 Level 6/7

Level 6/7 programmes are offered predominantly at institutes of technology. Level 6 awards (e.g. higher certificate) are usually made on completion of two years of full-time study; level 7 awards (ordinary bachelor degree) on completion of three years of full-time study. Level 6/7 graduates also have the possibility of entering a 1-2 year *add-on* programme, leading to a level 8 honours bachelor degree. Traditionally, Level 6/7 graduates find employment in technician or associate professional occupations. The data on the inflows and outflows of students from programmes at level 6/7 is an indicator of the supply of skills of people with skills necessary for technician/super-operative roles.

#### 4.3.1.1 Level 6/7 Inflows

CAO acceptance data is an indicator of inflows to higher education at undergraduate level each year. CAO data however does not necessarily equate to enrolments as some CAO acceptors may decide not to enrol on the programme offered.

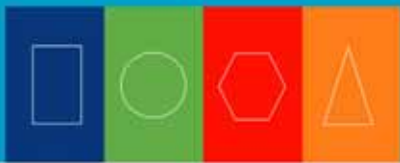
- Overall, CAO acceptances increased by 14 per cent over the period 2005 to 2009.
- However, in relative terms, the increases for biopharma-pharmachem and related science courses were even stronger, growing by 21 per cent and 46 per cent respectively.

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<sup>44</sup> The data in the 'related science' category in this document does *not* include subjects such as agricultural science, medicine, cognitive science, business information systems.

<sup>45</sup> Remaining disciplines include: other engineering; construction; other science & computing; other health, vet & agriculture; arts & humanities; social science, business & law; education; and social services.

<sup>46</sup> For this reason, the total science and computing output presented in this section is not comparable to the reported science output in other EGFSN publications, notably the National Skills Bulletin and Monitoring Ireland's Skills Supply.



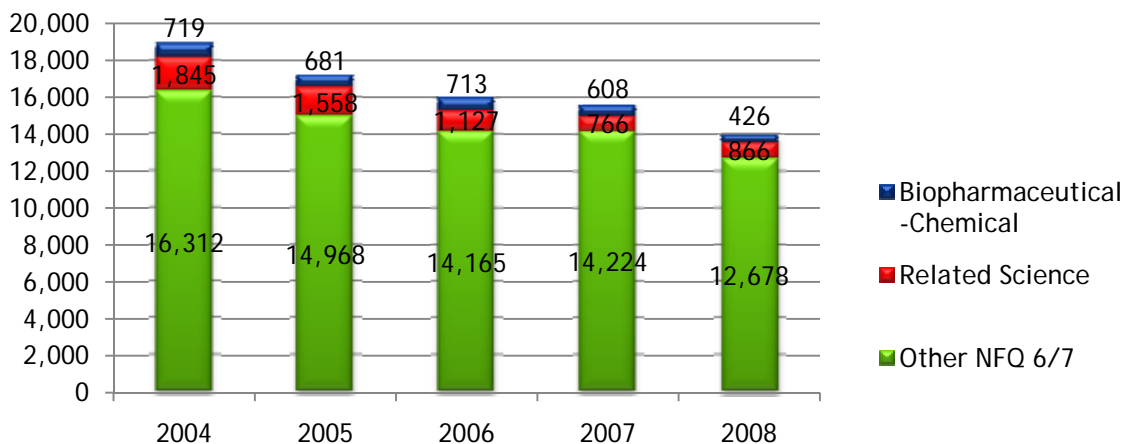
Students who accepted a place in 2007 normally graduate within 2 years in the case of level 6 awards or 3 years in the case of a level 7 award. Therefore, the greatest impact of these increased CAO acceptances on graduate output is expected in 2010-2011.

#### 4.3.1.2 Level 6/7 Outflows

Overall graduate output for level 6/7 courses has been in decline over the last number of years, as illustrated in Figure 4.3 below.

- The total number of graduates at these levels declined sharply (-26 per cent) over the period 2004-2008.
- The declines for biopharma-pharmachem and other related science courses were even more pronounced at 53 per cent and 41 per cent respectively.
- Although the number of graduates in each of the three categories declined between 2004 and 2008, there was a small recovery (+100 graduates) in the related science category in 2007-2008.

Figure 4.3 Level 6/7 Graduates (Total), 2004-2008



Source: HEA

Graduation data by biopharma-pharmachem subject (Figure 4.4) shows:

- a decline in numbers (from 327 to 255) for biology/biochemistry between 2004-2008
- a decline for chemistry and chemical processing graduates from 368 to 146 over the same five year period
- the share of biology/biochemistry graduates increased annually over the period 2004-2008 (going from 45 per cent to 60 per cent over the five years)
- there was an almost concomitant decline in the share of chemistry/chemical processing graduates over the same period (down from 51 per cent to 34 per cent)
- the HEA First Destination Survey shows that a high percentage of these graduates progress to Level 8 programmes, numbering 73 per cent in 2007. Therefore, the pool of Level 6/7 graduates available for employment would be expected to be approximately 115 in 2008.

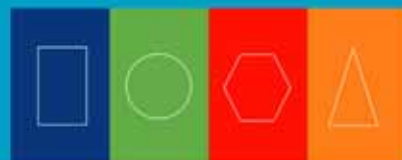
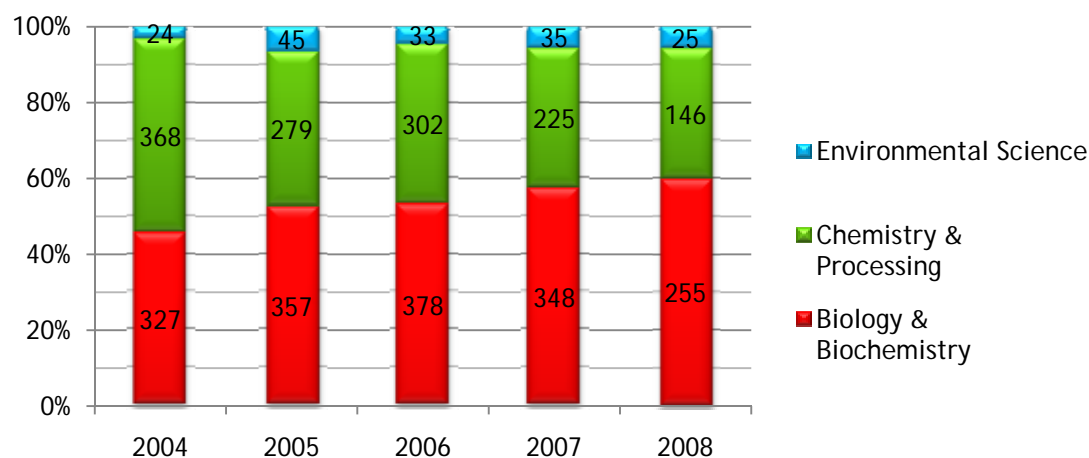


Figure 4.4 Level 6/7 Graduates for Biopharma-Pharmachem Subjects, 2004-2008



Source: HEA

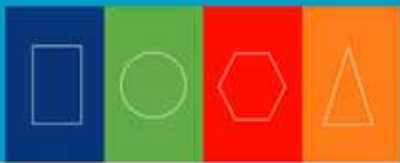
### 4.3.2 Level 8

Level 8 programmes (undergraduate) are offered at institutes of technology and universities and lead to an honours bachelor degree. Level 8 graduates have traditionally found employment in professional level occupations, although some may begin their careers at technician/associate professional level. The data on level 8 inflows and outflows from the higher education sector serves as an indicator of the supply of skills for professional occupations.

#### 4.3.2.1 Level 8 Inflows

The number of CAO acceptors increased by 26 per cent overall between 2005 and 2009. There were increases for each of the three categories considered here:

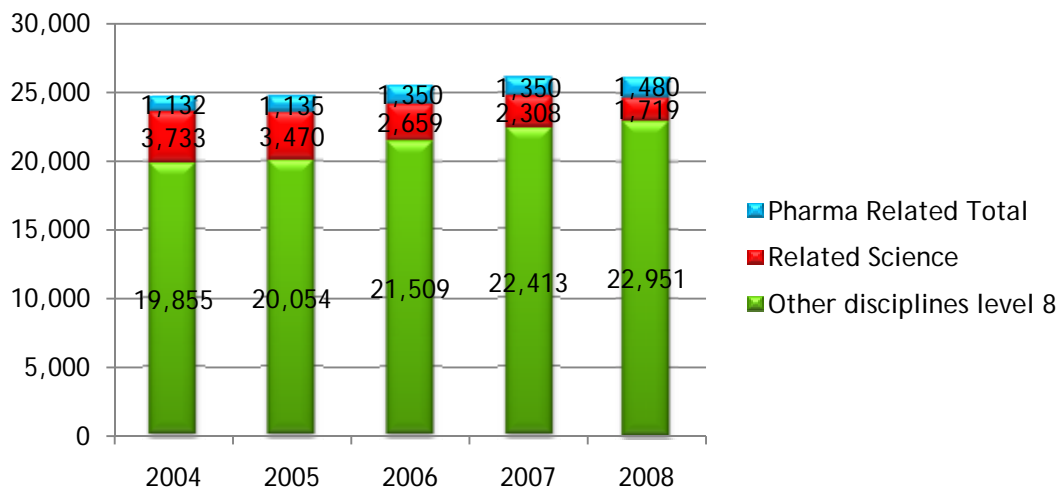
- biopharma-pharmachem acceptances increased by almost a third between 2005 and 2009; with an annual average increase of 7 per cent, acceptances reached almost 1,900 in 2009
- related science acceptances rose to 3,420, a rise of 24 per cent over the five year period
- the number of acceptances in all other disciplines increased to over 26,100 (+26 per cent)
- while CAO acceptances increased by 6% between 2008 and 2009, science and biopharma-pharmachem course acceptances grew more strongly at 27 per cent and 8 per cent respectively over the two year period.
- this increase in CAO acceptances coincided with a decrease in points required for entry to science programmes.



#### 4.3.2.2 Level 8 Outflows

The number of Level 8 graduates increased each year between 2005 and 2008, although the overall increase between 2007 and 2008 was small (0.3 per cent). However, graduates from related science courses declined each year due in part to declines in the number of computing graduates. In contrast, there was a 10 per cent increase in biopharma-pharmachem related graduates which reached their highest number (1,480) over the five year period in 2008.

Figure 4.5 Level 8 Graduates (Total), 2004-2008

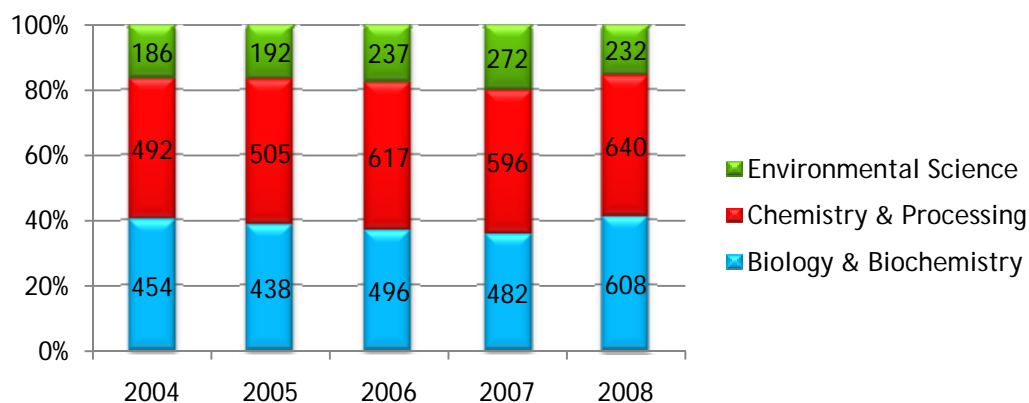


Source: HEA

Each of the three subjects within the biopharma-pharmachem category showed increases in the number of graduates over the period 2004-2008 (Figure 4.6).

- The largest increase, in both absolute and relative terms, was for biology/biochemistry graduates - a 34 per cent rise (+154 graduates) over the five years.
- Graduates in chemistry/chemical processing and environmental science rose by 30 per cent and 25 per cent respectively.

Figure 4.6 Level 8 Graduates for Biopharma-Pharmachem Subjects, 2004-2008



Source: HEA



The HEA First Destination Survey indicates that in 2007 and 2008, approximately one third of level 8 graduates progressed to further study. These students will be at the upper end in terms of performance, normally requiring a minimum of second class honours, grade II to progress to postgraduate study.

The remaining stock of level 8 graduates (approximately 980 in 2008), combined with level 6/7 graduates that do not progress to level 8 programmes (approximately 115 in 2007<sup>47</sup>) represent the available pool of graduates for employment in the biopharma-pharmachem industry. Just over 1,100 graduates, therefore, were available in 2008 to enter the industry at technician/super-operative level. CAO data for acceptances shows that in the 2005-09 period acceptances for biopharma-pharmachem related level 8 courses increased by almost a third, and by 21 per cent at level 6/7.

This analysis indicates that graduate numbers will be sufficient to meet industry demand at this level.

## 4.4 Postgraduate Education

Postgraduate level education spans levels 9 and 10 on the National Framework of Qualifications. Level 9 awards include postgraduate certificates/diplomas and masters degrees; doctoral awards (PhDs) have been placed at level 10. The focus of this section is on the postgraduate students enrolled in and emerging from these three programme types.

### 4.4.1 Postgraduate Enrolments

Table 4.1 shows the number of postgraduate enrolments by programme type and field of learning for 2007 and 2008. The data shows that:

- in 2008, there were 2,630 postgraduate enrolments in biopharma-pharmachem related subjects; this compares to 2,785 for 2007
- the number of PhD enrolments increased (by 16 per cent) but there were declines at masters degree (-19 per cent) and postgraduate cert/diploma levels (-32 per cent)
- over the period 2007-2008, there was a shift in the distribution of postgraduate enrolments by programme type; while masters degrees made up the larger share of enrolments in 2007 (52 per cent), they accounted for just 47 per cent in 2008; in contrast, doctoral enrolments went from 41 per cent to 50 per cent of biopharma-pharmachem enrolments.

In terms of mode of study:

- just over one third of masters degree enrolments (in both 2007 and 2008) were for part-time students
- the share of part-time students enrolled in postgraduate cert/diploma courses was 84 per cent and 87 per cent in 2007 and 2008 respectively

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<sup>47</sup> The HEA First Destination Survey shows that in 2007, the latest available data for level 6/7 graduate destinations, 73% of level 6/7 graduates progressed to level 8 programmes. We are assuming the same rate of progression for 2008.

- a minority of doctoral students are enrolled part-time (4 per cent in 2007; 3 per cent 2008 respectively).

A breakdown of masters degree enrolments by research and taught programmes (available for 2008 only) shows that over one half (58 per cent) were for taught programmes.

Table 4.1 Postgraduate Enrolments by Programme Type and Field of Learning, 2007- 2008

	PhDs		Masters		PG Certs/Dips	
	2007	2008	2007	2008	2007	2008
Total Enrolments						
Combined Life Science*	123	112	112	127	0	0
Biology/biochemistry	467	539	370	304	17	5
Environmental & Earth Science	117	118	214	202	0	4
Chemistry & Processing**	432	553	750	539	183	127
Total Biopharma-pharmachem	1139	1322	1446	1172	200	136

\*The 'combined life science' field of learning comprises programmes with biology, biochemistry and environmental science content

\*\* Includes pharmacy, food science/processing and chemical & process engineering

Source: HEA

#### 4.4.2 Postgraduate Awards

Graduate data by field of learning and award type is outlined in Table 4.2. There was a similar distribution of award types for each of the two years:

- there were almost 800 awards for biopharma-pharmachem subjects each year
- more than one half of awards were for masters degrees
- approximately 30 per cent of postgraduate awards were for doctoral degrees, with biology/biochemistry subjects holding the larger share
- less than 15 per cent of postgraduate awards were at certificate/diploma level

In 2008, over 80 per cent of masters degree awards were for taught programmes.

Table 4.2 Postgraduate Award Types (Graduations), 2007-2008

	PhDs		Masters		PG Certs/Dips	
	2007	2008	2007	2008	2007	2008
Graduates						
Combined Life Science*	26	15	75	135	0	5
Biology & Biochemistry	119	115	81	57	16	17
Environmental & Earth Science	19	17	95	86	1	0
Chemistry & Processing**	94	86	200	160	73	88
Total biopharma-pharmachem	258	233	451	438	90	110

\*The 'combined life science' field of learning comprises programmes with biology, biochemistry and environmental science content

\*\* Includes pharmacy, food science, processing and chemical & process engineering

Source: HEA



This analysis indicates that there would appear to be sufficient supply of graduates at post-graduate level. Chapter 6 explores the alignment of these programmes with industry requirements.

#### 4.4.3 Student Work Placements

Most undergraduate programmes offered by the institutes of technology include a student work placement, which vary in form from institute to institute. Typically, the work placement takes place in year 3 of the programme for 14-16 weeks with a company from the relevant industry sector. Within the university sector, DCU and UL programmes also include work placements. While programmes such as UCC's B.Sc Chemistry of Pharmaceutical Compounds, includes a work placement, it is not commonplace in most other university programmes. The critical issue here is that large numbers of students complete their studies in biopharma-pharmachem related subjects without any practical experience in the industry.

Industry representatives interviewed for this study emphasised the importance of student work placements. The sector sees placements as an excellent source of future employees, and as a useful resource during busy and holiday periods. All of the industry representatives interviewed for this study concurred that graduates from programmes with work placements hit the ground running, being already familiar with industry practices when they entered employment. Nonetheless, industry representatives were strongly of the view that placements should be of 6-9 months in duration, as it takes at least 8-12 weeks for students to familiarise themselves with their positions.

Work placements with industry were also considered to be extremely beneficial for students, by the third-level providers interviewed for this study. Students receive an insight into how industry operates and practical experience, which shows in their studies following the placement. It was acknowledged that effective work placements require a partnership approach between students, education institutes and industry. This includes site visits to the student by the education institute, a clearly defined role for the student by the company, and a designated person in the company for liaison with the student. Most education institutes interviewed acknowledged that 14-16 weeks is a short time-frame but stated that many companies keep students on over the summer months. However, this is not an official part of the placement.

While all of the education institutes interviewed considered that ideally students should be graded on their work placements, currently this presents difficulties. Chief among those difficulties is the fact that it is often difficult to secure placements for all students, particularly during an economic downturn. Companies are reluctant to take on students when they may be making staff redundant. For education institutes, this presents the problem of awarding a proportion of marks to a placement when not all students may have secured a placement. Additionally, education institutions interviewed emphasised that where not all students had participated in a placement, difficulties arose in the following year with a clear distinction between those students who had participated in a placement and those that had not.





Currently, a combination of evaluation methods are used to assess students performance. These include on-site visits to students, employer feedback, reflective journal reports by the student or oral presentations by the student to academic staff.

Graduate internship programmes, such as Enterprise Ireland's Graduates for International Growth Programme (see section 6.4.5) were also considered very worthwhile by stakeholders, providing valuable experience to newly qualified professionals.

#### 4.4.4 Other Industry Participation

There is widespread informal engagement between the higher education institutes and the biopharma-pharmachem industry in Ireland. While structured engagement with industry has improved in recent years, overall formal industry engagement remains weak. Academics still have few incentives to engage with industry. The metrics used to measure academics' performance are traditional measures such as graduate numbers, papers published and funding obtained. Industry engagement depends on individuals, and where it works well is usually due to particular individuals in HEIs who are committed to fostering relationships with industry, rather than the system itself.

Currently, industry participation includes involvement in the following areas but varies considerably between individual departments and HEIs:

- programme reviews
- delivery of modules
- guest lectures
- sponsorship of student prizes and events
- site visits
- research funding
- equipment funding

Chapter 5 examines industry-academia collaboration in other international locations, and Chapters 6 and 7 further analyse this area in Ireland.

#### 4.4.5 State Agency Provision

A number of state agencies also provide training and development programmes for the biopharma-pharmachem industry in Ireland. The principal agencies with relevant offerings for this sector are NIBRT, Enterprise Ireland, FÁS and Skillnets.

**The National Institute for Biotechnology Research and Training (NIBRT)**, established in 2006, has a training mission to develop and deliver training solutions specifically focused on the needs of the bioprocessing industry. NIBRT's training solutions are developed in partnership with HEIs and third parties, such as the International Society of Pharmaceutical Engineers (ISPE). Programmes consist of masters courses, targeted at individuals who wish to advance their career in the bioprocessing



industry and an industry programme consisting of customised training modules, designed in partnership with individual companies to meet the specific needs of industry. Masters courses include an MSc in Engineering Science in Biopharmaceutical Engineering, and a Postgraduate Diploma/Master of Science in Biopharmaceutical Science. The industry training programme consists of a suite of accredited training modules that include introductory modules that deal with the principles of biotechnology, upstream and downstream technology modules including areas such as cell culture, bioreactor design and operation, formulation and formulation engineering. Modules are also available in facility design and project management, regulatory affairs and lean sigma principles. These modules can be combined and customised to meet companies' requirements.

**Enterprise Ireland** provides a range of training and development programmes for their client companies. These comprise a mixture of cross-sectoral and sector specific programmes in a variety of business disciplines, and a mentoring network. Indigenous biopharma-pharmachem companies particularly value EI's Leadership for Growth programme (see also section 6.4.2), targeted at company CEOs, which seeks to build and enhance leadership skills. Enterprise Ireland has recently launched a Leadership for Chief Financial Officers (CFOs) to complement the Leadership for Growth programme and to support the development of the strategic financial management function in growth businesses. Other courses considered by industry to be valuable include the International Selling Programme, which focuses on building export sales growth (see also section 6.4.5), the Lean Techniques programme (see also section 6.4.4), the Transform Programme, targeted at strengthening management teams so that companies are prepared to capture the next growth opportunity, and the Graduates for International Growth Programme (see also section 6.4.5).

