Sustaining the Skills Pipeline

in the pharmaceutical and biopharmaceutical industries

CONTENTS

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RECOMMENDATIONS AND TARGETS

RECOMMENDATION 1: Government should facilitate the establishment of a UK *In Vivo* Sciences Task Force that would:

- **i.** **Consist of key stakeholders across employers and the education sector, along with appropriate welfare organisations such as the National Centre for the 3Rs;**
- **ii.** **Consolidate information from all stakeholders on the current provision of skills; and**
- **iii.** **Identify existing initiatives; gaps; and develop an action plan for the next five to ten years.**

TARGET 1: Key stakeholders, facilitated by Government, to establish an *In Vivo* Sciences Task Force to report by the end of July 2006.

RECOMMENDATION 2: The Science Learning Centre network, industry and teacher training institutes, should work together to develop and support courses to update the practical skills of teachers, and those training to be teachers, and help them update their knowledge of cutting-edge scientific research. ABPI and other stakeholders should review how they can support recruitment of specialist science teachers for 14-16 education in critical subjects.

TARGET 2: Develop action plan on practical skills with teacher training institutes and Science Learning Centre network for implementation during the 2006-7 academic year.

RECOMMENDATION 3: A 14-19 Diploma in Science should be developed, with appropriate support from industry, to support science skills and careers. The relevant Sector Skills Council (SEMTA) should lead the development of the Science Diploma, working with other Skills Councils, industry and other stakeholders as appropriate.

TARGET 3: SEMTA to develop a proposal for a Science Diploma, working with relevant stakeholders to establish a diploma development partnership by January 2006 for introduction of the diploma in September 2009.

RECOMMENDATION 4: The ABPI will develop clear profiles, including expectations on practical skills, for priority areas to share with stakeholders and initiate dialogue to fill the skills gaps. Stakeholders encompass the Research Councils, Higher Education Funding Councils, Professional Bodies, Government and academia in Higher Education.

TARGET 4: ABPI to develop profiles, including practical capabilities, on priority skills areas – and complete all "red light" priority profiles by end 2006.

RECOMMENDATION 5: ABPI will support Royal Society of Chemistry initiatives to encourage continued dialogue between industry employers and university chemistry departments to promote understanding of the needs of industry and to encourage

implementation of measures within undergraduate and postgraduate courses to meet these needs.

TARGET 5: Support RSC in preparing a report of workshops held with industry and academic representatives in 2004 and arranging follow on meetings to be held 1st quarter 2006.

RECOMMENDATION 6: ABPI will build on the liaison with Research Councils and universities to target CASE awards to strategic areas and doctoral training accounts to support PhD and MSc studentships of relevance to industry. ABPI will review provision of work placements as part of PhDs.

TARGET 6: By end of 2nd quarter 2006, ABPI to complete paper after consultation with member companies and key stakeholders on proposals to target studentships more strategically in line with priority skills areas and to review and expand opportunities for work placements for undergraduate and postgraduate students.

RECOMMENDATION 7: The Government should set targets for HE funding councils to expand physics and chemistry courses in line with UK strategy on science and innovation

TARGET 7: To expand numbers of chemistry and physics undergraduates in line with total expansion of HE using a baseline of 1997/8.

RECOMMENDATION 8: Industry should work more effectively with key stakeholders to co-ordinate liaison with schools through carrying out survey of industry activities at both primary and secondary education levels to:

- **Identify their geographical coverage, approach and goals, to complement the DfES STEM Mapping Review; and**
- **Develop appropriate metrics to evaluate the impact of engagement.**

TARGET 8: Complete a survey of primary initiatives by mid-2006 and secondary initiatives by end 2006, then identify areas for cooperation and collaboration.

RECOMMENDATION 9: ABPI, with member companies, will review current activities with schools to identify new opportunities and share best practice to stimulate awareness of the pharmaceutical industry and facilitate good course selection to achieve career goals.

TARGET 9: Over the next two years, to benchmark and improve effectiveness of industry engagement with schools.

RECOMMENDATION 10: The QCA should include relevant information on scientific careers within course content to ensure appropriate selection of scientific subjects at Key Stage 3 and in 14-19 education.

TARGET 10: QCA, following work with relevant industry sectors, to specify information on careers in scientific subjects at Key Stage 3, GCSE and in all post-16 courses.