Enterprise Ireland's Mentor Network was established to help companies identify and overcome obstacles to growth. Mentors in this network provide tailored advice, guidance and support, helping companies to accelerate growth and build management capability. Mentors are senior executives, drawn from the private sector, with a proven track record in business. They act as a confidential sounding board, advising companies on key operational and strategic issues.

A number of bespoke programmes are also offered to companies. These include programmes such as the Innovation Capability Building Programme which supports the development of the innovation function in client companies and supports their ability/processes of developing internationally competitive products. A number of these courses have been run a number in the life sciences arena.

**FÁS**, the national training authority, has a training facility for the biopharma-pharmachem sector in Cork, which was developed in response to the identified training needs for both new and existing industries in the sector. It aims to provide trainees with the opportunity to develop their practical diagnostic skills and related knowledge training in complex inter-relation technologies. The unit consists of a process training area, a clean room, three class rooms and related services.

The centre is supported by individual companies in the biopharma-pharmachem sector, UCC, Cork Institute of Technology, Education, Training & Organisational Services (ETOS) and NIBRT.

FÁS runs two programmes (biopharmaceutical processing and medical devices) but the facility is also available to relevant industry and third party training providers who aim to train, up-skill or re-skill employees.



The FÁS course in biopharmaceutical processing for operators leads to a FETAC level 5 major award. It is a part-time course which runs over a period of 6 months. Topics covered include : cell biology, cell culture processing, cleanroom technology, bioreactor operations, protein purification and sterile fill finish.

**Skillnets** is a state funded, enterprise-led support body dedicated to the promotion and facilitation of training and upskilling as key elements in sustaining Ireland's national competitiveness. Skillnets supports and funds networks of enterprises to engage in training under the Training Networks Programme (TNP). These networks are led and managed by the enterprises to design, manage and deliver specific training programmes across a broad range of industry and service sectors nationwide. In the Training Networks Programme (TNP) 2010/11 Skillnets networks are also providing training to job-seekers, who are training with those in employment. By training with those in employment, job-seekers can access networking opportunities and keep up to date with their sector while participating in relevant industry-specific training programmes.

The Pharmachem Skillnet is the principal network that supports the biopharma-pharmachem sector, with member companies drawn from the biopharma-pharmachem and medical devices industries. The network was established in 2006 and provides industry specific technical training to small and large companies in the sector, using a variety of training providers.

#### 4.5 Further Education and Training

The Further Education and Training Awards Council (FETAC) is the national awarding body for further education and training (FET) in Ireland. FET awards have been placed across levels 1-6 on the National Framework of Qualifications.

In 2009, there were more than 100 FETAC major awards (Table 4.3) in food science, laboratory techniques and pharmaceutical processing skill which were made to learners who had followed programmes provided either by the Vocational Education Committees (VECs) or by FÁS. All major awards relevant to this study were level 5 awards. In 2008, the number of relevant awards in this category was 59, mostly for laboratory techniques and food science.

Table 4.3 FETAC Major Awards (2009) in Food Science, Laboratory Techniques & Pharmaceutical Processing Skills

Award	Level 5
Food Science	10
Laboratory Techniques	70
Pharmaceutical Processing Skills	31
Grand Total	111

Source: FETAC



In addition, there were more than 3,100 minor awards and 266 special purpose awards in subjects related to the biopharma-pharmachem industry. The skills developed by these learners are an important step in developing industry relevant skills and can lead to further progression to other awards on the NFQ (e.g. level 7 - ordinary bachelors degree)

#### 4.6 Key Chapter Findings

- The analysis indicates that graduate annual output numbers in biopharma-pharmachem related subjects (approximately 1,100 in 2008) will be sufficient to meet industry demand at technician level (NFQ levels 6/7 and 8). CAO acceptances data suggests that this will continue for the next 3-4 years. It is noticeable that high-performing students tend to progress to further study before entering the industry.
- In 2007 and 2008, there were almost 800 postgraduate awards for biopharma-pharmachem subjects each year. More than half of awards were for master degrees, approximately 30 per cent for doctoral degrees, with biology/biochemistry subjects holding the larger share, and less than 15 per cent of awards at certificate/diploma level. There would therefore appear to be sufficient numbers at postgraduate level to meet industry demand.
- There is widespread informal engagement between higher education institutes and the biopharma-pharmachem industry in Ireland. While structured engagement with industry has improved in recent years, overall formal industry engagement remains weak, with academics having few incentives to engage with industry.
- Industry and HEI representatives consider student work placements to be very valuable, giving students practical experience of industry. Most undergraduate programmes offered by the institutes of technology include a placement, and likewise DCU and UL programmes. While programmes such as UCC's B.Sc Chemistry of Pharmaceutical Compounds, includes a work placement, it is not commonplace in most other university programmes. The critical issue here is that large numbers of students complete their studies in biopharma-pharmachem related subjects without any practical experience in the industry. Chapter 6 examines how student work placements can contribute to the alignment of third level programmes with industry requirements.
- In 2009, there were more than 100 FETAC major awards (Table 4.3) in food science, laboratory techniques and pharmaceutical processing skills which were made to learners who had followed programmes provided either by the Vocational Education Committees (VECs) or by FÁS. The skills developed by these learners are an important step in developing industry relevant skills and can lead to further progression to other awards on the National Framework of Qualifications (NFQ).
- A number of state agencies also provide training and development programmes for the biopharma-pharmachem industry in Ireland. The principal agencies with relevant offerings for this sector are NIBRT, Enterprise Ireland, FÁS and Skillnets.

Chapter 6 examines the future skills requirements of the biopharma-pharmachem industry, and the alignment of education and training programmes with those requirements.



## Chapter 5 International Approaches: Learnings for Ireland

### 5.1 Introduction

This chapter assesses the views of industry and related organisations on the future skill needs of the biopharma-pharmachem industry in three international locations in which this sector is active, and where skills have been a key element of the industry's success. It also reviews international practices in skills provision, and the mechanisms by which educational organisations maintain contact with industry so as to assure the currency of their graduates. The three locations chosen were:

- North Carolina
- Switzerland
- Singapore

The overall objective was to obtain information on useful practices which might be introduced in Ireland, and to better understand the role of training initiatives and practices as an element of attraction for manufacturing location. Such practices include any initiatives which involve education-related interactions between companies, or executives, in these sectors and educational institutions.

The research was conducted by interviews with relevant companies, educational institutes, public agencies and other organisations on site at the three locations during April - May 2010.

At each of these locations, logistical support and sectoral information was provided by local consultants. These consultants were selected for their local knowledge of the sector and their extensive contacts with relevant organisations. The consultants identified appropriate contacts, assisted in arranging interviews, provided background information and context, and also attended at least some of the meetings in each location.



## 5.2 North Carolina (NC)

### 5.2.1 Background

North Carolina is approximately 1.5 times the size of Ireland and has a population of 9.38 million and a labour force of 4.55 million<sup>48</sup>. Local employment has been badly hit by transfers of jobs in textile and furniture manufacturing to Asian countries. However, there has been a significant growth in high-tech industries. It is geographically diverse with a highly indented coastline and, in the west, mountainous terrain. It is the ninth wealthiest US state in terms of GDP (\$400 billion). Historically, the state's economy was based on agricultural produce (particularly tobacco of which it is still the major US producer), and also textile and furniture manufacture. Local employment has been badly hit by transfers of jobs in these sectors to Asian countries, but there has been a significant growth in high-tech industries. Current unemployment is 10.8 per cent<sup>49</sup>.

The state has historically been innovative and reactive in addressing its economic needs. In 1959 it established the North Carolina 'Research Triangle Park' (RTP)<sup>50</sup> which is the largest (7,000 acres) and oldest continuously operating technology park in the United States. RTP houses over 170 companies (including both R&D Centres and manufacturing) and also federal and state S&T agencies. Total employment within RTP is estimated at 52,000. The 'Triangle' is formed by three of the state's main universities, i.e. Duke University (Durham), NC State University (Raleigh) and University of North Carolina (Chapel Hill) and interactions with these, and other, colleges are significant to the success of the park.

The state also has an active and effective 'North Carolina Biotech Center' which is one of the oldest such organisations in the US and is actively involved in biotech infrastructure development, education and promotion.

### 5.2.2 Biopharma-Pharmachem Industry

The state estimates that it is host to 528 biotechnology-related companies, of which 43 are biopharma or traditional pharma manufacturers. The NC Biotech Center estimates that 18 of the latter are biopharmaceutical companies, and that they jointly employed 5,933 employees at the end of 2007. Between 2002 and 2007, these biomanufacturing companies grew 5.12 per cent per annum<sup>51</sup>. There is also a significant cluster of 110 Clinical Research Organisations, including Quintiles, the world leader in clinical trial management, and also other technical service companies providing testing and analysis<sup>52</sup>. The wider biotechnology sector employs 57,000 staff.

Research Triangle Park has been the genesis of many of these companies, as companies which developed products in their R&D functions proceeded to manufacture in the state. University technologies are also estimated to be the basis of 75 of the 528 biotechnology companies.

<sup>48</sup> Employment Security Commission of NC. [www.ncesc1.com](http://www.ncesc1.com)

<sup>49</sup> April 2010 - <http://www.bls.gov/lau/>

<sup>50</sup> [www.rtp.org/main/](http://www.rtp.org/main/)

<sup>51</sup> Personal comment from NC Biotechnology Center staff

<sup>52</sup> Source: North Carolina Biotechnology Centre - [www.ncbiotech.org/news\\_and\\_events/media\\_center/fast\\_facts.html](http://www.ncbiotech.org/news_and_events/media_center/fast_facts.html)

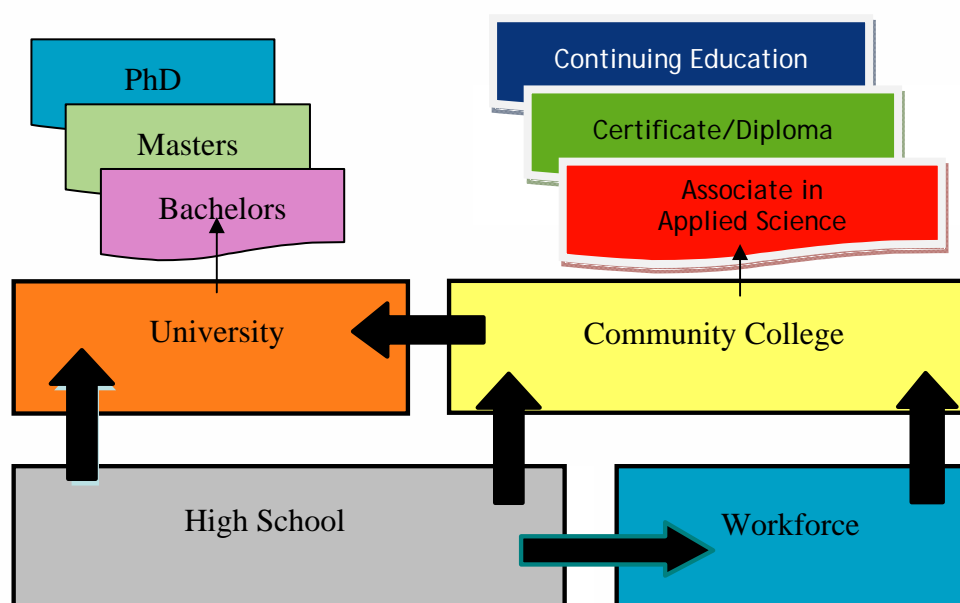
Current prominent biopharma-pharmachem companies with a presence in the state include Biogen-Idec, DioSynth, Eisai, DSM, GlaxoSmithKline, Merck, KBI, NovoNordisk, Wyeth, Trimeris, Talecris and Salix, as well as a wide range of medical device companies.

The industry is represented by the NC BioSciences Organisation<sup>53</sup> which has 150 member companies with 18,000 employees. Within this organisation is a sub-group called the Biotech Manufacturers Forum which has been active in the establishment of NCBioImpact, i.e. the training and educational initiative described overleaf.

### 5.2.3 Education System

Like Ireland, the relevant training of biopharma-pharmachem staff occurs after High School, and there is no vocational training such as occurs in Singapore or Switzerland. Training of technicians and operatives mainly occurs within community colleges (see below) and of higher qualifications at university.

Table 5.2: North Carolina Education System



Technician and operative training is mainly conducted within some of the 58 community colleges within the state. These are widely distributed and there is a general principle that there should be one community college within 30 minutes of everyone. The colleges are variable in size and student enrolment varies from hundreds to thousands depending on the area. There are 800,000 courses being taken by students in these colleges, but individual students may take several courses. About 25-30 of these colleges provide some courses of relevance to the sector. In 2002, a core group of seven of the colleges most active in life science education were formed into the BioNetwork as part of the wider NCBioImpact programme (see below).

<sup>53</sup> See [www.ncbioscience.org/about\\_us/](http://www.ncbioscience.org/about_us/)



NC BioImpact is fundamental to the way in which the NC education and training system operates for the benefit of the biopharma-pharmachem industry. This programme was initiated by the state in 2002 as collaboration between industry, state organisations and educational institutions. Its mission is *"providing a full spectrum of training for biomanufacturing and pharmaceutical production"* and its coordinates several interactive programmes:

- **Bionetwork:** This network comprises 20 community colleges (including six specialized centres) with training competence in specific aspects of biotechnology. The network also has access to a dedicated area within the BTEC for training purposes.
- **Biomanufacturing Training and Education Center (BTEC).** This is an 81,000-square-foot biomanufacturing training and education facility located on the campus of North Carolina State University. The pilot-scale production plant provides advanced, hands-on training and education for students and for industry employe. This facility has similarities with NIBRT, but includes dedicated space for education of BioNetwork students, as well as University Students and Industry staff. The facility has several international collaborations and would welcome further interaction with NIBRT.
- **Biomanufacturing Research Institute and Technology Enterprise.** BRITE, located at North Carolina Central University, provides degree programs and laboratories for scholars conducting research in several areas critical to biotechnology and biomanufacturing.

Funding for this initiative was provided by the Golden Leaf Foundation, which is the organisation founded to invest half of the \$2.3billion settlement received by the State from North Carolina's 'Master Settlement' with the Tobacco industries. Approximately \$80m was invested in the NCBioImpact initiative. In summary, NCBioImpact is a highly industry-focused approach to training for the biomanufacturing sector.

Qualifications available from the community colleges include Certificate, Diploma and Associate in Applied Science (AAS). Certificates and diplomas are described by the community colleges as industry 'entry-level' qualifications achieved through 18-24 hours (certificate) or 36-42 hours (diploma) of study. Associate in Applied Science qualification is a two-year course of study. Courses available of relevance to the biopharma-pharmachem sector include AAS in Biotechnology; Industrial Pharmaceutical Technology, Bioprocess Technology and several other options which would typically lead to positions as lab technicians and process technicians. Approximately 13 per cent of the workforce in eight NC biomanufacturing plants have this qualification. Surveys conducted at two community colleges<sup>54</sup> show that *"for biotechnology graduates, about 15 per cent of associate degree graduates move on to pursue bachelor degrees"*.

A large proportion of BioNetwork trainees are 'career changers' who have previously been employed in other sectors, particularly the declining furniture or textile industries. To illustrate this, the average age of entry of students for technician and operative training is 27. In effect, therefore, although there is no formal process of 'vocational' education, a high proportion of graduating

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<sup>54</sup> Personal Communication from Phil Sheridan, Industry Liaison Office, BioNetwork System





operatives and technicians have significant industry experience, albeit in other sectors. These individuals are sought by the biopharma-pharmachem industry because of their maturity and experience. A specific course that has been developed for the sector, and which is popular with career-changers, is BioWork. This is a 128 hour course designed to '*bring together the basics of manufacturing technology and the fundamentals of science - two essentials for competent, entry level technicians in biotechnology, pharmaceutical and chemical manufacturing*'.

**Graduate education** is undertaken within several of the universities within the state. These include in particular the University of North Carolina system (which has 16 colleges) including NC State University (NCSU), and the University of North Carolina at Chapel Hill. The other major local university is Duke University. In addition North Carolina Central University is a major player (see below). Both Duke University and Chapel Hill are within the top 100 World Universities in the Times HE rankings (Nos 13 and 78 respectively).

NCSU offers many graduate programmes of relevance to the biopharma-pharmachem sector, mainly in association with BTEC. These include Bachelors in BioProcessing Science, Biotechnology and Pharmaceutical (or BioPharmaceutical) Science. In the Engineering faculty, the BS offerings include BS in BioChemical & Bioprocess Engineering; Bioprocessing Science and others. There are currently about 220 students per year involved in bio-manufacturing courses involving BTEC facilities. A Masters Course in BioManufacturing is also being developed.

**Workforce Education.** Provision of specialist courses for specialist roles within the workforce is a feature of the US system. These courses are offered both by the community colleges, by NCSU/BTEC and also by the North Carolina Biotech Centre. Professional development courses are offered by NCSU/BTEC in three tracks: BioManufacturing, BioProcess Development and BioProcess Engineering<sup>55</sup>. As with other services, the design and availability of these courses is highly influenced by industry. NC Biotech Center also offers a series of one-day seminars on bioprocessing and process development.

**In summary**, there are several interesting features which should be noted in reviewing the education and training system in North Carolina:

- Firstly, the state has identified and supported elements of the education system which are highly industry-focused, and approaches the delivery of trained staff at all levels in an integrated fashion. North Carolina has recognised biomanufacturing as a sector with specific skill needs, and has worked with the industry to closely define the required skills and provide appropriately trained staff. It has, in effect, recognised biomanufacturing as a career choice and implemented a support system for those who make this choice. The publication "*Career Pathways: A guide for students, parents & educators in NC*"<sup>56</sup> notes the state's commitment to '*programs at community colleges and universities that are industry-focused and provide hands-on training for an industry that places enormous value on the scientific and technical training of its employees*'. Not all of the state universities could be defined as 'industry-

<sup>55</sup> See [www.btec.ncsu.edu/industry/short\\_courses](http://www.btec.ncsu.edu/industry/short_courses)

<sup>56</sup> NC Dept of Public Instruction (2006). (The content was developed by NC Biotechnology Center)



focused'. Indeed it might be noted that neither of the two most prestigious universities, Duke and UNC Chapel Hill, are involved in the formal state training activity. The education organisations involved in the state-funded system described below, subscribe strongly to the concept of industry focus.

- The process of defining and implementing further courses and degrees to serve the sector continues. Two examples are:
  - (a) a BioSciences Management MBA is offered by NC State University. This degree is an MBA specifically designed for those working in the life sciences industry. The programme brings together both the scientific and management sides of the business to better prepare for a career, or for career advancement, in biotechnology and pharmaceuticals<sup>57</sup>.
  - (b) a Masters in BioManufacturing is also in planning by BTEC and NCSU. PhD programmes are also planned.
- Finally, a large proportion of BioNetwork trainees are 'career changers' who have previously been employed in other sectors, particularly the declining furniture or textile industries. Education is seen as a means to meet employment needs, and there is frequent entry and exit from the education system. The average age of entry to community colleges for biopharma-pharmachem-related training is 27.

Extensive research and consultation to establish industry views and needs was conducted in 2002/2003 by the NC Biotechnology Centre, and this process continues. The initial research resulted in several reports<sup>58</sup> which define the training programme required, and also describe the qualification requirements for 9 'model employees' required by the biopharma-pharmachem industry. These are outlined in Table 5.3.

These requirements, refined on an on-going basis through consultation, are the basis for the training programmes in place.

The industry consultation process, which involved an industry/educator committee, and focus groups involving 35 Industry representatives and 10 trainers, also defined some critical characteristics for biopharma-pharmachem workforce training programmes:

- Operation in a GMP-like manner
- Provision of hands-on experience with production equipment, at least at pilot scale, as well as laboratory equipment
- Training in aseptic manufacturing processes and clean-room work
- Instruction by faculty with prior experience in the industry
- Close oversight of curricula and programmes by industry

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<sup>57</sup> [www.mgt.ncsu.edu/mba/concentrations/biosciences/](http://www.mgt.ncsu.edu/mba/concentrations/biosciences/)

<sup>58</sup> Most notably *Window on the Workplace: Training Needs Assessment for the BioManufacturing Workforce* (2003) and *The Model Employee: Preparations for Careers in the BioPharmaceutical Industry* (2005).



Table 5.3 Qualification Requirements for Model Employees defined by N Carolina BioPharma industry

<b>R&amp;D (Process Development)</b>
Process Development Scientist (PhD or Masters of Science + 2-5 years experience)
Process Development Associate (Bachelors of Science or Associate in Applied Science + 2-5 years experience)
<b>Production</b>
Process Technician (High School Diploma + + relevant short courses)
Process Engineer (Bachelors of Science or Masters of Science)
<b>Quality Assurance/Quality Control</b>
QC Control Assistant (High School Diploma - Associate in Applied Science depending on nature)
QC Associate (Bachelors of Science or Associate in Applied Science + 2 years experience)
Quality Assurance Associate (Bachelors of Science or Associate in Applied Science + 2 years experience)
<b>Manufacturing Support</b>
Maintenance Technician (HS/GED + relevant short courses)
Instrumentation Technician (AAS + + relevant short courses)

Delivery of the defined skill-base required the establishment new training programmes with all of the attendant need for faculty and support staff, and also of new facilities for training. This was implemented through the **NCBioImpact Programme**<sup>59</sup>, which ensures close contact, and facility sharing, between those training at bachelors and technician level staff.