RECOMMENDATION 11: The STEM community, including ABPI, should work together to coordinate and enhance delivery of careers information in schools. Advice should portray opportunities, not just in terms of high-level research skills, but also vocational and technical support opportunities across R&D, manufacturing and engineering.

TARGET 11: To make a measurable difference in information flow to pupils and enhance teachers' knowledge on careers to increase demand for foundation and honours STEM degrees, including:

- **ABPI to re-launch new-look careers website by September 2006 and monitor impact on an annual basis.**
- **The Science Council and Engineering Training Board, should work together with stakeholders to develop a one-stop portal for STEM skills covering: information for students at various stages of the skills pipeline and support for careers advisors and science teachers.**
- **Develop a media communications strategy to broaden the positive portrayals of the range of STEM careers (using an approach akin to the Coalition for Medical Progress).**

RECOMMENDATION 12: DfES and Government to consider establishing Technical and Vocational University Funding streams through the RDAs/LSCs, with appropriate engagement with the Funding Councils.

RECOMMENDATION 13: DfES to move teaching towards a full economic costing model to ensure appropriate funding of all subjects and reflect regional variation in the cost of HE provision.

1 INTRODUCTION

1.1 Context and Objectives

This report examines the skills landscape in the UK pharmaceutical and biopharmaceutical industries. This includes trends in skills needs – and thereby strategic opportunities for the UK – as well as current and imminent skills shortages which negatively impact these UK industries.

The data on which the report is based is drawn primarily from the results of a broad study undertaken by the ABPI on the skills landscape in the UK pharmaceutical and biopharmaceutical industry. It is supplemented by additional consultation with members of the ABPI. The study was initiated by the ABPI's Science, Technology, Engineering and Manufacturing Education and Skills Taskforce, which was set up by the ABPI Research and Development, Manufacturing and Medical Committees to investigate growing concerns over the wide range of current and likely future skills shortages which negatively impact the UK industry. The study follows a smaller survey undertaken by a British pharmaceutical company which confirmed that there are a number of areas warranting concern and action.

The study has concentrated on investigating the issues around the skills and knowledge of new graduates, postgraduates and postdoctoral scientists and engineers. We are also aware of concerns over skills and training of non-graduates and of specific issues regarding recruitment in medically related areas, such as nursing, but these have not been further investigated within this study. The recruitment of experienced scientists is also beyond the scope of this study.

Section 1 of the report outlines the study methodology and respondents. In Section 2, the results of the study are summarised, detailing general trends, issues relating to core graduate skills, core disciplines, emerging disciplines, and trends and concerns associated with organisation type. Where relevant, priorities are assigned to each skill area.

In order to be successful and tenable, any plan to address these skills shortages and opportunities will require the concerted and sustained effort of the key stakeholders – Government, educational institutions and the pharmaceutical industry. Some skills shortages will be easier to rectify than others, and while the primary responsibility to address a skills shortage may lie with one stakeholder, all have a part to play. As such, this paper seeks to present the issues and concerns around each skill area in a manner which will facilitate a constructive dialogue between stakeholders, around realistic and mutually acceptable strategies to rectify problems, and make the most of opportunities.

1.2 Study Methodology and Respondents

The study questionnaire enabled respondents to address the following areas, with a combination of qualitative and quantitative responses.

- **Skills:** Companies were asked to comment on a wide range of skill areas. In addition to those identified as important at the outset of the study, several companies contributed additional skill areas which resulted in an amalgamated list of 19.
- **Priorities:** Skill areas were allocated numerical priorities, from 1) "very high priority, recruiting very difficult" to 5) "not a priority at present or in the foreseeable future."
- **Quality and Number:** Skill areas could also be denoted as being problematic in terms of quality and / or number of applicants.
- **Skill Level and Geographical Source of Candidates:** For each skill area, respondents could differentiate between i) skill level (graduate, PhD or post-doc) and ii) the geography from which they sought candidates for their UK operations (from within the UK, from mainland Europe or from elsewhere).
- **Future Skills and Detailed Comments:** The questionnaire included a section for comments on future skill needs, and any other comments to supplement the main section.

Respondents: 16 of the 66 companies which received the questionnaire completed it – on behalf of either R&D, manufacturing or, in some cases, both divisions.

R&D	**Manufacturing**
3M	Abbott
AstraZeneca	AstraZeneca
Boehringer Ingelheim	Boehringer Ingelheim
Cambridge Antibody Technology	Eli Lilly
Covance	GlaxoSmithKline
Eli Lilly	Merck Sharp and Dohme
GlaxoSmithKline	Novartis
Huntingdon Life Sciences	Pfizer
Inveresk	
Merck Sharp and Dohme	
Novartis	
Organon	
Pfizer	
Roche	
sanofi-aventis	

Several other companies responded to the survey. However, due to the fact that they were not currently recruiting, or not recruiting scientists, they were unable to complete the questionnaire. The representatives of some companies made additional comments, supplementary to the questionnaires, in response to specific questions.

In some cases, the responses were from only some of the divisions which comprise R&D or manufacturing. For example, several companies only provided a response from clinical pharmacology. Some companies addressed R&D and manufacturing in the same questionnaire. Where possible, this was clarified by a detailed examination of the comments and by subsequent follow-up with companies.

2 THE SKILLS LANDSCAPE

2.1 Overview of Results

An analysis of the skills landscape can be broadly divided into the following sections. None of the categories are completely independent and while addressing their respective problems may necessitate different strategies, improvements are likely to have spill-over benefits in other areas.

- **General Trends:** These are very broad issues and trends which, while important, often relate only indirectly to skills shortages.
- **Core Graduate Skills:** These skills tend to be generic needs, and problems and shortages affect a wide range of disciplines. Although problems might manifest themselves more negatively in certain disciplines, they cannot necessarily be addressed by reforming the curriculum or funding of any one educational course.
- **Core Disciplines:** Addressing problems in these specialisations may require a more focused approach, although many of the underlying causes are associated with core graduate skills. These disciplines are evaluated according to current priority, and probable future importance. Companies may experience some differences between R&D and manufacturing.
- **Emerging Disciplines and Skills:** These disciplines tend to be small, but rapidly growing. Implicitly, they are an important future concern. They offer new training opportunities and may require the specialisation of candidates from more mainstream disciplines. Thus skills shortages in core disciplines may negatively impact the emerging disciplines.

2.1.1 Quality and Number

Both opportunities and problems associated with skills are all, directly or indirectly, related to either quality or number of candidates. The results of the survey moreover indicate a close relationship between the two characteristics. In the areas where number was considered a problem, quality was almost always likewise of concern. However, in some instances quality but not number was considered a high priority.

2.2 General Trends

- ***In vivo* disciplines and chemistry**: A general decline in interest and in the number of relevant courses in chemistry and *in vivo*-related disciplines, such as pharmacology, physiology and pathology, is seriously affecting a range of core and emerging disciplines. Redressing these shortages will be an important step towards increasing UK competitiveness.
- **Emerging disciplines:** New disciplines are numerous, and the speed at which they develop is increasing. Proactively addressing future skill needs will place the UK at a strategic advantage, as well as helping to avert shortages. The ability to do so successfully depends largely on improving and ensuring the quality of core graduate skills, as many of the emerging disciplines build upon these.
- **Perception and awareness of careers in pharmaceuticals**: Some companies believe there is a negative perception of careers in the pharmaceutical industry and find that talented scientists may choose other occupations where analytical thinking and problem solving are highly valued. The underlying cause is thought to be a combination of several factors, including remuneration, a lack of awareness of the wide variety of career opportunities in industry, perception of industry versus academia as a career, and perception of the pharmaceutical industry versus other industries.
- **Manufacturing versus R&D**: In several of those disciplines relevant to manufacturing and R&D, manufacturing appears to struggle relatively more to recruit good candidates, possibly due to negative perceptions and a lack of awareness of careers in manufacturing.
- **Assessing graduate quality:** It is increasingly difficult to gauge graduate quality as the level of honours degree is no longer a reliable indication. Many companies therefore have to use their own assessment procedures, such as intellectual ability tests.
- **Higher level mathematics and communication skills:** There is a serious and widespread decline in higher level numeracy and literacy skills across all levels. Of particular concern is a decline in the ability to apply mathematics skills. This negatively affects a broad range of disciplines and skills, both core graduate skills and specialisations.
- **Recruitment from the UK versus from Europe and elsewhere:** Overall, skills shortages do not appear to be significantly worse in the UK: if companies experience difficulties recruiting locally, they are more likely to recruit from beyond the UK, but they generally allocate equivalent priorities, and comments around quality and number, to local and foreign recruitment sources. In a few disciplines, European or American candidates are thought to be of a higher quality. Big pharma is more likely to recruit outside of the UK, but this may reflect a wider presence, rather than greater difficulty or demand experienced by these companies.