As an indication of the relative employment of different qualifications within the biomanufacturing sector, Table 5.4 shows the results of a survey conducted in eight biomanufacturing companies by NC BioTechnology Center in 2007/8. This shows that 31 per cent of staff had only High School diplomas (HS) or High School Diplomas with College Credits (HS+). High School students can earn credits for college by taking certain additional courses or activities during their high school period. These grades are very predominantly employed in manufacturing or plant operations activities. However, it is emphasised that those with only HS qualifications are rarely employed directly from High School. The vast majority would have experience in other sectors prior to employment in the Pharma sector.

<sup>59</sup> Originally called the North Carolina BioPharmaceutical & Pharmaceutical Training Consortium.



AAS grades are also predominantly employed in plant operations and manufacturing. College graduates (BS, MS & PhD) are predominantly employed in quality roles, and in research and process development.

BRITE does not have a PhD programme, and is planning a programme which “will require students to take 30 credits in course work (same as our master program) and passing the qualification exam, then complete their research. It will take three semesters for course work; depending how hard they work on their thesis, it may take 4 to 5 years to graduate”<sup>60</sup>.

BTEC also does not yet have a PhD programme but are “in the process of creating a MS degree in Biomanufacturing this coming year (2010). It will have both a thesis and a non-thesis option. Both will require industrial internships and case studies, and professional skills development courses.

Table 5.4: BioManufacturing Qualifications in 8 NC Plants 2007/8<sup>61</sup>

	High School Diploma	High School Diploma with College credits	Associate in Applied Science	Bachelors of Science	Masters of Science	PhD	No. Staff	%
	%							
Res. & Process Dev.	1	2	1	50	25	21	610	14
Plant Operations	5	20	26	36	11	2	903	21
QA/QC	1	5	5	74	13	2	1098	25
Manufacturing	40	20	16	20	4	0	1709	40
<b>Average</b>	<b>17</b>	<b>14</b>	<b>13</b>	<b>41</b>	<b>11</b>	<b>4</b>	<b>4320</b>	

#### 5.2.4 Industry-Academia Interactions

Interactions between the Universities or Community Colleges and the industries they serve are extensive and essentially routine. The system has been designed through consultation with industry and on-going consultation is built into the system. The ways in which communication and mutual understanding is achieved are:

- **Industry-Experienced Faculty:** Staff in all of the NCBioImpact institutions have industry experience and this was one of the ‘Critical characteristics’ defined by industry for implementation of training programmes. 75% of the BRITE faculty have industry experience (a total of almost 100 years between 13 faculty); while BTEC management staff are predominantly ex-industry with additional teaching staff from NCSU. Industry experience is also a requirement for staff employed within the BioNetwork staff.

<sup>60</sup> Pers. Comm. from Dr. Li-An Yeh - Director of BRITE

<sup>61</sup> Data derived from material supplied by NC Biotechnology Center

- **Collaborative Research.** Both BRITE and BTEC are involved in collaborative research with industry, and offer their facilities for use by industry in their R&D activities.

## Student Work Placements

Cooperative training is where a student is placed within a firm for a period as part of their training and within term time; these placements can be up to 3 semesters, usually interspersed between semesters of coursework. *“Co-op is a program of alternating semesters of work and school. Paid work terms of increasing responsibility enable students to graduate with the minimum equivalent of one year of relevant work experience”*.<sup>62</sup>

## Internships

Internships are usually performed during the summer vacation. They are preferred by students, as they do not use up term-time. They are the most usual form of placement. Companies like them as a means of reviewing potential employees, while students gain credits for completing them. No payment or other incentive is offered to companies. As an indication of industry interest in internships, NC BioSciences Organisation (the industry representative group) has hosted three internship fairs so students can meet with companies and find out about internships.<sup>63</sup> The university position is summarised by NC State University as follows: *“The University Career Center does not offer any incentives to companies to hire our students, either for full time, post-graduation employment or for internships. ....the only incentive is for companies to find talent for which they have either an immediate need or a perceived long term need, the latter usually reflected in training/rotational/developmental programs offered by some companies. Another point to consider is that our career center does not “place” students in companies; we post jobs and internships and also schedule on-campus job/internship interviews. It is the student’s responsibility to apply for employment, to sign up for interviews, and to be prepared for those opportunities”*.<sup>64</sup>

- **Student experience.** As noted above, most students in the community college system are already experienced in industry, and will bring this experience to the course.
- **Board Representation.** The boards of BioImpact, and of the constituent organisations all have industry representation. For instance, BTEC has a 23-person Advisory Board which includes 14 Industry representatives.

### 5.2.5 PhD Deployment

The predominant view of all of those interviewed is that PhDs are employed for leadership roles in R&D. This could include both discovery, and process development. The only role in the ‘Model Employee’ document for which a PhD is an option is a process development scientist, and an MS with 2-5 years experience is an option for this role. This view is borne out by the survey conducted by NC Biotech Center in 2007/8 (see tables 5.3 and 5.4) which showed that PhD employment in 8 major biomanufacturing companies (4,320 employees) was 168 or approximately 3.8% of total staff. The extent of PhD employment had fallen from 183 (5.3% of total staffing) in 2003 to 168 in 2007,

<sup>62</sup> Description of BioProcessing Science course at [www.ncsu.edu](http://www.ncsu.edu)

<sup>63</sup> Pers Comm. from Brenda Summers, NC BioSciences Organisation. 8.2010

<sup>64</sup> Pers. Comm. from Carol Schroeder, Director, Career Centre, NC State University. 8.2010



despite a 25% increase in total employment, and an 80% increase in employment in the research & process staff.

In the 2007/8 survey 78% of the PhDs employed were in research and process development roles. The employment of PhDs almost exclusively in the development roles is borne out by the interviews with almost all of those interviewed in the region. Other than development, no role could be envisaged within the biomanufacturing industry where a PhD qualification would be a requirement.

### 5.2.6 Summary

North Carolina has recognised biomanufacturing as a sector with specific skill needs, and has worked with the industry to closely define the required skill needs and provide appropriately trained staff. An integrated process involving state agencies, academia and industry, has defined 'model employees' for the sector and then created courses to train these employees. This programme, NC BioImpact has created three organisations for delivery of skill needs:

- BioNetwork is a consortium of community colleges specialising in life science education for technicians and operatives.
- BTEC is a custom-built bioprocess training facility with the equipment and faculty to provide hands-on training and experience to Bachelor, Masters and PhD graduates. A section of BTEC is also set aside for the training of students within the BioNetwork programmes.
- BRITE is a separate facility designed to train non-manufacturing staff within the industry. It mainly trains staff for roles in discovery, and QA/QC.

Interaction between industry and educational facilities is extensive and routine, and there are multiple avenues for communication. Most of the educational faculty have industry experience, and even students entering into the community college programme will usually have had many years of industry experience, albeit in other sectors of industry.



## 5.3 Switzerland

### 5.3.1 Background

Switzerland has a population of 7.62 million and the labour force is estimated at 4.1 million (2009 data). Annual average unemployment in 2010 is estimated at 4.4 per cent<sup>65</sup>. The location of industry, and the organisation of the education system, reflects the strongly federalised nature of Switzerland, and the cultural diversity of the Swiss people who share three languages (French, German and Italian). The country is mainly governed through 26 cantons which manage most aspects of education, industry support and some aspects of regulation, and whose populations range from 69,000 to 1.2m (total Swiss population is 7.2m). The Federal Government has a relatively 'light touch' in most areas of national administration. In relation to training and skills development, control is with the individual cantons. The Federal Government funds and manages the Federal Institutes and also coordinates the activities of the cantons, but cannot tell them what to do. Canton policy in relation to education strongly reflects local economic needs and concerns.

### 5.3.2 Biopharma-Pharmachem Industry

Switzerland has been a major international location for the chemical industry for over 150 years, and the origin of several major industry names. The current biopharma-pharmachem industry can be seen as having 3 groupings: (a) some of the original pharma-chemical companies, (b) chemical companies which have transformed themselves into bio-based companies, and (c) new 'biotech' start-up companies.

There are three industry representative groups which are relevant to the companies in the biopharma-pharmachem sector:

- The **SGCI Chemie Pharma Schweiz**<sup>66</sup>, founded in 1882, is the major industry body for the wider chemical sector and has 250 members. As many of the bigger pharma companies started as chemical companies, they are also members. Its objective is to promote and protect the interests of the wider chemical and pharma industry.
- **Interpharma**<sup>67</sup> was formed to represent the special interests of the seven major pharma companies and is a lobby group representing their specialist interests in areas such as regulation, R&D and tax incentives.
- **Swiss Biotech Association - (SBA)** represents the newer biotech companies, most of which are start-ups by researchers out of the industry or universities. The Swiss Biotech Report 2010 states that there are 162 Biotech companies in Switzerland employing 19,072 staff. The majority, but not all of these companies are in healthcare, but it is not clear how many could be classed as biopharma companies.

Overall, the Pharma/Chemical sector employs a work force of about 66,300 which makes it one of the largest industrial employers in Switzerland. Some 35,400 of these are employed within the pharma sector<sup>68</sup>. The Pharma industry share of total Swiss exports was 26.8% and this proportion

<sup>65</sup> Data derived from World Factbook 2010.

<sup>66</sup> See [www.sgci.ch](http://www.sgci.ch)

<sup>67</sup> See [www.interpharma.ch/de/Ueber-Interpharma.asp](http://www.interpharma.ch/de/Ueber-Interpharma.asp) (In German & French only)

<sup>68</sup> The Significance of the Pharma industry for Switzerland. Polynomics Report for Interpharma. 10.2009.



has been increasing for several decades. Switzerland ranks number nine in the world as an exporter of chemicals (4 per cent of world exports), just ahead of Ireland at number ten<sup>69</sup>.

The most significant companies in the sector are Hoffman La Roche and Novartis, both of which are undoubtedly among the world leaders in pharmaceutical bioprocessing and bio-discovery. In general, the technological base of the older companies in the sector is rapidly moving from chemistry to biological production, and their product output is becoming more pharmaceutical in nature. The original giants of the Swiss pharmaceutical industry were Roche, Ciba, Geigy and Sandoz. Roche remains as one of the major international healthcare companies, while the business units within the other three have been re-organised to form Novartis (mainly pharmaceuticals), Syngenta (agri-chemicals), Clariant (polymers) and Ciba Chemicals, which has recently been merged with BASF. Other significant Swiss players in the pharmaceutical industry include Lonza, and Merck Serono. In addition to their Swiss activities, companies in this sector have Foreign Direct Investments of €43 billion in other countries, and only 14% of the staff of the top 10 Swiss companies work in Switzerland.

The new start-ups are also technological leaders in the sector, and significant among them are Actelion, Cytos, Basilea & Novimmune.

The sector is also a significant investor in research. Swiss pharmaceutical companies reinvest an average of 18% of revenue in research and development of new and innovative products and processes. In 2007, the chemical-pharmaceutical industry's expenditures for research amounted to €4.3 billion in Switzerland alone. Swiss companies also have significant innovation activities, and staffing, in company facilities in other countries. A particular concern of Interpharma, for instance, is to improve the ability of Swiss companies to conduct R&D in Switzerland. Current difficulties include the low involvement of Swiss youth in science studies. This concern was also voiced by the Federal Ministry of Education SBF.

The high investment in innovation is reflected in the employment profiles of companies. According to SGCI, the sector employs over 8,000 highly qualified people in research, and "62 % of employees ... are assigned to a higher qualification category by official statistics, compared to an average 42% of staff in all industries".

The SGCI have been active promoters of both educational quality, and also of the innovation society. In a recent position paper<sup>70</sup> they state "The most important driving force in industrial research and development is the availability of scientific and technical knowledge and know-how in a company... (thus) ... government education and research policies must be such that excellence is to be strived for at all levels and in all fields"

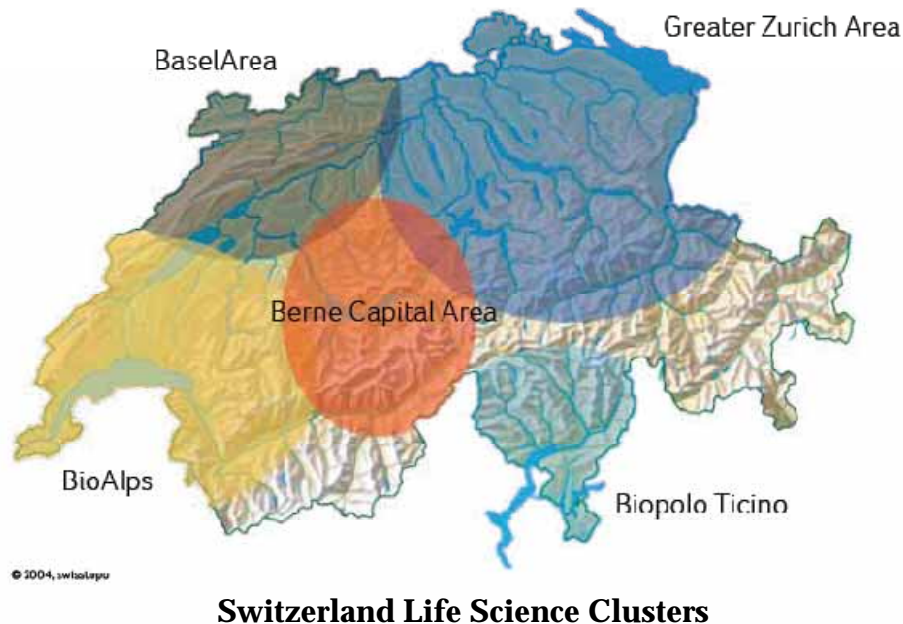
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<sup>69</sup> The Swiss Chemical & Pharmaceutical Industry. SGCI Report 2010.

<sup>70</sup> Innovation action plan -for a successful Switzerland. SGCI Position Paper - [www.sgci.ch/plugin/template/sgci/164/44544/---/SGCI-Positionspapier\\_Innovation\\_18-02-2009\\_e.pdf+%28EN%29](http://www.sgci.ch/plugin/template/sgci/164/44544/---/SGCI-Positionspapier_Innovation_18-02-2009_e.pdf+%28EN%29)



Figure 5.1 Switzerland Life Science Clusters



Because Switzerland is composed of culturally and administratively distinct regions, bio-Industry development and promotion is organised within regional clusters. These are represented in the map above, and are:

- [Basel Area](#) - Basel Area Life Science Cluster. This is the major cluster of biotech companies in Switzerland, with a powerful mix of older companies, new start-ups and excellent research and technology for development (RTD) institutions.
- [Greater Zurich Area](#) - Zurich Area Life Science Cluster. This is the second most important area, particularly for start-up companies which have been locally supported. It is also the location of the foundation for technological innovation (FTI), which is a major centre for life science research.
- [Berne Capital Area](#) - Bern Life Science Cluster. The biotech companies in this region are primarily focused on equipment and devices, building on the region's strong history in instrumentation and precision equipment.
- [Bioalps](#) - Lake Geneva Biotech Cluster. This region is host to 200 bio- and medical technology companies and more than 10 research institutions. Research parks and technology transfer institutions support fast development of innovation.
- [Biopolo](#) - Ticino Biotech Cluster. This is a minor player in Swiss biotech.



### 5.3.3 Education & Training System

Switzerland has a highly regarded educational system, but very different from that in place in Ireland. School starting age is usually six and education is compulsory to age 15. This varies to some extent among cantons, which have total control of primary and secondary education. The secondary school system, in summary, involves a process of early streaming of pupils into those who will go to the main universities and those who will undertake vocational, or other specialised, education. This selection is made on academic merit, which includes teacher recommendation, from about 12 years on and those pupils destined for university (about 30% of total) will enter the Gymnasium school system (upper secondary) at age 16.

The remaining pupils have several options, but a high proportion (~60 per cent) will enter into an apprenticeship, which is highly formalised and includes both schooling and practical training.

**Apprenticeships.** Almost all trades and professions require an apprenticeship, including those of relevance to this study such as lab technicians and pharmaceutical technologists. Apprenticeships are generally 3 years in duration and apprentices are paid a small wage. Companies are obliged to take apprentices and are fined if they fail to do so. Equally, students who do not qualify for the Gymnasium (and subsequent university entry)<sup>71</sup>, must complete an apprenticeship to qualify for any form of further education.

The pharmaceutical industry in Basel has formed a specific institution, called Aprentas ([www.aprentas.com](http://www.aprentas.com)) to provide specialist training for technicians and operatives for their sector. This is a private training organisation, originally developed by CIBA, Syngenta and Novartis for their staff, but now trains apprentices for 37 member companies. Companies pay an initial fee to become a member (based on total employment) and then a small annual fee. The apprentices entering the course are usually about age 16 and are hired by the member company and then assigned to Aprentas for training. They provide a comprehensive service for the companies. They note that a lot of their students come from Germany and that German students are 'very willing to commit to practical training'. Aprentas regularly surveys the companies, and training is customised for member needs. They envisage training as having three places of learning:

- Operational training at Aprentas - practical skills
- Vocational school at Aprentas - job-related theory and general education
- On-the-job

A typical distribution of apprentice time in these three areas can be seen in table 5.5. As the training is customised for clients, the interaction with companies is inherent in their approach. They also interact with other local institutions, and lecturers from the universities of applied science (UAS) come to Aprentas for presentations. The local UAS noted that a large proportion of their intake come from Aprentas.

Other companies, including Roche, have their own apprentice training systems. Following apprenticeship the graduates have several options. They may be retained as employees of the companies in which they conducted their apprenticeship, or they may opt to attend a university of

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<sup>71</sup> Excepting teacher-training and some other specialist roles, which have separate career paths

applied science (UAS) to begin a BSc or equivalent. Youth unemployment is approx 4 per cent in Switzerland, which is largely due to this system.

Table 5.5: Learning Blocks for Chemistry Lab Technician in Aprentas

1st Year of Apprenticeship												
Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	
	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job
	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas
	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas
	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams
2nd Year of Apprenticeship												
Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	
	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job
	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas
	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas
	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams
3rd Year of Apprenticeship												
Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	
	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job	On-the job
	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas	Operational Training at Aprentas
	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas	Vocational School at Aprentas
	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams	Exams
		On-the job										47%
		Operational Training at Aprentas										28%
		Vocational School at Aprentas										25%
		Exams										

Third level education institutions are comprised of (see map: figure 5.1):

- Ten universities (run by the cantons)
- Two federal institutes of technology (FITs) (ETH in Zurich and the EPF in Lausanne)
- Seven universities of Applied Science (UAS) or Hochschule.

The third level system is also the direct responsibility of individual cantons, except for the two federal institutes of technology (FITs), which are funded and managed by the Federal Government through an appointed board.

### Universities

The term university is used for all ten universities and for both FITs. Most of these universities are considered to be of a very high standard. Two of these are in the top 50 universities in the world in most classifications<sup>72</sup> and are funded and managed by the Federal Government. In 2007, around 115,000 people studied at one of these twelve Swiss universities. Of these, about 20,000 are within one of the 2 FITs. These students are the best students from the school system and will have attended a Gymnasium or equivalent school to age 18/19. There is an emphasis on theoretical

<sup>72</sup> See [www.universityrankings.ch/results/results\\_main\\_rankings](http://www.universityrankings.ch/results/results_main_rankings)



education, as distinct from the UASs, which focus on practical education. There was a clear view from those interviewed (including academics from within the classical universities) that the Bachelor graduates from the universities were not employable within technical roles by industry as they have no practical training. Some may be employed in sales & marketing roles as they have the theoretical training. Most will go into non-industry roles in state agencies, finance or law for example. PhDs from the main universities will find roles in industry R&D. In terms of salary expectations, for instance, a Bachelor from UAS would command the equivalent of a Masters from ETH. However, this perception is less prevalent among the multinational corporations (MNCs), who regard the UAS graduate as purely a lab technician.

The **FachHochschule** or **Universities of Applied Science (UAS)** are managed by the canton, and funded by a combination of canton and federal funding. They are somewhat akin to the institutes of technology in Ireland, but there is a very strong emphasis on practical training and '*learning by doing*'. They produce the technical staff for industry, and all students entering these colleges will already have completed an apprenticeship. Only bachelor and masters degrees are offered. The UAS is obliged 'by law' to produce graduates who are '*ready for employment*' and this is reflected in the systems which are in place to ensure that the curriculum addresses industry skill needs. There are frequent and multiple interactions between faculty and industry about content. Even students will be well acquainted with industry practice as all have completed an apprenticeship before entering a UAS.

To emphasise the distinction between these institutions, it should be noted that they have totally separate governance at all levels. Within the Swiss Confederation, university affairs are the responsibility of the Federal Dept of Home Affairs (EDI) (via the State Secretariat for Education and Research), while UAS matters are the responsibility of the Federal Department for Economics (via the Federal Office for Professional Education and Technology). However, a new law aimed at providing for a joint governance of third level education is currently being debated by the Swiss Parliament<sup>73</sup>.

While several interviewees noted that UAS researchers would like to do more basic research, it is effectively not possible for them to do so as the main R&D funding available to them is through the Commission for Technology and Innovation (CTI) which is exclusively for industry R&D collaboration. Some more fundamental research may also be funded by the Swiss National Science Foundation.

The Swiss third level education system is a dual system and those interviewed emphasise that both parts are essential to the effective running of the biopharma-pharmachem industry. The graduates are regarded as '*different but equal*'. The main universities provide the PhDs, who often end up in research management positions, while those with more practical training will usually be involved in production and other technical roles within industry. The masters course within UAS is half theory and half practical and will provide the graduate with basic skills in research, including understanding scientific literature. UAS graduates are not usually the innovators other than in relation to equipment '*but they make it happen*'.

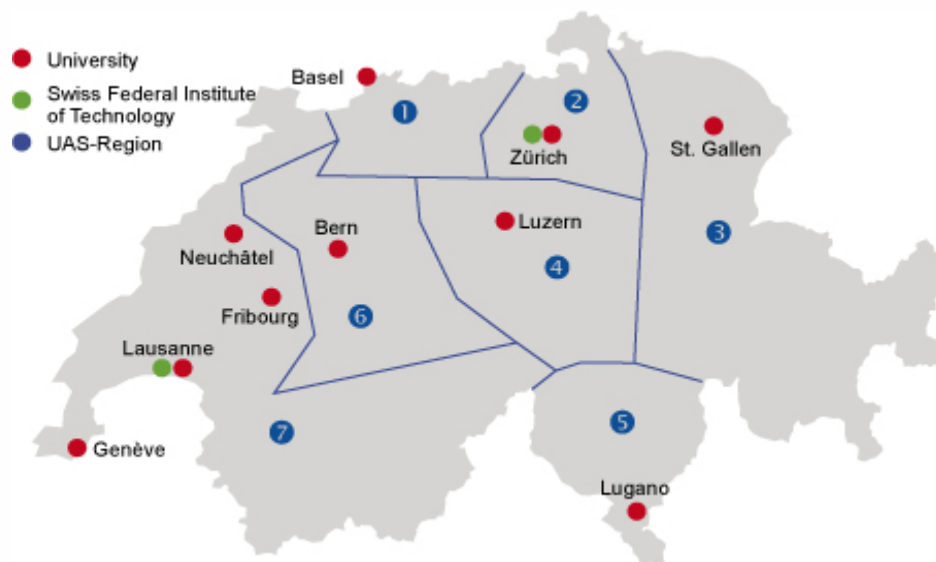
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<sup>73</sup> Personal comment from Corina Wirth, Staatssekretariat für Bildung und Forschung SBF (July 2010)



The dual system also has 'bridges' at various points and those within the UAS track may move to the main universities to do a further degree. These students, with a combination of strong practical training and also theoretical training, are often very successful within industry.

Figure 5.2 Swiss Third Level Institutions



Switzerland has been in the process of compliance with the Bologna system since 2002. The process is not yet complete<sup>74</sup> and some institutions therefore offer courses under the old systems of diplomas and licentiates. A draft Qualifications Framework was developed in late 2009 and is being discussed by the relevant organisations<sup>75</sup>.

### 5.3.4 Industry-Academia Interactions

#### Placements

In effect, placement is not an issue for students at UAS as they will all have had 3 years of apprentice training in advance of entry. During their BSc they will have a further 12 weeks placement (in year 3) which involves conducting a practical project of specific relevance to the host company. There will be some interaction between the student and the company in advance of the placement to ensure relevance to both parties. Students doing an MSc have an 8 month placement. If the purpose of placement is to ensure that the student is acquainted with industry practices, and general work-place systems, within-course placement is not an issue for the Swiss UAS system.

Students who go through the Matura or Gymnasium system (i.e. who have not completed an apprenticeship) and then wish to enter a UAS must complete a *“one year internship in a company working in the field of the study topic. This internship has to be completed before starting the*

<sup>74</sup>See [www.crus.ch/information-programme/study-in-switzerland.html?L=2](http://www.crus.ch/information-programme/study-in-switzerland.html?L=2)

<sup>75</sup>[www.crus.ch/information-programme/qualifications-framework-nqfch-hs.html?no\\_cache=1&L=2](http://www.crus.ch/information-programme/qualifications-framework-nqfch-hs.html?no_cache=1&L=2)



*study programme. This internship has to be accepted by the study director and it is the candidate's responsibility to make sure that this is the case."*<sup>76</sup>

Within the 'classical' universities, there is a less-intense system of interaction and placement. In University of Basel, for instance, the placement is optional but is widely used. There is no incentive offered to companies to accept students, nor is there a penalty for not doing so. The advantages of placements for the companies are (a) an opportunity to review potential employees, (b) a cheap and usually inexpensive source of labour.

### Company Interactions with tertiary Education

There is very strong interaction between the companies and the UAS on all aspects of curriculum development, and a significant degree of interaction on delivery. The UAS system is required to produce graduates who are immediately employable. This is ensured in several ways:

- Many of the UAS faculty are ex-industry and have first-hand knowledge of industry expectations. Faculty who do not have this industry network for interaction will be expected to do more teaching in lieu of the interaction time they might otherwise have contributed.
- There is a formal process of discussion between UAS and local industry on a bi-annual basis and companies have an opportunity to 'challenge' existing or planned courses. ZHAW, for instance has an alumni association with regular get-togethers. These events are often used to capture their views.
- Industry needs will be reflected directly by industry representatives on UAS boards, and indirectly by other cantonal representatives
- Students will themselves be aware of work-place expectations for graduates
- Finally, in the Basel area the colleges are physically very close to companies and even share some buildings.

Industry input is also reflected in the design of new courses, which is primarily a matter for UAS faculty, but with the expectation that full liaison will be had with the potential employers to ensure that the graduates are employable. Course changes will also be left to the faculty on the same basis. The major test of a new course is whether the graduates are employable. Company approval is the major justification for new courses or changes.

Within the 'classical' universities, there is also a wide range of interactions but they are less pervasive than in the UAS system. Students in the pharmacy college of the University of Basel, for instance, have a system of mentoring by industry scientists, mainly designed to assist with career choice. On the other hand, despite a well-known shortage of pharmacists and toxicologists, the U Basel has not made available the resources to allow the pharmacy school to increase their output of pharmacy graduates.

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<sup>76</sup> Personal comment from Tobias Merseburg, Zurich Univ of Applied Sciences.



### Collaboration with other colleges

The UAS already collaborate significantly with other educational institutions, particularly in delivery of MSc courses. Among the UAS colleges, the core theoretical themes are delivered centrally among those which specialize in pharma-related topics. These are often delivered in English as a 'lingua franca' among the three Swiss languages.

The classical universities have a wide range of international collaborations in research, but less so in teaching.

### Course Content

Within all UAS courses, the major component is practical training, but there is also a core content which includes a range of business-related subjects such as management, communications, law, IP management, general business principles, budgeting, and English language. Within the MSc, there is some additional material of a similar nature, but the major additional content is more scientific theory.

### 5.3.5 PhD Deployment

There is significant diversity of views on this subject. Firstly it should be noted that only the main universities and the FITs produce PhD graduates. The UAS system cannot graduate PhDs. Swiss PhDs are therefore regarded as having a theoretical rather than practical training. The consensus view is that PhDs are essential in any R&D leadership capacity within industry, but that UAS graduates are more valuable in any process or operational role due to their high level of practical understanding. The graduates who are particularly valued are those who do a BSc or MSc within the UAS system and then transfer to the main universities for additional study, e.g. PhD. They combine the practical and theoretical skills and have a wider perspective than graduates from either system.

It was also noted that a lot of PhDs do not go to industry at all, but will be employed in various policy or business roles (venture capital, IP, state agencies, for example). There is a division of views on the value of PhDs and the only area of agreement is that R&D leader roles within industry will almost always be occupied by PhDs.

On in-house training of PhDs, the nature of R&D within the big companies has changed so that project life is much shorter. It is therefore very difficult to accommodate a PhD thesis within the R&D projects conducted by industry. Consequently this practice has reduced in recent years.



## 5.4 Singapore

### 5.4.1 Background

Singapore is an island city-state with an area of 271 sq miles<sup>77</sup> which is constantly being increased by reclamation projects. The citizen population is mainly ethnically Chinese (74 per cent) with the remainder comprising a highly diverse range of other groups, particularly Malay and Indian. Almost 50 per cent of the resident population is foreign nationals, and approximately ten per cent of the population have 'Singapore Permanent Resident' (PR) status which has most of the benefits of citizenship. The country actively encourages inward migration of skilled individuals of relevance to its economic base<sup>78</sup>.

The population is 4.84 million and the labour force is 3.03m (2009 data)<sup>79</sup>. Annual average unemployment in 2009 was 3 per cent, or 4.3 per cent among citizens and permanent residents. It has a diverse economy based on financial services, shipping, tourism & a range of manufacturing industry based around petroleum & chemicals, IT, and biomedical manufacturing. Within Asia, it has the highest standard of living<sup>80</sup> and provides an attractive living environment for foreign nationals. Politically, it has been ruled by the same party since its independence in 1965, and there is a high degree of central planning.

### 5.4.2 Biopharma-pharmachem Industry

Overall, healthcare industry employment in Singapore is 13,174 of which 4,880 are within the biopharma-pharmachem industry<sup>81</sup>. The biomedical sector has been a priority area of investment for the Economic Development Board (EDB)<sup>82</sup> since 1999. Attraction of FDI is a major activity of EDB which also coordinates economic planning and implementation. It has a wide range of economic investment programmes in operation, and there is "*almost unlimited government support*" for priority investments<sup>83</sup>. Establishment of Singapore as a hub for the biopharma industry (and related biomedical industries) involved a series of initiatives. Significant among these is the BioMedical Science Initiative which comprised a series of investments and activities by several local Ministries and agencies to create a hub of biomedical R&D, and related commercial activity. The policy is similar to Ireland in that both manufacturing and R&D functions are being targeted by separate measures. This biomedical sector is planned to be the 'fourth pillar' of the manufacturing economy (with electronics, chemicals and engineering). EDB has made an investment of SIN\$10 billion (€5.8 billion) over the last 10 years to develop an impressive infrastructure for the sector.

<sup>77</sup> Dublin county, for comparison purposes, is 445 sq miles

<sup>78</sup> See, for instance, [www.contactsingapore.sg](http://www.contactsingapore.sg)

<sup>79</sup> Ministry of Manpower website: [www.mom.gov.sg](http://www.mom.gov.sg)

<sup>80</sup> Economist Intelligence Unit 2006 (also the 11<sup>th</sup> highest in the World)

<sup>81</sup> Figures from Singapore Economic Development Board. (2008 data)

<sup>82</sup> [www.edb.gov.sg/edb/sg/en\\_uk/index.html](http://www.edb.gov.sg/edb/sg/en_uk/index.html)

<sup>83</sup> Life Sciences Cluster Analysis. Forfas (2008)





Major infrastructural investments of relevance to the sector include:

- **Tuas Biomedical Park (TBP).** This is a 360-hectare designated area with services and infrastructure for biomedical manufacturing industry. It presents a 'plug-and-play' environment that enables leading biomedical sciences companies to set up manufacturing facilities with minimal lead time. These companies can also access third-party utilities and services such as steam, natural gas, chilled water and waste treatment. It is currently home to leading pharmaceutical, biotechnology and medical technology companies such as Abbott, Alcon, CIBA Vision, Genentech, GlaxoSmithKline Biologicals, Lonza, Merck Sharp & Dohme, Novartis, Pfizer and Wyeth. These companies have collectively invested over S\$6 billion to set up manufacturing facilities in the park.
- **BioPolis** is a biomedical science park and the flagship of the biomedical science initiative in attracting biopharma R&D activity. It contains more than 200,000sq metres of space for research and development in its first two phases (investment of S\$300m). Phase three is now under construction. It is designed as a research cluster for companies and national research institutions. It is home to seven research institutes run by A-STAR (see below), and also the research centres of several MNCs (including Novartis, GSK, Takeda, Lilly and MSD), as well as some SMEs. It is situated in an area called "One North" (one degree in latitude north of equator) which is a technology hub that also contains the "Fusionopolis" which houses groups in materials science and engineering, data storage, microelectronics, manufacturing technology, high-performance computing, and information and communications.

Singapore has also accommodated the biopharma manufacturing sector in many other ways including the establishment of integrated educational packages, training incentives, and reinforcement of the Intellectual Property protection system. It has also supported a related service industry by developing legislative and financial incentives for clinical trial management, which is now a major element of the Singapore healthcare industry. Many international companies use it as a base for managing clinical trials in Asia. The major local recruitment agency, RSA, noted in an interview for this study that CRO staff recruitment is the major component of their business.

In parallel to the development of the BioPolis facility, Singapore has also developed its S&T capabilities to support the sector. The main agency involved in this initiative is **A\*Star - Agency for Science, Technology & Research**. According to their own literature A\*STAR "*actively nurtures public sector research and development in Biomedical Sciences, and Physical Sciences & Engineering, and spurs growth in Singapore's key economic clusters by providing human, intellectual and industrial capital to our partners in industry and the healthcare sector.*" In addition to its corporate management group, it comprises several related organisations:

- Biomedical Research Council (BMRC)
- Science and Engineering Research Council (SERC)
- A\*STAR Graduate Academy,
- Exploit Technologies Pte Ltd. a commercialisation arm.
- Both BMRC and SERC promote, support and oversee life science R&D research activities in seven A\*STAR research institutes and five consortia and centres in life sciences, and also support



collaborative research with universities, hospital research centres, and other local and international partners.

**A\*STAR Graduate Academy (A\*GA)** supports A\*STAR's key thrust of human capital development through the promotion of science scholarships and other manpower development programmes and initiatives. They have attracted many prominent researchers to these institutes using a model similar to Science Foundation Ireland (SFI). Approximately 700 top graduates have received post-doc funding to work in universities and other institutions overseas. In return they are 'bonded' for a period of three years after their return to work in a Singapore public institution (usually one of the A\*Star institutes).

**Exploit Technologies Pte Ltd (ETPL)** manages the intellectual property created by the research institutes and facilitates the transfer of technology from the research institutes to industries. Singapore has drafted in senior scientists and policy makers from around the world to advise and drive the sector forward.

In summary, Singapore has a highly integrated and favourable environment for the biomedical industry. It is also developing itself as a major location for clinical trial management for Asia.

### 5.4.3 Education & Training System

In the area of industrial and commercial training and education, the main agency is the Singapore Workforce Development Agency (WDA), whose mission is to "*enhance the employability and competitiveness of all in the workforce, young and old from rank-and-file to professionals, managers and executives*"<sup>84</sup>. In 2008 the WDA launched an ambitious programme of training contained within the Continuing Education and Training (CET) Masterplan. This plan aims to ensure that 60% of the workforce is educated to at least diploma level by 2020 (currently 36%). This involves increasing academic institutions and their capacities and also the numbers of training courses and capacities. The budget, from the Lifelong Learning Endowment Fund, was increased to €1.73billion (with an indication of a further rise to €2.9billion) to meet these increases. According to all of the companies interviewed, Singapore government agencies are in regular and intensive contact with FDI firms regarding their training, skills and other needs. The approach is comprehensive and includes ensuring availability of relevant graduates, and also support for in-company training of industry staff. Some examples (from the interviews conducted) of the ways in which the system has reacted to industry views include:

- AMRI came to Singapore in 2005 and found there were almost no chemists available. Those trained locally (in the National University of Singapore) were all destined to become school teachers. The Government made a major investment in equipment (including 10 NMRs) and designed a new course for industrial chemists. The first graduates from the revamped course will qualify in September 2010.
- Lilly indicated their need for bio-informatics skills and a course was established at NUS.

<sup>84</sup> See [www.wda.gov.sg](http://www.wda.gov.sg).



- Several companies noted that Singapore graduates lacked creativity. The Ministry of Education is reacting to this concern. The National Institute of Education, which is the main teacher training college, is currently in the process of recruiting additional teachers for a schools programme in music, arts and physical education on the basis that these subjects will enhance creativity among school-children.

In summary, Singapore has set up programmes to upgrade employees' skills, train new workers and promote best practices through several agencies and ministries. Funding of these initiatives is partly achieved through the Skills Development Fund, a levy payable by all firms (see [www.sdf.gov.sg](http://www.sdf.gov.sg)). Generic training initiatives include:

- **Skills Programme for Upgrading and Resilience (SPUR)**. This programme is for skill development among company employees. The incentives include 90% of the costs of training or retraining of professional and technical grades; and also an 'absentee payroll' fee of \$12/day per employee absent on training. These courses are typically designed as 20 or 40 hour block courses so as to fit into the industrial time-frame.
- **Initiatives in New Technology (INTECH)**. This programme is aimed at developing new high-tech skills within companies. It will support training within companies developing new activities or entering new areas of technology, including new start-ups and MNC plants. The grants cover all costs (travel, fees, and subsistence) for up to 2 years overseas for Singaporeans. These grants allow new staff employed by MNCs to be trained in the MNC plants overseas at minimal cost to the company. Trainees are 'bonded' to the employer for up to 2 years post-training. For example, when Lonza established in Singapore, 500 staff were funded to travel to Lonza's US operations for 18 months for training.
- **Company Training Scheme (CTS)** To encourage companies to recruit and train above their immediate manpower needs, grants of up to 70% of the gross salary of the trainee is available.

Other grant and subsidy schemes are also available for special circumstances, and some of the above incentives are also available to individuals seeking training.

A further initiative for training of in-company staff is NUSAGE<sup>85</sup> - the National University of Singapore Academy of GxP Excellence, which is a collaboration between government, the National University of Singapore, and industry to develop and implement professional development and training initiatives in the region.

It may be useful to note that the Irish company DPS Engineering has developed a Specialised Training Programme in Pharmaceutical Manufacturing (Validation)<sup>86</sup> in association with Dublin Institute of Technology and that this course is among those locally available to companies.

Some important points to be noted about Singapore's biomedical status and initiatives include:

- It is very young relative to that in Ireland and other biopharma centres, but has grown rapidly and effectively.

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<sup>85</sup> Formerly SAGE

<sup>86</sup> [www.dpseng.com.sg/](http://www.dpseng.com.sg/)



- Like Ireland, Singapore is independently targeting both biopharma manufacturing industry and also the pharma industry R&D functions through different initiatives
- All companies note the frequency and depth of contact between the Economic Development Board and industry, and the speed and effectiveness of Singapore's reaction to expressed needs
- There is a very high degree of international collaboration in many aspects of Singapore's programmes, including attraction of foreign scientists to A\*STAR Institutes, partnering of Singapore universities and polytechnics with overseas institutions, and appointment of top scientists to Singapore institutional and programme boards
- The major skill gap is experience, which is probably to be expected within a sector of such recent vintage. Whereas western experience is valued, experience in the region is highly desirable in understanding issues such as working practices and cultural differences.
- The majority of staff in senior positions in the discovery organizations are non-Singaporean.

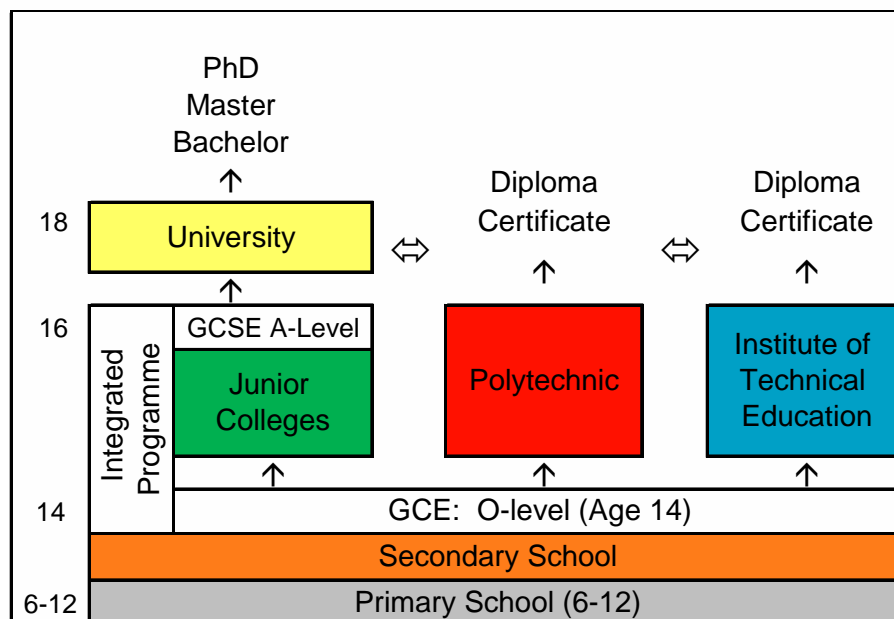
#### 5.4.4 Education System

Singapore has a highly regarded educational system and education is a high priority among its predominantly Chinese population. Singapore children are highly driven to achieve in their careers. Many interviewees noted the high levels of ambition, and the high priority put on qualifications. While this has benefits in regard to achievement of skill levels, it has also resulted in a 'certificate-driven society' where qualifications and status are an end rather than a means.

It is also useful to note that education is 'big business' for Singapore and many educational institutions operate in the country. Many of these are collaborations between Singapore and overseas academic institutions. Singapore is acting as 'schoolhouse for the region' in many respects and has attracted many educational institutions to the country which provide education for students from surrounding countries.

The education system provides for streaming of students at an early age, and one Irish respondent compared the system to that in Ireland in the 1970s with separate academic and vocational streams. The education system uses the British GCE/GCSE model but with increasing numbers of both local and foreign schools offering the International Baccalaureate Program (IB). Children achieving high grades up to the age of 14 will be directed toward the universities. This usually involves attendance at junior colleges for their final 2 years of school, after which they will sit a GCSE A-Level exam, A recently introduced alternative for these top performers is that they may be streamed even earlier and pursue an integrated programme which by-passes the O-level system and aims directly for A-Level.

Table 5.6: Singapore Education System



By one or other of these routes, some 20-25 per cent of the best students will go to one of the universities. The main public Universities are **National University of Singapore** (Founded 1905; 33,000 students) and **Nanyang Technological University** (founded 1991; 30,000 students). Both of these universities are listed within the top 100 universities according to the QS ranking<sup>87</sup>. There is also a **Singapore Management University** (SMU), and a further public university - the **Singapore University of Technology & Design** - is planned to open in 2011. There are also many private universities in Singapore, and the government has also encouraged the establishment of private universities, sometimes as collaborations with local universities. It should be noted that many of the top students will become civil servants, who are among the best-paid personnel in Singapore, and the highest paid public servants in the world.