2.3 Core Graduate Skills

- **Mathematics:** Many science graduates lack an adequate grounding in higher level mathematics. This is essential for a wide range of core and emerging disciplines and is consistently thought to be a serious and worsening problem.
- **Practical Experience:** Graduates often have inadequate practical experience, particularly in chemistry, *in vivo* disciplines, pathology, toxicology and engineering. The cause lies both in insufficient practical components in degree courses as well as a lack of opportunities for industrial experience.
- ***In vivo* skills**: The low and declining availability of *in vivo* skills is felt mainly in the core disciplines, but the problem begins even before specialisation. There is an urgent need for more and improved university courses and modules – despite growth in the number of bioscience graduates, *in vivo* skills are becoming scarcer. Administrative hurdles associated with obtaining appropriate Home Office licences for *in vivo* work do not encourage universities to offer courses which develop *in vivo* skills. Industry needs to improve the clarity of *in vivo* career options to raise interest in pursing *in vivo* courses. The negative public image of *in vivo* research may further deter individuals from pursing *in vivo* careers.
- **Chemistry:** A decline in the interest in and number of chemistry courses – both chemistry degrees and chemistry components in other degrees – is seriously affecting this core graduate skill, as well as the specialisations which build upon it.
- **Communication Skills:** Science graduates may not possess adequate verbal and written communication skills. These are essential for an industry environment, both for scientific roles and later for those individuals who take on management positions.
- **Modular Degrees:** With many flexible science degrees, students may avoid essential but difficult subjects by selecting easier modules.
- **Computational Analysis Skills:** The ability to apply mathematical techniques to a wide range of biological and physical sciences is an increasingly important skill. In some cases, such as bioinformatics, this demand can be addressed through specific courses. But, in general, graduates with a combination of mathematics and other sciences are highly sought after.

2.4 Core Disciplines

2.4.1 Priorities

Each core discipline is assigned one of three overall priority levels. These priorities are based upon a combination of quantitative information and comments provided by companies. In determining priorities, response rates as well as the range and variability of data were taken into account. Within some areas there was considerable variation, so while these figures should fairly represent general trends, individual companies' experiences may differ. Within each discipline, each skill level – graduate, PhD and post-doc – was assigned an individual priority.

2.4.2 R&D and Manufacturing

This section represents responses from both R&D and manufacturing. As these two areas experience a shared demand for a number of the core disciplines, they cannot be examined independently. Consequently, for that subset of disciplines important for manufacturing as well as to R&D, the manufacturing priority is noted.

2.4.3 Current and Future Priorities

Many respondents made a distinction between the priority of a core discipline at present, and in the future. Clearly, without intervention, those areas of high priority today are likely to be problematic in the future. However, some areas of moderate and low priority are also on a trajectory to become more serious.

2.4.4 Key

● (grey)	**Current Priority**	Priority for the discipline as presently affecting companies
Q	**Priority for Quality**	Problems associated with candidate quality
N	**Priority for Number**	Problems associated with candidate number
F	**Priority for Future**	Reflection of how important this area will be in the future.
M	**Priority for Manufacturing**	M reflects manufacturing priority in disciplines which are important to manufacturing and R&D.
● (green)	**Low Priority**	Important area to watch
● (orange)	**Medium Priority**	Requires action
● (red)	**High Priority**	Requires immediate action

Respondents allocated a priority to each discipline, ranging from 1 – Very high priority, recruiting very difficult to 5 – Not a priority at present or in the foreseeable future. This data formed the quantitative part of the results; the qualitative material was drawn from the comments made by respondents.