A further 35-40% of school-leavers will attend one of 5 **Polytechnics** which are similar to the Institutes of Technology and provide training up to Diploma and Specialist Diploma Level. According to the Ministry of Education, they were "*set up with the mission to train middle-level professionals to support the technological and economic development of Singapore*". They also provide a significant range of continuing education courses. They are the major source for lab technicians, process technologists and other specialist technical staff for the pharma industry. It was noted that many students who could qualify for junior college will elect to attend a Polytechnic because of the attraction of the technical programmes.

Many of the remaining students, the third stream in terms of academic performance, will attend the **Institute of Technical Education**, which has many facilities but operates as a single entity providing "*pre-employment training to secondary school leavers and continuing education and*

<sup>87</sup> [www.topuniversities.com/university-rankings/world-university-rankings/2009/results](http://www.topuniversities.com/university-rankings/world-university-rankings/2009/results)



*training to working adults*". It provides training for motor mechanics, maintenance technicians and also some biomedical technicians and process technology specialists.

These three streams of education are shown in Table 5.6. According to interviewees, there is very low level of transfers from one stream to others. The consequences of this are discussed below. For the purposes of this study, the significant elements of this system are the universities, which provide a wide range of engineering & science graduates, and the polytechnics which are the main local source of technicians and operatives for the sector. Note, however, that a high proportion of staff for the R&D functions are hired from outside Singapore.

Both polytechnics and universities maintain very close links with industry in different ways. In addition, there is also a closed loop between the Economic Development Board and the Ministry of Education whereby the Board surveys of industry skill needs result in changes in funding levels for courses run by all colleges. The course attendance is also controlled by funding of scholarships for certain subjects. Curriculum changes are also addressed in a top-down fashion by the Ministry and policy changes are communicated at a mass meeting of school and college principals each September to discuss the annual work plan.

#### 5.4.5 Industry-Academia Interactions

As a general principle, universities are expected to justify their activities (both educational and R&D) in terms of economic relevance. Contact between industry and academia is achieved in 2 ways: (a) The Economic Development Board EDB regularly consults with industry regarding their future needs, and these needs are communicated to the Ministry of Education which regulates funding for specific courses, or establishes new courses, as appropriate; and (b) The colleges also have a range of direct mechanisms for consultation with enterprises. These are described below.

The National University of Singapore (NUS)<sup>88</sup> has many mechanisms for industry interaction both on R&D topics, and on curricula. The university actively encourages collaborative research with industry and this is to some extent encouraged by the need to show economic relevance of R&D proposed for funding by the public funding agencies. Involvement with industry is a means to define their needs, and to plan projects with demonstrable relevance. For the purposes of defining curricula, the following mechanisms are in place:

- Surveys of employers are conducted on a regular basis.
- A Department Consultative Committee is set up with industry and academic representatives and has formal and informal meetings to provide feedback on courses and graduate quality.
- Feedback from students on placements is also a useful mechanism. Students generally do 12 weeks on placements, usually in the vacation period. The students are used for whatever the company decides. There are no R&D project placements.

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<sup>88</sup> Information was obtained from Engineering School - Dr S K Chou



There is also significant interaction between the polytechnics and industry at a wide range of levels, to define both curricula, and also R&D priorities.

- Polytechnics staff must have industry experience (the objective is 5+ years) and will therefore be aware of industry needs. Their experience is not necessarily of the biopharma-pharmachem industry given the short life of the sector within Singapore. However, staff experience will often be from the food industry.
- There is a formal structure of committees which advise on curricula and other academic services. These include industry representatives, and specialist sub-groups will be formed where specific 'domain experts' are required.
- There is also a formal review of all curricula on a 3-year cycle which also involves surveys of companies and graduates.
- The polytechnics also conduct collaborative R&D, and the college will generally not approve participation in any project which does not involve collaboration with industry.
- The Polytechnic Board has industry representatives

### Placements

Polytechnics offers students for placement (locally known as 'attachments') within industry. No payment or other incentive is offered to the companies for acceptance of students, nor is there any penalty for not doing so. Temasek Polytechnic offers a Diploma in Biotechnology which includes a 20-week student internship programme. This period includes the period for completion of a 'Major Project'. The course prospectus states: "*Students are attached to related life sciences industries for a period of sixteen or twenty weeks. Students are expected to undertake various activities assigned by the participating host organisations. This program helps students to prepare for the working world and enables them to apply knowledge and skills to solve practical problems. Emphasis is placed on training of transferable skills such as teamwork, written and oral communication skills*". It is suggested that the host pays the intern an allowance of €256/month.

Nanyang Polytechnic offers: (a) a three month placement to work on unspecified work within the company or (b) a six month placement where the student is working on an agreed project of mutual benefit to student and company. This appears to be a very successful and active programme and many of the companies interviewed had regular placements (e.g. Novartis has seven-ten attachments at any one time; MSD manufacturing has approximately 40 per year).

In the universities there are also placements of five-six months (i.e. one semester) for bachelor students<sup>89</sup>. These placements may be made in companies outside Singapore if necessary, and the role of the student during this placement is decided by the company.

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<sup>89</sup> Personal Communication from Dr Loh Kian Ping, Vice-Dean of Research, Science Faculty, National University of Singapore



## Discussion

The system of education shown in table 5.6 essentially consists of three streams of students based on academic achievement during schooling. Commentators suggest that there is minimal movement of these students from one stream to another, and particularly into the universities from the polytechnics. This is said to be motivated by the elitist position of the universities, which are unwilling to accept students from polytechnics. However, the other feature of Singapore is educational ambition, and the desire for further education. Approximately 75 per cent of diploma-holders from polytechnics are said to enter bachelor programmes. However, many of the polytechnic students who wish to pursue a bachelor degree are not admitted to the Singapore Universities. According to a source in National University of Singapore<sup>90</sup> only 15 per cent of students entering Singapore colleges are students from the polytechnics. Many polytechnic graduates are said to go to overseas universities, while others (if funding allows) attend private universities in Singapore. Australia gives scholarships to students attending their universities, which results in loss of graduates, as those who go abroad often do not return.

Because of concern about the loss of these skills, the Government established the **Singapore Institute of Technology**<sup>91</sup> in 2009. This is a virtual Institute established to confer degrees on polytechnic students wishing to do further study. The target is to convert 2,500 polytechnic diploma holders to degree-holders by 2015. The model is that the Institute is developing partnerships with overseas colleges for the purpose of degree awards. These partner universities (and other international colleges) must be top-ranked international colleges, or a special case must be made for acceptance of universities outside this ranking. The rationale for this condition is not clear. So far, the Institute is not offering any degrees of relevance to the biopharma-pharmachem sector, but these are understood to be in planning.

A consequence of the high level of transfers to a bachelors course is that there is a transient population of technicians of Singapore origin. However, the industry can hire from other labour pools in the ASEAN region and there is no shortage of technicians.

### 5.4.6 PhD Deployment

The only role for which a company might hire a PhD is for R&D leadership position. This could include process development roles in manufacturing plants. The major local recruitment agency noted that only about 10% of the posts they are asked to fill would specify a PhD. Even for recruitment of CEO positions, a PhD is regarded as "*nice, but not necessary*".

Several interviewees noted that, while Singapore graduates are technically competent, they lacked creativity and independence, and required a lot of direction. This was also expressed as a '*lack of passion for science*'

In summary, the companies have no major issue with the level of skills available in Singapore, but note that they recruit widely in the ASEAN region and beyond, and are not dependent on Singapore

<sup>90</sup> Personal Communication from Paul Teng, Dan of Graduate Programmes & Research, National Inst of Educ., Nanyang Technological University

<sup>91</sup> See [www.singaporetech.edu.sg/](http://www.singaporetech.edu.sg/) for courses and university partners





recruits. They also note that Singapore has only been actively in the biopharma-pharmachem business for ten years, during which there has been very significant progress in infrastructure, services and skill development. The Singapore Government seems determined to maintain this progress and there is general optimism that infrastructure and service improvements will continue. The EDB are in continuous contact with industry about their needs and are highly pro-active in addressing these needs. There are good contacts between industry and academia where this is warranted.

On the quality of graduates, the major negative views related to (a) the highly ambitious nature of Singapore graduates. There is a high focus on qualifications (a 'certificate-driven society') which results in a constant drive for more education and a consequent transience at technician level. (b) A perceived lack of creativity among Singapore PhD and research staff in all but the very best graduates. The Singapore Government has recognised this and are changing the school curriculum to enhance creativity in children, and (c) the difficulty in finding experienced staff, but all recognise that this is purely a feature of the recent entry of Singapore into the biopharma-pharmachem industry.

#### 5.4.7 Future Skills Needs in North Carolina, Switzerland and Singapore

The views of companies as to their future skill needs were highly consistent in all three locations, which is perhaps to be expected given the international nature of the industry. It should be noted that the executives interviewed include executives from both discovery and manufacturing functions within their companies. The differences in skill needs within these functions are indicated where appropriate.

A useful indication of the qualification levels in different roles within the biomanufacturing industry was provided by data obtained from NC Biotechnology Center, which is shown in Table 5.4. This shows that the overall employment included the following qualifications:

- 31 per cent of staff have high school diplomas (some with additional training)<sup>92</sup>
- 13 per cent have an Associate in Applied Science (equivalent to an IoT diploma (2 years))
- 41 per cent have a bachelors degree
- 11 per cent have a masters degree
- 4 per cent have a PhD.

Note also that the NC industry's views on skill needs are defined in detail in the publication '*The Model Employee: Preparations for Careers in the BioPharmaceutical Industry*' (NC Biotech Center 2005).

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<sup>92</sup> Most of these have working experience in other sectors and few are recruited directly from school.



The main skill needs defined during the interviews were:

### Good Basics

There was a consistent view from industry that a graduate could never be completely ready to work within industry and that further training will always be required to make the new graduate (or new hire) suitable for their industrial role. It is not expected that a graduate would be completely 'ready to go' within industry. Therefore, the preference is for a graduate who is smart, well equipped with the basics of S&T and Engineering, their core specialism, and ready to learn. The essential requirement is for staff with excellent basic understanding of bioprocess technology (aseptic processes, microbiology etc) and a hands-on knowledge of the instrumentation used. The specific requirements of the particular production regimes can be taught in-house to those who have these fundamentals. Loading the graduate with a lot of specialisations is therefore widely regarded as a mistake.

### Understanding of the Drug Chain

Graduates intending to work in the biopharma-pharmachem industry should have an understanding of the drug process from discovery to market and of the different professional inputs at each stage. Staff within the industry work within company-wide teams of experts who have roles at various parts of the chain from discovery to manufacture to marketing. The four disciplines which dominate these teams are chemists, scientists, engineers and clinicians. Whereas academic researchers also work in teams, it is acceptable to work alone. In industry team-working is an absolute requirement. It is therefore important for staff to have an understanding of the purpose and function of the overall team, and a cross-disciplinary understanding so as to appreciate and consider the needs and viewpoint of the other skills within the team. Because of the nature of the modern biopharma-pharmachem industry, these team members are often geographically separate.

Working in such a system requires the hard skills necessary to understand the roles of other team members and soft skills relevant to working in large teams of mixed disciplines, and to developing and maintaining relationships with other team members. These include social skills, communication, team-building and other skills related to the ability to develop and maintain real collaborations with industry colleagues. Project management skills are also highly relevant to the process of team-based working and an essential component of training needs.

### Informatics

There is a widespread view that all involved in the drug industry will be increasingly involved in, and often dependent on, analysis and interpretation of large data sets. The increasing use of sensors within bioprocessing, and of the ability to monitor a greater range of parameters at all phases of the drug chain will increase the range and scale of data to be handled. Typical data sets include genetic or protein data at the discovery phase; clinical trial data; process data; and market data. Even in a Singapore tableting plant it was noted that the scale of data on individual tablet quality was increasing. It is therefore important that industry staff have the ability to understand the basics of data management processes and equipment as a basic grounding for usage of whatever systems will be used within industry.



### Statistics

While sophisticated informatics systems will be increasingly used, a good understanding of the statistical principles which underpin the data is an essential requirement for staff at all levels.

Other trends, and discipline shortages which were noted during interviews are:

### Multi-product facilities

An increasing trend in biomanufacture will be multi-product facilities where the same equipment is used successively for short runs of different products. This trend is the result of consolidations of manufacturing facilities, and an increase in products for smaller patient groups.

### Disposable technology

Biomanufacturing is increasingly using disposable liners and bags for bioprocess manufacture. This has significant time advantages (lower down-time as cleaning) and also reduced water usage. These technologies are likely to be more commonly used in the future and should be included in any courses for those in the industry.

### Nutrition/Medicine Interaction

Nutrition and medicine are moving closer together, and health-related claims are being increasingly made for food and nutraceutical products. It is likely that functional products may become part of the product base of the pharma industry in the future. Graduates should therefore have an understanding of nutritional principles and of the trends in functional food products.

### Bioinformatic skills

Within the discovery process, there is an increasing need for bio-informatic skills. Analysis of major data-sets of biological information is an increasing need as new analytical equipment becomes capable of generation of increasing levels of data and as more parameters for analysis come into use. Availability of professionals trained in bio-Informatics is poor and there will be increasing demand from industry research groups for such skills.

## 5.5 Summary

The core objectives of the study visits were to assess views on future skill needs for the biopharma-pharmachem sector through interviews with industry and other relevant organisations, and to review the ways in which skills provision is currently delivered within each region. Of specific interest within the latter objective was to establish the mechanisms by which educational organisations, and development agencies, maintained contact with the industry so as to ensure a continuing supply of appropriately trained expertise.

Industry views on future skill needs were very consistent at all three sites. However, the processes for education of biopharma-pharmachem staff, and the mechanisms by which educational agencies interact with industry are very diverse across the three sites.



A summary of the major infrastructural and socio-political features of each site is presented below:

## North Carolina

- Biotechnology is a priority activity within NC and it has a well-developed biotech sector with 528 companies in a wide range of sectors, including 18 biomanufacturing plants, most of which are MNCs with no local allegiance.
- A state agency, the NC Biotechnology Center, has been central to the development of the biotech industry within NC. Among its many initiatives, it has undertaken a process of defining 'model employees' for the biopharma industry and their training needs, through wide consultation with industry.
- A programme - NCBioImpact - to develop and deliver these defined skill needs has been agreed by the state, academia and industry and an \$80m investment has been made in the necessary facilities.
- Relevant education is provided by community colleges (technicians and operatives), and by universities of which there are many of high reputation within the State. However, NCBioImpact has concentrated its programme within 2 universities, and a selected number of community colleges. These were selected for their expertise in the area, and their extensive contact with industry. The delivery of skills to the sector is therefore concentrated in a small proportion of institutions.
- A high proportion of students seeking training in the community colleges (i.e. technician and operative qualifications) are 'career-changers' who have been made redundant in the furniture and textile sectors. These staff, with their experience of manufacturing, and with appropriate basic training, are highly valued by the industry as entry level staff.

## Switzerland

- The biopharma-pharmachem industry is extensive and almost all indigenous, and includes several international players. It has long-standing and traditional mechanisms of operation, and its interests are strongly entrenched in local politics. Because of the importance of the sector to the local economy in Zurich and Basel, industry has significant input to decision-making in the FachHochschulen or Universities of Applied Science (UAS) in these regions.
- The most relevant educational institutions are controlled at local level by the canton (rather than by the Federal Government) and there is a strong imperative within these institutions to ensure training of graduates which are suited for employment by industry. The UAS is obliged 'by law' to produce graduates who are '*ready for employment*' and this is reflected in the systems which are in place to ensure that the curriculum addresses industry skill needs.
- Switzerland has a very traditional system of education involving early streaming of children either towards university (about 30%), or to a vocational route involving apprenticeship. A significant strength in terms of training is the excellent practical training which results from the combination of apprenticeship and a UAS degree.



## Singapore

- The biopharma-pharmachem industry is relatively new sector within Singapore. It is almost entirely FDI which have been attracted to Singapore primarily by tax incentives, and by its strategic position as an Asian hub with good facilities and living standards.
- Singapore has a very strong central government and agencies. The main economic development agency, EDB maintains very close contact with industry to assess developing needs and challenges, and the system is highly reactive to any skill or other needs defined by companies.
- The educational system is similar to that in Switzerland in that students are streamed early (~age 14) into those who will enter university and those who will pursue a more vocational education route. The educational institutes are also obliged to ensure that economic relevance is a guiding principle of their activities. Consequently, they also involve industry in committees and other advisory groups which define academic services.
- There is an apparently unlimited budget for investment in infrastructure for the sector, and for development of worker expertise through funded training programmes;
- Singapore is not dependent on local graduates for its workforce. It is accepted and encouraged that companies attract staff from all parts of the world to work in Singapore, and a high proportion of staff in industry are foreign nationals.

In summary, the availability of training for the sector is influenced by a wide range of historical, infrastructural and policy issues. In all countries there are processes designed to maintain contacts between the educational institutions and industry. These are also influenced by historical practice, the policy of funding agencies and other factors. A summary of the options for maintaining contact between industry and academia are reviewed below in relation to their usage in each region.

## Interaction between Education Organisations and Industry

### Industry-Experienced Staff

An effective way in which academia can ensure that faculty and support staff understand industry needs and practices is to employ staff who have experience in industry. In effect, industry-experienced staff are a feature of most of the institutions which train lab technicians and operatives, but less so within universities.

- North Carolina. Staff in the community colleges will usually have industry experience, and such experience is implicit in the highly practical nature of the training provided, and is a requirement for those BioNetwork staff who work within BTEC. The university-employed staff within the BTEC centre are a mix of those with academic backgrounds and those with industry experience. Those involved in practical training are generally from industry, while those in theoretical training are generally from academia. In the BRITE centre 75 per cent of the 13 faculty have a combined total of almost 100 years of industry experience.
- Switzerland. Staff in the universities of applied science will almost all have industry experience, and the industry network of these staff is used to develop contacts for placements and consultation. Indeed, one interviewee noted that staff without such a network will be



required to do additional lecturing to compensate. The main Swiss universities do not have any such requirement.

- Singapore. Staff in the polytechnics are also required to have industry experience, although they admit that it is difficult to find staff with experience of the biopharma-pharmachem industry due to the relatively short time in which the industry has been operating within the country. Staff within the life science schools in polytechnics may therefore be experienced within the food or other related sectors of industry. The main Singapore universities do not have any requirement for industry experience of staff.

## Student Work Placements

A further useful way to ensure that students gain some familiarity with industry work practices is placement, i.e. a period in which the student works within a company either during term-time or during holidays. These are also favoured by many companies as they provide an opportunity to assess potential employees. They are also regarded as a 'social obligation' by many companies. Placements are widely used at all sites and practices are reviewed below, but it should be noted that the issue of providing students with industry experience is less relevant in some regions. . No payments or other inducements are offered to companies to accept students in any of the three regions, nor is there any form of penalty for not doing so. **It is noteworthy that placements are generally of a longer duration than is offered in Irish colleges.**

In North Carolina, a large proportion of students in the BioNetwork scheme (i.e. training as lab technicians and process operatives) are 'career-changers' who already have years of experience in industry, particularly in furniture or textile manufacture, sectors which have had significant redundancies. The average age of entry to the BioNetwork colleges is 27. These students already have significant experience of industrial practice and placements are less relevant. In addition, most students attending courses in the community colleges are also working part-time. Placements are therefore less relevant for these students. Nevertheless, placements of students by universities are common. There are 2 options offered:

- Cooperative training places a student within a firm for a period within term time; these placements can be up to 3 semesters, and are usually interspersed between semesters of coursework;
- Internships place a student within a firm during the summer vacation. They are the most usual form of placement, and are preferred by the student as they do not use up term-time but yet earn credits. There is no incentive offered to companies, who regard them as an element of their social obligation, and are also a means of reviewing potential employees.

In Switzerland, the UAS graduate (bachelors and masters) is the preferred employee for any production or technical role within the biopharma-pharmachem industry. Students within the UAS will have completed 3 years as apprentices in industry. This is a combination of instruction and work practice, but ensures that the students are very familiar with industry work practices even before they enter the UAS. Placement of UAS students for general usage within the company is less relevant to their development. It therefore tends to be for a specific project, often an R&D project, which is agreed in advance with the company. UAS students will have a placement of 12



weeks during their Bachelor degree (year 3) and Masters students will have an 8 month placement. There is no incentive offered to the companies to accept placements.

In Singapore, placements are widely used both by the polytechnics and the universities. The placement length varies among the polytechnics, but there will typically be a placement (locally known as Attachment) of 12 to 20 weeks for diploma students. Nanyang Poly will extend the placement period to 28 weeks if a specific project of educational benefit can be defined for completion by the student. The universities will also place bachelors students for one semester (5-6 months). These placements can be made within companies outside Singapore if necessary. No incentive is offered to the companies for these placements. A company guide to internships in Nemasek Polytechnic is shown in Appendix C.

### Consultative Groups and Processes

A further means of maintaining contacts between academia and industry is through direct consultation on committees or similar consultative groups. A huge variety of such processes were presented by the institutions interviewed. These range from temporary or ad-hoc groups established to review new or amended curricula, or other academic services; permanent boards or committees to provide on-going industry views on all aspects of academic activity; alumni groups which are asked for comments as one element of their interaction with their colleges. In addition, academic staff who have extensive networks of industry contacts (through working in industry, or through R&D collaboration) will also use their contacts on an informal basis to obtain views.

The most extensive formal consultation process is probably that undertaken by the NC Biotechnology Center in defining model employees and their skill needs. This used focus groups involving 35 Industry representatives and 10 trainers, and an industry/educator committee.

A different approach is used by the Economic Development Board in Singapore which undertakes a very intensive process of meetings (3-4 per year) with individual FDI clients to assess developing needs. Finally, Switzerland has industry representation built into the decision-making process within the Universities of Applied Science, which is their main source of technical staff. Consultation, in short, is a feature of every site but is achieved in different ways in each.

### PhD Deployment

Within the companies interviewed, there was a unanimous view that the main role in which PhD graduates are required within the biopharma-pharmachem industry is for leadership roles within R&D or within process development. This view was consistent at all sites visited. Also consistent with this view is the fact that manufacturing plants had very few PhDs, while the discovery units visited in Singapore, and some of the SMEs in Switzerland which are still in the discovery phase, had a high proportion of PhD employees.



## Soft Skills

The specific 'soft skill' content of many of the courses is difficult to assess as some of these skills will be taught as much by the manner of teaching, as by formal modules. Nevertheless, soft skills such as team-work and communication are highlighted as a feature of several of the courses relevant to the biopharma manufacturing sector. Some of the references to soft-skills in relevant course descriptions are contained in Appendix D.

## 5.6 Conclusions

While education and training provision differs in all three international locations, this analysis shows that the main difference between these three locations and Ireland relates to industry-academia links. The strength of these links and the formal processes used to achieve them in North Carolina, Switzerland and Singapore, helps to ensure that graduates are equipped with relevant skills required by industry.

In contrast, industry-academia links in Ireland are mainly informal and depend on individuals rather than structures and formal processes. Individual lecturers, departments or institutes may choose to foster links with industry but the current system does not actively support or reward that activity.

The learnings from these international study visits include:

- improving industry-academia links through formal processes and incentives
- Embedding business and generic skills in S&T programmes
- Ensuring that S&T courses have a practical application
- Structured work placements that may include holiday periods
- Including taught components in post-graduate courses

The study visits also revealed that for the companies interviewed, there was a unanimous view that the main role in which PhD graduates are required within the industry is for leadership roles within R&D or within process development. This view was consistent at all sites visited. Also consistent with this view is the fact that manufacturing plants had very few PhDs while the discovery units visited in Singapore, and some of the SMEs in Switzerland which are still in the discovery phase, had a high proportion of PhD employees. In contrast, PhDs in Ireland are deployed in manufacturing roles as well as R&D. It is likely that in future the role of PhDs in the Irish biopharma-pharmachem industry will be more in R&D and process development.





## Chapter 6 Future Skills Requirements of the Biopharma-Pharmachem Sector

### 6.1 Introduction

This study involved intensive consultation with senior management in industry, state agencies and industry representative bodies to identify skills challenges for the biopharma-pharmachem industry in Ireland. As the analysis in Chapter 2 showed, the industry is undergoing global transformation which particularly impacts on Ireland, given the strong international presence in the industry here. This transformation necessitates a suitably skilled workforce, including skills that may not have been prevalent in the sector in the past. The challenge now is to embrace the concepts of manufacturing and supply-chain excellence, as well as those of on-site innovation, such as process and product development, thus linking research directly to manufacturing and supply. To achieve that goal, the industry must ensure that its employees have the relevant skills to allow the industry transform and compete internationally.

The industry consultation revealed that companies have been broadly satisfied with graduates of the Irish education system. The competencies and expertise of Irish scientists and engineers helped position Ireland as a world-class manufacturing location for the biopharma-pharmachem industry. Now, as the nature and scope of the business changes, so too will the competences required. This will require industry to ensure that its workforce is continually upskilled through continuous professional development (CPD), and keep the education and training sector advised of its changing requirements. Education and training providers will then need to offer appropriate undergraduate, postgraduate and executive education programmes.

Following the industry consultation, stakeholders in the education and training sectors were also interviewed. A stakeholder workshop was then held, involving industry and education/training professionals, to clarify the skills challenges and explore education/training solutions. The material for this chapter is drawn from that process.

The focus of the following sections is on the skills challenges associated with this transformation process, and the gaps identified during the industry consultation. It is also recognised that science and engineering students pursue diverse career path in fields other than the biopharma-pharmachem sector, and that university programmes must cater for that.



Skills challenges were identified in the following broad thematic areas:



The following sections outline the main skills gaps identified in each of these areas.

## 6.2 Science and Technology Skills Challenges

In overall terms, the biopharma-pharmachem industry's challenges tend to be cross-disciplinary and not confined to a specific scientific discipline. Consequently, graduates should ideally emerge from the education system with their specialism, supported by an overall perspective of how that specialism fits into various scientific and engineering disciplines. The industry requires graduates with good core disciplines and cautions against hybrid degrees which do not provide the level of specialism required. These are dealt with by specific subject area below.

Stakeholders interviewed for this study consider that there needs to be more collaboration between industry and academia, capitalising on the expertise that exists, whatever the location. Initiatives will be needed to break down walls between academia and industry, and also within academia and industry themselves, to facilitate collaboration and maximise resources. Virtual centres of excellence, such as the Solid State Pharmaceutical Cluster (SSPC), led by the University of Limerick and funded by SFI, may represent a way forward, offering the benefits of pooling resources and expertise throughout industry and academia. The SSPC, established in 2008, intends to provide the necessary skill set to comprehensively investigate pharmaceutical solids by bringing together complementary academic and industrial groupings from the disciplines of chemistry, pharmaceuticals, pharmaceutical technology, chemical engineering and mechanical engineering.



### 6.2.1 Chemistry Disciplines

The Irish biopharma-pharmachem sector considers that chemistry programmes provided by higher education institutes (HEIs) need to reflect industry practice. While the fundamental principles of chemistry have not changed, the research landscape and industry practice is constantly evolving and should be reflected in HEI programmes. Industry considers that the use of peer review papers to supplement textbook material would help ensure that HEI programmes are in alignment with industry needs.

As the industry moves to achieve its strategic objective of engaging in more upstream activities such as process and product development, a specialised skills set is required that had not previously been required of Irish graduates. Among the key areas highlighted by industry which need to be covered at some stage of the education process are the following:

- **Analytical Chemistry** - including process analytical technologies (PAT), chemometrics, quality by design (QBD), and impurity identification.



- **Organic Chemistry** - high level skills required to underpin process development including synthesis, mechanism, understanding impurity formation and how this can be avoided, and polymer chemistry.
- **Crystallisation** - solid state properties of pharmaceuticals
- **Formulation** - critical that chemistry and chemical engineering graduates are familiar with formulation in an industrial context linking active pharmaceutical ingredients (API) and finished dosage form (FDF), and physical properties of APIs

Problem solving competences, IT systems skills and informatics are becoming increasingly important and will also need to be embedded into HEI programmes.

The consultation process for this study indicated that undergraduate programmes will need to include modules in physical characterisation and method development, formulation, innovation methodologies and polymer chemistry. It is also considered that all relevant undergraduate programmes should include a work placement (See section 6.5). The industry identified a particular skills gap in the area of industrial formulation, with few graduates having expertise in this area. Formulation skills in Ireland have tended to be covered in pharmacy programmes, with most of these graduates opting to pursue careers as hospital or community pharmacists. Industry believes that consideration should be given to introducing industrial pharmacy programmes in HEIs.

At postgraduate level, stakeholders consulted for this report considered that structured Masters and PhD programmes would help address the current skills challenges. Many postgraduate programmes in Irish HEIs are research focused, oriented to the academic profession and do not prepare students for a wider employment programme. Structured programmes would include taught modules as an integral part of the programme and include an industry work placement to give students practical experience of the industrial environment.

The workforce will also need to be continually upskilled through CPD that can be provided by HEIs and state agencies. For example, CPD in organic chemistry to develop the expertise required to undertake process development in the sector is critically important.

#### 6.2.1.5 Pharmacology

The industry interview process for this study revealed that many chemistry and engineering professionals have little understanding of the drug/body interaction. This is partly due to the fact that third level programmes contain very archaic modules which do not reflect the more recent developments in the industry. Graduates' skills need to be more practical so that they transfer easily to industry.

Education solutions will include developing more electives in first and second year undergraduate programmes, so that chemistry students can take biology modules, and biology students can take chemistry modules. Cross-disciplinary programmes at undergraduate level may also be appropriate.



Industry/academia interaction would also help in addressing this issue. For example, PhD students could have a 6 month industry placement to learn the practical elements of industrial pharmacology.

## 6.2.2 Biological Sciences

While the education system is producing a sufficient supply of biological science graduates, as noted in Chapter 4, many graduates in the biological sciences do not have industry relevant skills. Graduates do not have the expected areas of competence, according to industry. Formulation, cell culture, stem cell research and vaccine development are all key areas and should be covered at some stage of the education process.

The industry requires graduates that emerge with an awareness of the overall context in which their specialism features. There is therefore a need for a broader understanding of how specialisms might relate to the work of a team or a general problem in industry.

Education solutions will include developing target electives in undergraduate and postgraduate programmes. Student work placements would certainly help to address the current challenge, giving students practical experience of industry. Where industry has capacity problems with placements, then alternative locations should be sought, to give equivalent experience. For example, research institutes may be appropriate in some cases. SFI Research PhDs could also be used to lecture undergraduate students.

Structured PhDs, comprising taught modules in relevant areas would help resolve the core competency issues. For example, cycle 5 of the Programme of Research in Third Level Institutions (PRTLII) includes a structured PhD in Life Sciences at CIT. In addition, SFI Principal Investigators (PI) should be used to supervise laboratory work, thus ensuring that a skills transfer takes place.

As the Irish biopharma-pharmachem industry shifts its emphasis from chemistry-based small molecules to more complex, biologically derived entities, a centre of excellence to help the industry in that transition will be critical. The National Institute for Biotechnology Research and Training (NIBRT), established in 2006, has a training mission to develop and deliver training solutions specifically focused on the needs of the bioprocessing industry. NIBRT's training solutions are detailed in Chapter 4, section 4.4.5.

While the institute is still in its infancy, it is intended that it will provide the necessary expertise to ensure that the industry's workforce is continually upskilled. To ensure that this is achieved, it will be critical that NIBRT's work is closely aligned with the industry's requirements and that the institute has access to a wide number of scientific researchers.

### 6.2.2.1 Bioanalytics and Bioinformatics

Bioanalytics is concerned with analytical techniques in biotechnology, while bioinformatics refers to the science of using computer technology to gather, store, analyse and merge biological data.



These are important skills for drug design and DNA sequencing, and are not widely available in Ireland.

While a number of higher education institutes are now providing postgraduate programmes in this area, modules in undergraduate programmes are also required. In addition, a more strategic approach to the use of Principal Investigators (PI) would help to address this problem. PIs with bio-analytics and bio-informatics skills should be employed and used to transfer skills to students, also involving industry where appropriate.

Training within the sector in this area should also be given attention. In particular, CSETS and NIBRT should be used to develop new areas and to upskill the current workforce

### 6.3 Cross-Discipline Areas

A number of skills challenges arise in cross-discipline areas. These range from compliance and regulatory affairs to blended and converging skills and production processes, including continuous manufacturing and green technologies. In part, these skills challenges relate to the changing face of the industry, which requires a different skills set, and to technological advances.





### 6.3.1 Compliance and Regulatory Affairs

In today's competitive and highly regulated healthcare environment, it is essential for companies to bring new products to the market quickly - and to keep them on the market. Excellence in managing regulatory issues is therefore a key strategic advantage to healthcare companies.

Regulatory affairs professionals play an important part in co-ordinating scientific endeavour with regulatory demands throughout the life of a product.

The Irish biopharma-pharmachem sector has an excellent track record in terms of compliance and regulatory affairs. International regulatory authorities such as the US Food and Drug Administration (FDA), the European Medicines Agency (EMA) and the Irish Medicines Board (IMB) have increasingly demanding requirements for compliance. The number and diversity of regulations require professionals in the sector to have an excellent knowledge of the regulatory environment, in terms of current and future requirements.

With an increased focus in the sector on biotechnology and convergence with other sectors such as medical devices, the regulatory environment is becoming more complex and requires professional expertise. The biotechnology field is constantly evolving and requires on-going review from a regulatory perspective. The medical devices sector is accustomed to a less strict regulatory environment, but with the advent of devices such as drug-eluting stents, regulation will become more rigorous. Health technology assessment, which evaluates a range of methods used to promote health, prevent and treat disease, improve rehabilitation and long term care, is considered to be a future driver of change within the industry, and may also require the same skills set as compliance.

There is a general view that some industry experience is required to be aware of regulatory issues. Undergraduate courses in higher education institutes do not adequately cover this area currently, partly because it is very difficult to get undergraduate students interested in this field. It is therefore considered that the topic is more suited to postgraduate education, when industry experience has been attained. It also represents an area that could be covered during students work placements or internships, combining theory with practical experience.

From a training perspective, it is essential that industry executives are continually upskilled through CPD programmes. These can be delivered by distance learning if appropriate, but it is considered that they need to include practical case studies if they are to be beneficial. Theoretical courses which cover US and EU regulations are of limited value, according to industry. Another area considered to be important in this field is leadership and influencing skills. These skills, combined with technical compliance expertise would help to ensure effective compliance in biopharma-pharmachem companies.

Cranfield University offers an MSc in Medical Technology for the medical devices sector on a part-time basis. Students may also opt for individual stand-alone modules. Lectures are held over a 3-4 day period for each module, normally at Cranfield, but may also take place where there is an industry hub. An equivalent type of programme for the biopharma-pharmachem sector would be very valuable. In Ireland, Hibernia College offer an online Masters degree, designed for



professionals working in the pharmaceutical industry, in areas such as medical affairs, regulatory affairs, clinical monitoring, data management, drug safety and clinical project management. The programme provides a systematic understanding of the drug development process from initial discovery of a new chemical entity through research and development and on to the regulatory approval process and commercialisation of the product.

### 6.3.2 Blended and Converging Skills

Convergence stretches across pharmaceuticals, biotechnology, medical devices and diagnostics, and has already resulted in the creation of many convergent products. These include products such as drug eluting stents, transdermal patches that transport drugs locally and systematically through the skin, pre-filled, metered dose syringes, injector pens, or inhalers.

Technological convergence will impact on skills requirements in a number of ways. It will broaden the range of disciplines that are core to the biopharma-pharmachem sector to include not only chemistry, the biological sciences and chemical engineering but also encompass mechanical, biomedical and materials engineering, nanotechnology and information technology. It also requires an emphasis on innovation.

The main requirement will be for people with a deep knowledge of their core discipline who can work in a multi-disciplinary environment, able to contribute to a multi-disciplinary team. Soft skills, including team-working and communications, will be an important element and should be incorporated into undergraduate and postgraduate programmes. There will also be a requirement for people with skills that span different disciplines, particularly in the area of process development. As a general principle, it is considered that undergraduate courses should concentrate on core disciplines and that hybrid courses be avoided. As in other areas, undergraduate programmes should include a practical component in industry, possibly targeted at those students who intend to pursue careers in industry rather than all undergraduates.

For process development, industry requires engineers and chemists who have a strong core discipline but also have a good knowledge of each other's discipline. In this way, engineers become more familiar with chemistry, and chemists become more familiar with engineering. Postgraduate provision is considered the best way of addressing this, and could include conversion courses for Science and Technology graduates, possibly a Masters or Postgraduate Diploma programme in Transition Skills, with industry driving the course content. This would allow the development of technologists with both science and engineering skills. These courses, or particular modules within the programmes, could also be offered to industry executives to ensure upskilling within the industry.

### 6.3.3 Continuous Manufacturing

Faced with increasing pressure to reduce manufacturing cost, and a regulatory environment that supports manufacturing modernisation, companies in the biopharma-pharmachem sector are increasingly considering replacing batch manufacturing with continuous manufacturing. Although





common to other manufacturing sectors, such as food, continuous processing is at an embryonic stage in the biopharma-pharmachem sector, where batch manufacturing is the prevailing mode.

While the move from batch to continuous manufacturing may pose regulatory challenges, it is an area where the Irish biopharma-pharmachem industry may have an opportunity to excel, building on its world-class reputation for manufacturing excellence.

Currently, while some higher education institutes' engineering programmes have modules in this area, it is not uniformly offered. In particular, it is normally not covered in science programmes which should ideally contain a module on engineering processes. Where continuous manufacturing is offered, industry should be consulted and involved in the delivery of the programme.

#### 6.3.4 Green Technologies

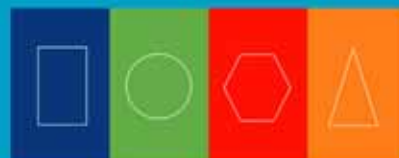
As energy efficiency becomes increasingly important from an environmental and competitive point of view, there is a greater emphasis on the use of green technologies in this sector. Chapter 2 revealed that the number one driver of change perceived by the Irish biopharma-pharmachem industry was cost competitiveness, as profit margins tighten and competition from other locations intensifies. Energy and utility costs were identified as being of particular concern, and the industry is keen to maximise efficiency and sustainability. There is also a consciousness that the industry must be sensitive to its image with consumers, and become more 'green' in its outlook.

From a skills point of view, both education and training solutions will be required to address this challenge. From an education perspective, green technology is already being incorporated into science and engineering programmes, and graduates, particularly in engineering disciplines, are increasingly specialising in green technology areas. The industry is keen that lean manufacturing be included in all green technology undergraduate programmes and that industry be involved in the design and delivery of these programmes. This area is dealt with in detail in Section 6.4.4.

On an ongoing basis, CPD programmes will be required to keep industry professionals updated on new developments.

### 6.4 Business Skills

The industry consultation for this study revealed a strong view that business skills need to be strengthened in the sector. For international companies, this is because traditionally Irish sites have been manufacturing sites, with excellent technical expertise, but have little experience in other functions. In the current environment, these multinational companies now have to manage their sites as a business rather than a manufacturing site. For the indigenous sector, business skills are a key priority, as companies seek to develop their businesses. Most indigenous companies in this sector fall into the SME category, and face many of the challenges common to SMEs throughout the economy. These include lack of time and resources, weak management skills, lack of innovation and entrepreneurship skills.



As the sector moves from pure manufacturing to a more service focused business, commercial awareness and business skills are critical. As a general principle, the industry believes that business modules provided by Higher Education Institutes should be embedded in the science and technology programmes. For example, science and engineering students should learn business skills that apply to the sector in which they intend to pursue careers, so that the skills learned are relevant to the work environment. Student work placements are also considered to be extremely valuable in this regard and are discussed further in Section 6.5. For those employed in the biopharma-pharmachem sector with some experience, MBA programmes can satisfy the skills requirements, as can CPD provision that is widely available.

In addition to commercial acumen, skills challenges were identified in the following areas:



These areas are detailed below.

#### 6.4.1 Legal, Tax and Finance Skills

Traditionally, expertise in this area has been outsourced rather than developed in-house, as these skills tend not to be required on a frequent basis. The industry would like to have more knowledge in-house than is currently the case but does not foresee having complete in-house expertise. It is considered that the current provision of legal, taxation and finance programmes will be adequate to meet the industry's needs.



#### 6.4.2 Leadership & Entrepreneurship

Leadership and entrepreneurship skills will become increasingly important in the biopharma-pharmachem sector, as the industry undergoes transformation. Patent expirations, coupled with a shrinking research pipeline and a changing consumer market, will require strong leadership and a willingness to take risks to develop and diversify business. One of the challenges facing the biopharma-pharmachem sector in this regard is its tendency to be risk averse. This is perhaps not surprising considering the high degree of regulation in the industry and the cushioning provided by patented product. In the coming years, as that landscape changes, some risks will need to be taken to transform the business. This will require organisational change in companies, as values and behaviours undergo a cultural shift, and entrepreneurial spirit is promoted. Companies will need to harness the knowledge of the entire organisation, fostering a team dynamic and moving organisations away from a focus on individuals and individual departments to a team perspective. This will require strong directional leadership.

For the multinational sector, continuous diagnostic analysis of processes and procedures will be required and consequent business decisions made, as companies increasingly move from being purely manufacturing sites. For indigenous companies, leadership and entrepreneurial skills will be critical in growing and diversifying businesses as the market demands. Leadership will also be required to encourage and promote upskilling at all levels of the organisation.

From an education perspective, the industry acknowledges that entrepreneurship courses are being provided by HEIs and that SIF funding is available in this area. These courses are considered to be best delivered as part of science and engineering programmes, where the skills learned are applicable to the appropriate industry. To date, there has been limited take-up by students on these modules and HEIs need to examine the reasons for this. Courses also need to cover sources of funding for entrepreneurs.

Ongoing executive education and training is also required. Indigenous companies in the biopharma-pharmachem sector have found the Enterprise Ireland Leadership 4 Growth programme extremely valuable in this regard. Delivered by the Stanford Graduate School of Business, the programme is designed for company CEOs, to build and enhance their leadership skills. Enterprise Ireland has recently launched a Leadership for Chief Financial Officers (CFOs), also run by Stanford, to complement the Leadership for Growth programme and to support the development of the strategic financial management function in growth businesses. Leadership and entrepreneurship programmes for the multinational sector would also be helpful.

#### 6.4.3 Team-Working, Communications, Creativity Problem Solving and Project Management

'Soft skills' such as team-working, creativity, communications, problem solving and project management were identified during the industry interview process as being critical to the industry. Other EGFSN sectoral reports and the National Skills Strategy have also identified 'soft skills' as key to effective performance across all job categories. The growing understanding of the importance of these skills to the modern workplace reflects the ongoing impact of globalisation and the



requirements of today's knowledge economy. It also reflects a greater emphasis on maintaining market competitiveness by delivering innovative, consumer-centred services with a consequent need for greater skills, particularly in terms of communications and team-working. This mirrors the changing face of the Irish biopharma-pharmachem sector.

Currently, graduates entering the sector are not skilled in these areas, according to industry.

As companies become more multifaceted and embrace convergent technologies, the ability to work in multi-functional teams is a key requirement for employees. Team-working, as with other work culture areas, takes time to develop and should be developed as early as possible in the education system. Higher education institutes should incorporate team-based project work at an early stage.

Scientific communication modules would be beneficial in undergraduate programmes, to address written and oral communication skills. During the consultation process with industry, communications was highlighted as a particular skills gap. Many science and engineering graduates enter the workforce without technical writing skills, which negatively impacts on their performance. Influencing skills are also a key part of communications and need to be improved. Graduates need to be able to confidently state their professional views and to convince others that their views should be taken into account in decision-making processes. This is a particular issue for people working in multinational companies, where the parent company or sister organisations need to be convinced on a particular issue. Modules in MBA programmes may also be appropriate to address communications skills.

Problem solving was raised as a skills issue consistently during the interview process for this study, and is dealt with in the science and technology skills section. It is felt that all courses should incorporate problem solving techniques.

Project management is considered to be best taught in the final years of undergraduate study and in postgraduate taught modules.

#### 6.4.4 Lean Technologies & Six Sigma

Chapter 2 illustrated the competitive pressures being experienced by the biopharma-pharmachem sector. Companies are facing growing pressures on reducing costs and maximising returns on investment in an environment characterised by stringent regulation, loss of patent protection and increasing R&D costs. In Ireland, biopharma-pharmachem companies are especially concerned about high labour and utility costs which impact on the sector's competitiveness. Increased competition from other locations with a lower cost base and the cost containment strategies of health services globally, highlight the importance of addressing competitiveness.

The extended period of economic growth over recent years led to significant increases in the costs of doing business in Ireland - particularly in relation to key business inputs such as rents, pay and incomes, utilities and business services. For example, in the biopharma-pharmachem sector, total payroll costs in the industry in Ireland amounted to €1.6 billion in 2008, according to the Forfás



Annual Business Survey of Economic Impact<sup>93</sup>. This shows a per annum increase of 5.3% in the 2000-2008 period, compared to a per annum increase of 3.2% over the same period for all economic sectors in Ireland.

Companies in the biopharma-pharmachem sector are now actively seeking to regain competitiveness, and are embracing lean technologies and Six Sigma to maximise productivity gains and operational efficiency. Implementing lean technologies requires a major effort in learning lean skills. It requires a cultural shift in the organisation as it is a continual process, with the benefits accruing over time. Given the scale of skill building and change involved, committing to lean manufacture is a long term initiative.

The focus of lean is very much about teams. It requires everyone in the organisation to be involved, and it is based upon collective thinking. The basis of lean is that quality be improved and costs reduced. Aligned to this, are the six-sigma principles of eliminating waste and increasing line speed and output. Overall a key focus is to start eliminating all waste, such as non-conforming product, machine downtime, avoid breakdowns, minimise machine change-over times. Achieving lean is a challenge to the skills and competency of the individuals involved - they have to adopt a new way of working and have to take increased ownership of the production line.

Lean involves training at all levels in the organisation. Management levels need to acquire lean knowledge and need to develop and hone leadership styles best suited to a lean environment and lean principles. Typically a sub-set of the managerial team needs to undertake formal six sigma training, achieving black belt accreditation. This sub-set becomes central to the successful implementation of the lean programme and plays a pivotal role in embedding the lean principles across the organisation.

At operative level a significant investment is required in educating the employees on lean principles. Operatives need training on new approaches towards reducing waste, taking ownership of the workplace, maintaining an organised workplace, tagging pieces of equipment, tagging machine parts, logging machine faults. It involves developing a new focus on product quality and raising standards in terms of appreciation and approach to quality.

Given the importance of lean technologies to the sector, the industry would like to see a Lean Six Sigma Yellow Belt programme introduced as a mandatory module in higher education institute science and engineering programmes. These courses can be completed in two weeks, and would greatly enhance graduates' skills. A full-time postgraduate programme in this area would also be valuable.

Likewise, Lean Six Sigma Yellow Belt training should be provided for those already employed in the industry. This could be delivered as continuous professional development or through an appropriate Skillnet.

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<sup>93</sup> The Annual Business Survey of Economic Impact, 2010, Forfás, September



Enterprise Ireland has recently launched a suite of lean business programmes, tailored to companies depending on their existing lean capability. These range from Lean Start which provides an introduction to lean concepts, Lean Plus which is a medium-term business process improvement project geared to achieve significant measurable gains in capabilities and competitiveness, and Lean Transform, an extensive company transformation programme delivered by an external consultancy team of international reputation.

#### 6.4.5 Sales, Marketing & Business Development

Sales, marketing and business development skills are considered increasingly important by senior management in the biopharma-pharmachem sector. As the multinational sector moves to managing its sites as a business rather than a manufacturing site, the roles of business development, sales and marketing are key to its success. For indigenous companies, sales, marketing and business development are critical, as companies, mainly SMEs, position their companies and products in an increasingly global market.

Companies need to develop new business streams by entering new markets, expanding into less familiar areas of existing markets, or launching new offerings. This requires strategic marketing skills to identify where to position a company in the marketplace in terms of customer needs, competitors, available technologies and alternative solutions. Research and analysis, using various planning tools is required, for example. Expertise in pharmaeconomics will also be required, including economic evaluation of biopharma-pharmachem products and the development of cost-effective medicines. Sales is the process of winning business, and can be a lengthy process, involving many supplier and customer interactions. It can cover everything from product technical specifications to the detail of where and when product should be delivered over the life of the contract.

Experienced sales and marketing executives are difficult to source in Ireland, according to the companies interviewed for this study. Ideally, candidates should have a strong technical or industry background, together with sales and marketing skills and experience at an international level. The industry believes that the most effective way of addressing this gap is through CPD provision for science & technology professionals in the industry. For indigenous companies, Enterprise Ireland programmes are in existence in this area and focus on identified industry needs. For example, the International Selling Programme focuses on building and sustaining export sales growth and mastering international market entry strategy for companies. Enterprise Ireland has also developed a series of workshops, Excel at Export Selling - aimed at rapidly embedding the proven tools of good international selling practice into the sales teams of Irish companies across all industry sectors, including the biopharma-pharmachem sector.

Enterprise Ireland have also developed an internship programme - Graduates For International Growth which brings together a graduate and a company that are both focused on making a lasting impact in overseas markets. Graduates, with the potential to be the next generation of business development executives, are matched with an ambitious internationally trading company and provided with a structured means of acquiring new skills in international business.



#### 6.4.6 IP Management

As the knowledge economy gathers pace, intellectual property management has emerged as a key corporate discipline for every business, regardless of the economic sector it operates in. It is particularly important for the biopharma-pharmachem sector which relies more on innovation and the efficient transfer of knowledge than many other sectors.

Traditionally, this area has been outsourced to specialist companies, rather than undertaken in-house in this sector, as the expertise is only required on an infrequent basis. Nonetheless, the industry would like to see some expertise in-house and believes that technical professionals could do specialist add-on courses in this area, at postgraduate level.

#### 6.4.7 Information Technology

As earlier analysis has shown, information technology is becoming increasingly important to this sector, as computer technology is used to gather, store, analyse and merge scientific data. The biopharma-pharmachem sector's workforce needs IT skills at every level within organisations. Operatives need to be IT conversant, as production processes move to a paperless system. Scientists and engineers require IT skills to enable speed in integrating data sources and facilitate collaboration, leading to a faster decision-making process, helping speed to market. From a sales and marketing perspective, websites are increasingly important as a marketing tool for the sector, and will require web design and maintenance skills. Managers need to be self-sufficient on many IT solutions and proficient on enterprise resource planning (ERP) systems, that are increasingly being introduced by companies to standardise activities.

HEI programmes will need to embed IT skills in science & technology programmes on an ongoing basis, from undergraduate to postgraduate courses. CPD provision will also be required to ensure that the workforce is continually upskilled in this area.

### 6.5 Student Work Placements and HEI Staff Placements

As outlined in Chapter 4, student work placements are considered to be extremely valuable by industry and HEIs. If the industry is to achieve its goals in terms of the strategic development of the sector, these work placements will be critical. Placements are seen as an effective means of improving industry-academia collaboration, giving students practical experience which complements their academic studies and helps understanding of the workplace environment. Yet, large numbers of students taking biopharma-pharmachem related courses do not have access to a placement. Most institutes of technology programmes include work placements, and likewise DCU and UL programmes. While programmes such as UCC's B.Sc Chemistry of Pharmaceutical Compounds, includes a work placement, it is not commonplace in most other university programmes. This means that large numbers of students complete their studies in biopharma-pharmachem related subjects without any practical experience in the industry.



The industry interview process for this study revealed that companies see a considerable difference between graduates who have had a work placement as part of their studies, and those who have not. Previous exposure to a workplace environment ensures that graduates entering the sector are already familiar with industry practices, culture and terminology. Companies stressed that these placements need to be of at least 6-9 months duration, if they are to be valuable. Many HEI work placements are of 12-16 weeks duration, but industry finds that it takes at least 12-14 weeks for students to become familiar with the workplace environment, and only become a valuable resource for the company after that initial period.

The capacity problem for industry with regard to placements was raised by all third level institutes surveyed for this study. While all of the education institutes interviewed considered that ideally students should be graded on their work placements, currently this presents difficulties. Chief among those difficulties is the fact that it is often difficult to secure placements for all students, particularly during an economic downturn. Companies are reluctant to take on students when they may be making staff redundant. For education institutes, this presents the problem of awarding a proportion of marks to a placement when not all students may have secured a placement. Additionally, education institutions interviewed emphasised that where not all students had participated in a placement, difficulties arose in the following year with a clear distinction between those students who had participated in a placement and those that had not.

During the consultation process for this study, it was suggested that more flexibility is required regarding the location of the placement. While every effort should be made to secure placements for students in companies, in a small number of cases, alternative locations could be used, including education/research institutes. For those students who are unable to secure a placement, projects using visiting lecturers or industry professionals to attain work placement competences could be considered. Placements for HEI professionals in industry could also be used as a means of helping industry-academia collaboration and improving understanding of both environments.

Graduate internship programmes, such as Enterprise Ireland's Graduates for International Growth Programme (see section 6.4.5) were also considered very worthwhile by stakeholders, providing valuable experience to newly qualified professionals.

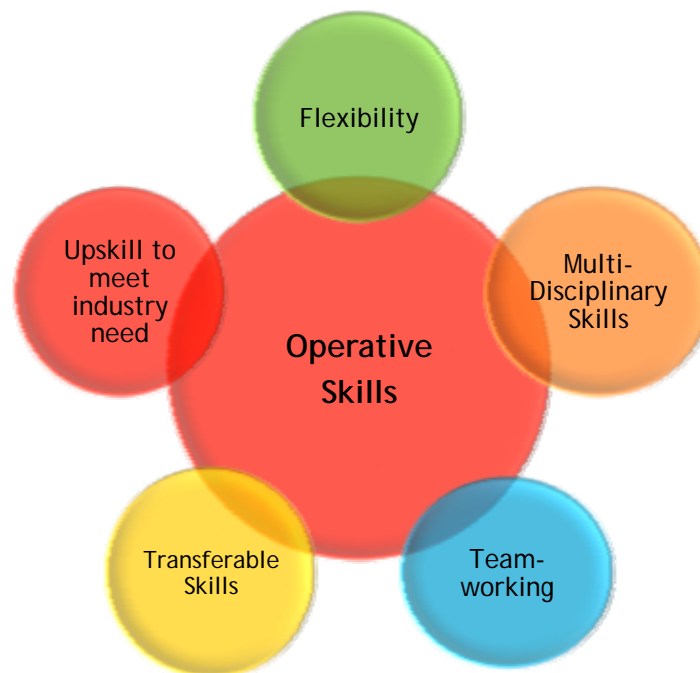
Chapter 5 showed that the key factor that differentiates education provision in North Carolina, Singapore and Switzerland from Ireland is the extent of industry academia collaboration and the consequent alignment of graduate skills to industry requirements. Student work placements and up to date faculty knowledge of the work environment are key factors in that process.

## 6.6 Operatives in the Biopharma-Pharmachem Sector

Chapter 3 examined the labour force profile of the biopharma-pharmachem sector, and showed that currently operatives represent 20% of the workforce. The industry consultation for this study showed that CEOs and senior management in the sector believe that current operator role needs to change. In future, operatives will need to be flexible and skilled in a number of areas, including mechanical changing of equipment, information technology, analytical offline testing, chemical



engineering and chemistry. As the industry embraces continuous manufacturing processes, there will be a move towards total work cell operations as opposed to the more traditional continuous line operations. Operatives will therefore be required to work as part of a multi-disciplinary team. As Chapter 3 showed, most operatives would have an educational attainment level of Leaving Certificate, and many have accumulated industry knowledge, having worked in the sector for several years. Nonetheless, these individuals will require upskilling to meet the industry's future requirements. If operatives are not upskilled, they run the risk of becoming unemployed.



In addition, there is unlikely to be capacity in the sector to absorb the numbers of operatives currently employed in the sector. As the industry becomes more high tech and automated, the number of operatives required will decline. Chapter 3 showed an occupational forecast for 2015 which estimates the number of operatives in the sector declining from 5,000 currently to 2,500 in 2015. Although the biopharma-pharmachem sector will be unable to absorb all of these individuals, those with Good Manufacturing Practice training would have saleable skills that could be transferred to other manufacturing sectors, emphasising the importance of an upskilling programme.

It is clear that a targeted, structured solution needs to be put in place to address this challenge, with specific organisations tasked with the role of ensuring this cohort is upskilled. Resources to fund this initiative will be required from industry, state agencies, HEIs and individuals. There is a consciousness that state funding for training those in employment has been significantly reduced. A change in attitude to CPD will therefore be required, with individuals taking on the responsibility to fund training initiatives and invest in their own future.



With regard to provision of CPD, FÁS, NIBRT, Skillnets and the institutes of technology are well placed to deliver upskilling programmes. Full-time and part-time programmes at level 6 and 7 on the NQF can be made available through flexible delivery modes.

## 6.7 Conclusion

In conclusion, while the industry has been broadly satisfied with graduates of the Irish education system, as the nature and scope of the business changes, so too will the competences required. The research for this study has identified the following skills challenges:

- Science and technology programmes lack practical application and are not aligned with industry's requirements. Proposed solution: increased industry-academia collaboration; use of peer review papers; inclusion of core key subjects in undergraduate programmes; structured masters and PhD programmes to include taught courses; student work placements.
- Informatics and bioinformatics are becoming increasingly important for the sector and this needs to be reflected in S&T programmes. Proposed solution: embed modules in undergraduate programmes, strategic use of PIs to transfer skills to students; use NIBRT and CSETS to upskill workforce.
- Technological convergence requires a skills set that is broader than the traditional skills found in the sector, encompassing mechanical, biomedical and materials engineering, nanotechnology and information technology, as well as the traditional disciplines of chemistry, biological sciences and chemical engineering. Industry requires professionals with a deep knowledge of their core discipline who can work in a multi-disciplinary environment, contributing to a multi-disciplinary team. Proposed solution: embed soft skills such as team-working and communications in undergraduate and postgraduate programmes; postgraduate conversion courses.
- For process development, industry requires chemists and engineers with a strong core discipline and a good knowledge of each other's discipline. Proposed solution: postgraduate conversion courses allowing the development of technologists with both science and engineering skills for full-time students, with modules offered to industry executives as CPD.
- A number of skills challenges arise in cross-discipline areas such as compliance and regulatory affairs, continuous manufacturing and green technologies, reflecting the evolving nature of the industry. Proposed solution: introduce modules in HEI programmes and use CPD to keep workforce upskilled.
- Business skills in the sector are increasingly important as the industry moves to a more service focused business and need to be strengthened. Proposed solution: embed business skills in S&T programmes; increased industry-academia collaboration; student work placements and internships; state agency provision for the workforce.
- The current operative role will need to adapt to meet industry's future needs. Proposed solution: targeted operative upskilling programme.



## Chapter 7 Conclusions and Recommendations

### 7.1 Conclusions

The research for this report revealed a number of important considerations in terms of the future skills requirements of the biopharma-pharmachem sector. The industry has flourished in Ireland due to an innovative and resourceful labour force; high education standards; a proven level of manufacturing and compliance experience; an inherent expertise to comply with demanding international regulations; a competitive corporation tax rate; and a world class research landscape.

#### Industry Challenges

The biopharma-pharmachem sector is currently facing significant global challenges. Cost pressures, patent expirations, the rise of competition from generic drugs, a shrinking research pipeline, an increasingly global market, biotechnology, technological advances and converging technologies, increasing and changing regulation, and mergers and acquisitions are the key drivers of change that are fundamentally altering the structure of the industry.

- The challenge for the Irish biopharma-pharmachem industry now is to retain its hard-earned size, scale and reputation by continuing to deliver world-class performance in all aspects of current operations. This will mean developing, embracing and leading the implementation of new concepts of manufacturing and supply-chain excellence. The industry will also need to grow by supporting and nurturing new indigenous biopharma-pharmachem companies while adding greater value within existing companies through a superior offering of new services. This will include on-site innovation such as process and product development, and services such as supply-chain management and corporate services, linking research directly to manufacturing and supply. In addition, the industry must improve its competitive position by reducing its cost base. In this way, the industry can position itself to compete internationally. An appropriately skilled workforce will be an important ingredient to meet that challenge.

#### Labour Force Profile

- The sector employs 25,300 people directly, with significant indirect employment. 86% of those employed in the sector are located in foreign-owned firms, with the remaining 14% employed in indigenous companies. The global biopharma-pharmachem industry is currently undergoing transformation due mainly to patent expiry and consolidation. This change will inevitably result in job losses in Ireland in the 2010-2015 period. These job losses are likely to be balanced by job gains in the biopharma sector and pharma companies moving to higher value added activities such as process and product development, and services such as supply-chain management and corporate services. If this transformation is achieved, employment in the 2010-2015 period is projected to be static.
- It is anticipated that the share of operatives in the biopharma-pharmachem occupational distribution will fall from 20 per cent currently to ten per cent in 2015. This equates to a loss of 2,500 jobs. If the industry transformation is achieved, these job losses are anticipated to be



balanced by job gains for professionals and associate professionals, particularly chemical, production, mechanical and electronic engineers, biological and other natural scientists, scientific and laboratory technicians and business analysts. The main challenge to 2015 will be to retain existing employment levels and position the industry for future growth thereafter.

- The biopharma-pharmachem sector has a highly skilled labour force, with educational attainment levels higher than the national average. 46 per cent of the sector's labour force have third level degrees or higher, compared to a national average of 24 per cent. 25 per cent of all PhD researchers employed in Irish industry are employed in the biopharma-pharmachem sector.

### Education and Training Provision

- Graduate annual output numbers in biopharma-pharmachem related subjects at NFQ levels 6/7 and 8 available for employment at technician level numbered approximately 1,100 in 2008. CAO acceptances data suggests that this level of graduate output will continue for the next three to four years. In terms of numbers, this is considered to be sufficient to meet industry demand in the 2010-2015 period.
- In 2007 and 2008, there were almost 800 postgraduate awards for biopharma-pharmachem subjects each year. More than half of awards were for masters degrees, approximately 30 per cent for doctoral degrees, with biology/biochemistry subjects holding the larger share, and less than 15 per cent of awards at certificate/diploma level. There would therefore appear to be sufficient numbers at postgraduate level to meet industry demand.
- In 2009, there were 111 major FETAC<sup>94</sup> awards in food science, laboratory techniques and pharmaceutical processing skills, from programmes provided by FÁS and the Vocational Education Committees (VECs). The skills developed by these learners are an important step in developing industry relevant skills and can lead to further progression to other awards on the NFQ (e.g. level 7 - Ordinary Bachelors Degree).
- A number of state agencies also provide training and development programmes for the biopharma-pharmachem industry in Ireland. The principal state agencies with relevant offerings for this sector are the National Institute for Biotechnology Research and Training (NIBRT), Enterprise Ireland, FÁS and Skillnets. As the industry transforms, this provision will be critical to ensure that the workforce is continually upskilled.

### International Benchmarks

International study visits carried out in North Carolina, Singapore and Switzerland showed strong links between industry and academia, helping to ensure that graduates are equipped with relevant skills required by industry. In contrast, industry-academia links in Ireland are mainly informal, and industry collaboration is not incentivised by academic institutes. The learnings from these international case studies include:

- Improving industry-academia links through formal processes and incentives
- Embedding business and generic skills in science and technology programmes

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<sup>94</sup> The Further Education and Training Awards Council (FETAC) is the national awarding body for further education and training (FET) in Ireland.



- Ensuring that science and technology courses have a practical application
- Structured student work placements that may take place during academic holiday periods
- Including taught components in post-graduate courses

The study visits also revealed that for the companies interviewed in the three locations, there was a unanimous view that the key role in which PhD graduates are required within the industry is for leadership roles within R&D or within process development. This view was consistent at all sites visited. In contrast, PhDs in Ireland are deployed in manufacturing roles as well as R&D. It is likely that in future the role of PhDs in the Irish biopharma-pharmachem industry will be more in R&D and process development.

### Skills Challenges

Interviews with senior management in the industry revealed that while graduates from the Irish education system have been satisfying the industry's needs, as the business changes so will the type of graduate required. In particular, academic courses in science and technology programmes will need to become more relevant to the changing industry, particularly with regard to the biological sciences and the shift to development for the small molecule business. Expertise in areas such as problem solving, informatics and bioinformatics will be essential and should be embedded in science and technology programmes. IT and business competences will also be critical as the industry becomes more service focused and should also be embedded in technical programmes. The interview process revealed that student work placements were considered by industry and HEIs to be an excellent way of familiarising students with the work environment, progressing study areas where industry has expertise, and helping develop business acumen in students. Companies would like to see these work placements being of at least 6-9 months duration and alternative locations such as research institutes could be considered for these placements when industry capacity proves challenging.

- Postgraduate conversion programmes were considered by stakeholders to be the most suitable means of addressing convergent and blended skills, building upon graduates' core disciplines. This will include post-graduate transition skills programmes for engineers and chemists, allowing graduates to combine their strong core discipline with a good knowledge of the other discipline.
- The workforce will need to be continually upskilled through CPD that is widely available from HEIs and state agencies. Industry will continue to require CPD that provides flexible learning opportunities, including part-time provision, work-based learning and short intensive upskilling programmes.



## 7.2 Recommendations

### 1. Strengthen business skills within the sector

This study has identified that business skills in the Irish biopharma-pharmachem industry need to be strengthened. These skills will be essential if the sector is to continue to develop and compete internationally. In particular, the EGFSN recommends the following:

- Business skills should be embedded in science and technology programmes, ensuring that graduates emerge with some business knowledge. For example, this would include innovation, entrepreneurship, IT and lean skills. *(Responsibility: HEA, HEIs)*
- Student work placements should be used to familiarise students with the working environment and to enhance their business acumen *(Responsibility: HEIs, PharmaChemical Ireland, Irish BioIndustry Association)*
- Mentoring and development programmes in business strategy for the industry's senior management will be required to ensure leadership in the sector. *(Responsibility: Enterprise, IDA, Enterprise Ireland)*
- State Agencies should continue to provide programmes that improve the industry's business skills. This will include provision by Enterprise Ireland, including offerings in leadership, lean techniques and sales and marketing. Skillnets will also be a useful vehicle in providing business programmes for indigenous and international companies. *(Responsibility: Enterprise Ireland, Skillnets)*

### 2. Align education and training provision with industry's requirements

The stakeholder consultation for this report revealed that there needs to be a greater alignment of education and training provision with the biopharma-pharmachem industry's requirements. The EGFSN recommends the following in this regard:

- Ensure science and technology programmes are aligned with industry's needs on an ongoing basis. This will include ensuring that course material includes peer review papers as well as textbooks, and reflects current industry practice. Industry will need to ensure that it keeps education and training providers informed of its requirements.
- Informatics, bio-informatics, business and generic skills will need to be embedded into S&T programmes
- Ensure that CPD provision continually meets industry needs and can be delivered in a flexible manner. This will include provision by public and private institutes and state agencies.
- The National Institute for Biotechnology Research and Training (NIBRT) is just beginning to roll out its training programmes. NIBRT will need to ensure that it has access to the best academic research, on an ongoing basis, and that its training programmes are aligned with industry's needs.

*(Responsibility: HEIs, HEA, Enterprise Ireland, FÁS, VECs, Skillnets, NIBRT, PharmaChemical Ireland, Irish BioIndustry Association)*



### 3. Enhance Industry-Academia Collaboration

The research for this study showed that many links between industry and academia in Ireland are informal and rely on individuals rather than structures and formal processes which is not sustainable. The Irish higher education system does not actively support or reward engagement with industry, with performance measures for academic staff focusing on numbers of graduates produced, papers published and funding obtained. In contrast, the study visits conducted in North Carolina, Singapore and Switzerland show that industry-academia collaboration is strong and plays a critical role in ensuring that graduates are equipped with skills required by industry. The EGFSN recommends the following to strengthen industry-academia collaboration:

- Formal structures and processes be put in place to ensure industry involvement in programme design and revision. *(Responsibility: HEA, HEIs, PharmaChemical Ireland, Irish BioIndustry Association)*
- Industry engagement be criteria considered for faculty appointments and promotion. HEI staff could also be encouraged to take sabbaticals to gain industry experience, and measures be taken to ensure that they are not penalised for that in their academic careers. This echoes recommendations of the Innovation Task Force and the Advisory Council for Science Technology and Innovation<sup>95</sup>. *(Responsibility: HEA, HEIs)*
- Industry professionals be used where appropriate in the delivery of course modules where the main expertise is in industry. *(Responsibility: HEA, HEIs)*
- Industry collaboration be a criterion for funding of HEI programmes. *(Responsibility: HEA)*
- Collaboration with research institutes in international locations such as Singapore, North Carolina and Switzerland be explored. *(Responsibility: NIBRT, SFI, HEIs)*

### 4. Develop Structured Postgraduate Programmes

The research for this study indicated that many postgraduate programmes in HEIs are research focused, oriented to the academic profession and do not prepare students for a wider employment market. This corroborates the findings of Advisory Council for Science Technology and Innovation in 2009<sup>96</sup>, which recommended the development of structured doctoral programmes, moving away from the traditional model of the student-supervisor relationship to a more structured research degree programme including research and generic skills development. The 2009 Forfás report on the health life sciences sector<sup>97</sup> makes a similar recommendation. This is also reflected in cycle 5 of the Programme of Research in Third Level Institutions (PRTLII) which includes a structured PhD in Life Sciences.

The EGFSN recommends the development of structured research masters and PhD programmes in biopharma-pharmachem disciplines, that would include taught courses as an integral part of the programme, and a student work placement of at least 6 months. Ideally, students would have the option to either complete a masters programme or decide to transfer to a PhD programme after 12-24 months.

*(Responsibility: HEA, HEIs)*

<sup>95</sup> Innovation Ireland, Report of the Innovation Taskforce, March 2010; Advisory Council for Science technology and Innovation, 2010, Maximising the Environment for Company Research and Development,

<sup>96</sup> Advisory Council for Science Technology and Innovation, 2009, The Role of PhDs in the Smart Economy

<sup>97</sup> Forfás, 2009, Health LifeSciences in Ireland - An Enterprise Outlook



## 5. Develop a standardised student work placement for all HEI biopharma-pharmachem related disciplines

Stakeholders consulted for this study, including industry and HEIs in Ireland and in the three international locations visited, considered student work placements an important part of science and technology programmes, giving students practical experience of the working environment. Yet, large numbers of students taking biopharma-pharmachem related courses in Ireland do not have access to a placement. While most institutes of technology programmes and some university programmes include work placements, it is not commonplace in most university programmes. The research for this study also showed that these placements differ in structure depending on the HEI or individual departments within HEIs. A number of core factors emerged as contributing to effective student work placements and should be progressed:

- Ensure that students taking biopharma-pharmachem related courses have access to a work placement
- Placements should be of 6-9 months duration and incorporate academic holiday periods if necessary.
- A partnership approach between industry, HEIs and students should be encouraged in the provision of work placements
- Placements should be sought in companies in Ireland and abroad
- While every effort should be made to secure placements for students in companies, alternative locations could be explored such as education/research institutes.
- Subject areas where the main expertise is in industry should be covered during the student work placement. This would include areas such as commercial awareness, business development, communication skills and problem-solving. Some technical areas, such as compliance, where industry has the main competence could also be covered.

*(Responsibility: HEA, HEIs, PharmaChemical Ireland, Irish BioIndustry Association)*

## 6. Address the strategic development of the Pharmachem sector by providing dedicated research and training

- (i) The EGFSN recommends that dedicated research and training in areas such as process development, synthesis, process analytical technologies (PAT) and formulation be provided to address the strategic development of the pharmachem sector. This will include horizon scanning of the environment on an ongoing basis to determine research and training needs, and provision of that research and training when demand is identified. While there is a dedicated agency (NIBRT) to address the research and training needs of the biopharma industry, no such facility exists for the pharmachem sector. If the industry is to achieve its strategic goal of increasing on-site innovation such as process and product development, a dedicated research and training resource will be required. This need was also identified by the Advisory Council for Science Technology and Innovation<sup>98</sup>.

The EGFSN recommends that this be done either through institutes that are already in place, such as the National Institute for Biotechnology Research and Training (NIBRT), or developing a separate virtual structure, through existing CSETs for example, drawing from appropriate expertise throughout academic institutions and industry.

*(Responsibility: IDA, SFI).*

<sup>98</sup> Maximising the Environment for Company Research and Development, Advisory Council for Science technology and Innovation, March 2010





## 6. Address the strategic development of the Pharmachem sector by providing dedicated research and training (Continued)

- (ii) One such training need in the area of process development was identified in the course of this study and will need to be met in the immediate term. As the industry moves to consolidate its manufacturing expertise by incorporating late stage development, technologists with both engineering and science skills will be required. This calls for engineers and chemists to have strong core disciplines but also a good knowledge of each other's discipline.

The EGFSN recommends that a masters or postgraduate diploma programme in transition skills be developed, with industry driving the course content. These courses, or constituent modules, could also be offered to industry executives to ensure upskilling within the industry.

*(Responsibility: HEIs, HEA, PharmaChemical Ireland)*

## 7. Develop an operative upskilling programme

As the biopharma-pharmachem sector undergoes essential change, the operative role in the sector will also change. Operatives will need to be flexible and skilled in a number of areas, including information technology, analytical offline testing, mechanical changing of equipment, chemical engineering and chemistry. Operatives will also be required to work in teams and will need to develop team-working skills. The EGFSN recommends that:

- An upskilling programme targeted at operatives be developed to include full-time and part-time programmes at NFO levels 6 and 7. Some initial provision at NFO levels 4/5 for those who have been in the workforce for some time, may also be required.
- Funding for this initiative be provided by industry, state agencies, HEA and individuals.
- Provision of these programmes be made available through flexible delivery modes.

*(Responsibility: Skillnets, FÁS, HEIs)*



## Appendices

### Appendix A: Steering Group Membership

Brendan Murphy	President, Cork Institute of Technology (Chairperson)
John Nason	Bristol Myers Squibb
Michael O'Brien	Pfizer
Dave Shanahan	IDA Ireland
Brian O'Neill	Enterprise Ireland
Eamonn Balmer	Department of Enterprise, Trade and Innovation
Ian Nelligan	NIBRT
Matt Moran	PharmaChemical Ireland (IBEC)
Michael Gillen	Irish Bioindustry Association (IBEC)
Stephen Simpson	Science Foundation Ireland
Margaret Cox	ICE Group and Pitman Training
Anita Maguire	UCC
Jasmina Behan	Skills and Labour Market Research Unit, FÁS
Ailish Forde	Forfás
Marie Bourke	Forfás



## Appendix B: EGFSN Membership

Una Halligan ( <i>Chairperson</i> )	Director, Government and Public Affairs for Ireland, Hewlett Packard
Inez Bailey	Director, National Adult Literacy Agency
George Bennett	IDA Ireland
Marie Bourke	Head of Secretariat and Department Manager, Human Capital and Labour Market Policy, Forfás
Liz Carroll	Training and Development Manager, ISME
Terry Corcoran	Director of Planning and Research, FÁS
Ned Costello	Chief Executive, Irish Universities Association
Margaret Cox	Managing Director, I.C.E. Group
Tony Donohoe	Head of Education, Social and Innovation Policy, IBEC
Brendan Ellison	Principal Officer, Department of Finance
Anne Forde	Principal Officer, Department of Education and Skills
Pat Hayden	Principal Officer, Department of Education and Skills
Garry Keegan	Director, Acumen
Enda McDonnell	Sectoral and Enterprise Development Policy, Enterprise Ireland
John Martin	Director for Employment, Labour & Social Affairs, OECD
Dermot Mulligan	Assistant Secretary, Department of Education and Skills
Frank Mulvihill	Former President of the Institute of Guidance Counsellors
Dr Brendan Murphy	President, Cork Institute of Technology
Alan Nuzum	CEO, Skillnets
Muiris O'Connor	Higher Education Authority
Peter Rigney	Industrial Officer, ICTU
Martin Shanahan	Chief Executive, Forfás
Jacinta Stewart	Chief Executive, City of Dublin VEC



## Appendix C: Sample Company Guide for Singapore Student Internship Program



Temasek Applied Science School

*Diploma in Biotechnology*

Student Internship Program  
&  
Major Project

Company's Guide



## Introduction

- After two and a half years of study, students pursuing the Diploma in Biotechnology are required to participate in the **Student Internship Programme (SIP)**. Incorporated in the 20 weeks SIP is the student's **Major Project (MP)**. Both SIP and MP are graduation requirements for the award of the Diploma in Biotechnology.
- The SIP and MP programmes are meant as mutual benefit to the student and your organisation. The student would obtain a holistic view of the industry and be able to participate in real life projects. At the same time, it is hoped that the students will be able to contribute in some way to the organisation.

## The SIP Program & Major Project

- Students are assigned to the participating companies according to the requirements of the company. In as much as we try to match student ability to company requirement, we appreciate your understanding that the match may not be perfect.
- A lecturer from the Diploma in Biotechnology will be assigned to liaise with you on all matters concerning the SIP/MP and the students. Please feel free to contact the officer should you require any information or clarifications.
- Students understand that they are to complete the tasks assigned to them by the Company Supervisor, as specified in the Student Task / Assignment Description Form (Appendix 1). Should there be significant change to the job nature, it would be appreciated that the Company Supervisor informs the Liaison Officer.
- Students are to record and describe the work they do in the company in a Logbook (SIP) and Workbook (MP). Please inform the students should there be confidential information that you do not wish to be recorded.
- Please review the Weekly Summary in the logbook and give the student your comments and advice for improvement. Your guidance and contribution to this learning process will be much valued. Similarly, review of the MP Workbook and guidance at regular interval is appreciated.
- The Liaison Officer will maintain regular contact with the company and the student. The officer will pay visit(s) to the company to discuss progress with both the company supervisor and student, and deal with any difficulties that may arise.
- In addition to the visit(s) by the Liaison Officer, students are required to return to the Polytechnic on 2 occasions for discussions with lecturers as listed in the Calendar of Events (Page 4). It is appreciated that the participating organisation makes provision for these discussions.



- The students understand that the quality of their work and their attitude will be assessed by the Company Supervisor. The Polytechnic will not hesitate to carry out disciplinary action against students should they commit any offence against the company.
- Towards the end of their attachment, students are to be appraised by the Company Supervisor via the Performance Appraisal Form (Appendix 2). Upon completion of the appraisal, please return the form to the Liaison Officer. This appraisal contributes significantly to the student's final grade for the SIP and MP programmes.
- Students are required to submit to the school a written report outlining their experiences and the learning outcomes of the SIP and MP. This includes a full account of the work done, the environment in which it took place, project results and analysis. The company may request for a copy for their perusal.
- If you find the results of the work/project carried out by the students of interest to your company, and wish to conduct further work/research in that area, we would be glad to discuss with you future projects of mutual interest.

## Conclusion

We are grateful for your participation in this programme. We hope that the students will learn much from this industrial experience, and be of benefit to your organisation. We also look forward to your continued support of the Polytechnic in future SIP and MP programmes.

Thank you.

The SIP and MP committees  
Diploma in Biotechnology  
Temasek Applied Science School



## Appendix D: References to soft skills in course descriptions in North Carolina, Singapore and Switzerland

### North Carolina

#### NC Community College Network:

This college graduates technicians etc. BioWork is a 128-hour introductory course bringing together the basics of manufacturing technology and the fundamentals of science-two essentials for competent, entry-level technicians in biotechnology, pharmaceutical, and chemical manufacturing. It is aimed at training technicians for biotech & pharma manufacturing. The course prospectus specifies: *“ Technical knowledge and skill is not enough. Successful process technicians need an ability to effectively communicate, work with a team, and solve problems. BioWork offers students many opportunities to develop and practice these skills.”*

#### North Carolina State University:

##### Bachelor in Bioprocessing Science

A four-year Degree Course designed specifically for biotech and pharma. “Graduates earning a Bioprocessing Science degree will have the technical competence and hands-on experience to immediately contribute to the North Carolina biomanufacturing and pharmaceutical industries.”

In addition to the technical competences, the course prospectus also highlights the provision of other skills, including...

- Manage and communicate source materials and data related to bioprocessing
- Work effectively and efficiently in teams
- Produce effective oral and written communications

### Switzerland

As examples of the soft-skill content of relevant courses, 2 representative courses are highlighted:

#### Zurich Univ. of Applied Sciences

##### Bachelor in Biotechnology:

A 3-year full-time degree with specialisations in Biotechnology and Pharmaceutical Technology. Semesters 1 and 2 contain 12 hours of Mathematics & Computer Science. Five of the Semesters contain a unit on Society & Communication (*Gesellschaft und Kommunikation*) which includes English language, Literature, Personnel Management (*Personalführung*) and other soft skills.

##### BSc in Material and Process Technology

A 3-year full-time degree designed to provide the technical and management skills required for work in a process manufacturing environment. The course prospectus notes that the student will be



provided with several soft skills including: “You will be provided with a distinct social competence which will be distinguished by an ability in communication, willingness to work in teams, and leadership quality”

ZHAW also offer an MSc in Life Sciences, specialising in Pharmaceutical Technologies.

The study programme is designed as “further education for graduates with a Bachelor’s degree in pharmaceuticals, chemistry or biotechnology. The core of the specialisation in pharmaceutical biotechnology is the production and diagnostics of biologically active molecules”. The course also highlights some soft skills and notes: “*We develop personalities - The study programme places the development of methodological and personal competences in the foreground. You will deepen your theoretical and scientific knowledge and improve your social, professional and general competences*”<sup>99</sup>

## Singapore

### Temasek Polytechnic

#### Diploma in Pharmaceutical Science

3 year full-time Course providing “the knowledge and skills required to design, analyse, manufacture and market new therapies for cancer and infectious diseases”.

In addition to the technical competences the course prospectus also notes that:

“Our course incorporates various approaches that develop not only technical knowledge and skills but also life skills such as teamwork, communication and time management.”<sup>100</sup>

#### Diploma in Chemical Engineering

3 year full-time Course providing aPharmaceutical specialization stream in the final year. This is based on “core chemical engineering modules to ground students in chemistry and process engineering, with additional modules such as Current Good Manufacturing Practice and Pharmaceutical Manufacturing Technology to equip students with knowledge and skills needed in the pharmaceutical industry.” There is no specific mention of soft skills in the prospectus for this course.

#### Diploma in Biomedical Science

3 years full-time general course on biology and chemistry of health science. The Course prospectus notes that the course is designed to “develop not only technical knowledge and skills but also life skills such as teamwork, communication and time management. The compulsory internship in relevant industries carried out concurrently with major projects helps you to experience real working life and allows you to apply theory to practice on real industry projects.”

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<sup>99</sup> ZHAW Website: [www.ibt.zhaw.ch/en/Isfm/institute-of-biotechnology/study/master.html](http://www.ibt.zhaw.ch/en/Isfm/institute-of-biotechnology/study/master.html)

<sup>100</sup> [www-as.tp.edu.sg/asc\\_home/asc\\_courses/asc\\_ft\\_courses/asc\\_courses\\_phs.htm](http://www-as.tp.edu.sg/asc_home/asc_courses/asc_ft_courses/asc_courses_phs.htm)





Nanyang Polytechnic

### Diploma in Biologics & Process Technology

3-year Diploma course for technical staff in the Pharma industry. It “combines biological and chemical sciences with engineering concepts, and with a strong emphasis on biopharmaceutical technologies”. In addition to the relevant technical skills, the course prospectus states that the course aims to provide graduates with “An analytical, independent and innovative mindset plus good communications and IT skills” <sup>101</sup>.

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<sup>101</sup> [www.nyp.edu.sg/SCL/bpt\\_courseaim.html](http://www.nyp.edu.sg/SCL/bpt_courseaim.html)



## Appendix E: List of EGFSN Publications 2005 - 2010

Report	Date of Publication
Monitoring Ireland's Skills Supply - Trends in Education and Training Outputs 2010	July 2010
National Skills Bulletin 2010	July 2010
Future Skills Needs of the Wholesale and Retail Sector	May 2010
The Expert Group on Future Skills Needs Statement of Activity 2009	April 2010
Future Skills Requirements of the Food and Beverage Sector	November 2009
Skills in Creativity, Design and Innovation	November 2009
Monitoring Ireland's Skills Supply: Trends in Education/Training Outputs 2009	November 2009
National Skills Bulletin 2009	July 2009
A Quantitative Tool for Workforce Planning in Healthcare: Example Simulations	June 2009
The Expert Group on Future Skills Needs Statement of Activity 2008	June 2009
A Review of the Employment and Skills Needs of the Construction Industry in Ireland	December 2008
Statement on Raising National Mathematical Achievement	December 2008
National Skills Bulletin 2008	November 2008
All-Island Skills Study	October 2008
Monitoring Ireland's Skills Supply: Trends in Education/Training Outputs 2008	July 2008
The Expert Group on Future Skills Needs Statement of Activity 2007	June 2008
Future Requirement for High-Level ICT Skills in the ICT Sector	June 2008
Future Skills Needs of the Irish Medical Devices Sector	February 2008
Survey of Selected Multi-National Employers' Perceptions of Certain Graduates from Irish Higher Education	December 2007
The Future Skills and Research Needs of the International Financial Services Industry	December 2007
National Skills Bulletin 2007	November 2007
Monitoring Ireland's Skills Supply: Trends in Educational/Training Outputs	June 2007
Tomorrow's Skills: Towards a National Skills Strategy	March 2007
National Skills Bulletin 2006	December 2006



Future Skills Requirements of the International Digital Media Industry: Implications for Ireland	July 2006
Careers and Labour Market Information in Ireland	July 2006
Skills at Regional Level in Ireland	May 2006
SME Management Development in Ireland	May 2006
Monitoring Ireland's Skills Supply: Trends in Educational/Training Outputs	January 2006
Data Analysis of In-Employment Education and Training in Ireland	December 2005
National Skills Bulletin 2005	October 2005
Skills Needs in the Irish Economy: The Role of Migration	October 2005
Languages and Enterprise	May 2005
Skills Requirements of the Digital Content Industry in Ireland Phase I	February 2005



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Expert Group on Future Skills Needs  
Secretariat support by

Forfás  
Wilton Park House  
Wilton Place  
Dublin 2, Ireland

Tel: +353 1 607 3000  
Fax: +353 1 607 3276

[www.skillsireland.ie](http://www.skillsireland.ie)