2.4.5 BIOLOGICAL AND MEDICAL SCIENCES

DISCIPLINE	KEY COMMENTS	LEVELS
Clinical Pharmacology / Experimental Medicine / ● QNF	**Very difficult to find appropriate candidates; worsening problem** § Variable quality. § Shortages are a long-standing and increasing problem, largely due to fewer academic clinical pharmacologists. § Overlap between experimental medicine and clinical pharmacology may lead to a lack of expertise in either area. § Drug development and pharmacology are not sufficiently addressed in medical degrees. § Worldwide problem.	**GraduateN/A** **PhD** **POST-DOC**
Pharmaco-kinetics and ADME (absorp-tion, distribut-ion metabolism and excretion) ● QNF	**Variable quality; difficult to find candidates with appropriate experience** § Small candidate pool; recruitment difficult and time-consuming. § Hard to find candidates with modelling experience. § Need for MSc course in UK, including PK/PD modelling. § Candidates may lack appropriate background in analytical chemistry, physiology, enzyme kinetics. § Graduates lack the necessary core skills for a sound understanding of this field.	**GRADUATE** **PhD** **POST-DOC**
Biochemistry ● QNF	**Undergraduate courses have inadequate breadth and rigour** § Quality very problematic for enzyme kinetics, physiology, metabolism, mathematics. § Expertise in enzyme kinetics lacking in some higher education biochemistry departments. § General "rigour" of programmes is poor. § Some graduates lack grounding in quantitative analytical techniques.	**GRADUATE** **PhD** **POST-DOC**
***In vitro* Pharmacology** ● QNF	**General quality concerns; need for new courses** § Graduates may lack simple skills such as making dilution series and constructing concentration response curves. § Need for increased practical component in current degrees as well as more MSc courses. § King's MSc is a good grounding course, but it does not address all necessary skills.	**GRADUATE** **PhD** **POST-DOC**
Biomedical Imaging / Physical Sciences ● QNF	**Difficult to find enough candidates; rapidly growing demand** § High growth area, as biomarkers become easier to use. § Need for interdisciplinary skills, particularly physics. § Requires widespread recruiting in Europe and elsewhere.	**Graduate N/A** **PhD** **POST-DOC**

DISCIPLINE	KEY COMMENTS	LEVELS
Pharmacy QNF	**Recruiting individuals with experience is becoming difficult** § Recruiting at graduate level is straightforward. § Recruiting PhD pharmacists is problematic due to a lack of industrial experience. § Future problems due to a reduced focus on industrial pharmacy in university courses, and by the Royal Pharmaceutical Society. § Quality is a very high priority for PhDs and post-docs. § Pharmaceutical Formulation is negatively impacted by the paucity of pharmacists with industry experience, who used to be the mainstay of this area. Finding individuals with experience in biopharmaceuticals formulation and materials science is particularly difficult.	GRADUATE PhD POST-DOC
Bioscience & Molecular Biology QNF	**Graduates may lack necessary grounding; generally large recruitment pool** § Some graduates lack grounding in quantitative analytical techniques. § Few PhDs and post docs with specialist knowledge of a disease or therapeutic area. § Large graduate recruitment pool but relationships with universities are important for access to good candidates.	GRADUATE PhD POST-DOC
Medicine QNF	**Additional skills required; generally provided by industry** § Need for a combination of technical expertise and commercial orientation. § Possible lack of career awareness: intercalated courses within medical training would encourage awareness of careers within pharma. § Skills required for drug development are generally provided by the industry through higher medical training programmes, in house courses and experience.	GRADUATE PhD POST-DOC

2.4.6 BIOTECHNOLOGY

DISCIPLINE	KEY COMMENTS	LEVELS
Biotechnology & Biopharma-ceuticals QNFM	**Important for R&D and manufacturing; wide range of skills amongst graduates** § For R&D, difficult to find experience in fermentation and antibodies. § For manufacturing, difficult to find creative people to work in separation science and downstream processing. § As the importance of biopharmaceuticals increases, analytical chemistry courses should develop to incorporate relevant skills. General lack of biotechnology product experience.	GRADUATE PhD POST-DOC

2.4.7 CHEMICAL SCIENCES

DISCIPLINE	KEY COMMENTS	LEVELS
Analytical & Physical Chemistry ● QNFM	**Very high priority for manufacturing; hard to find candidates with experience** § Few specific courses; universities may lack necessary high-tech equipment. § Physical properties experience rare; separation science skills often lacking. § Need for graduates who can develop new analysis methods, diagnostic tests, biomarkers. § Significant recruitment in Europe and elsewhere.	GRADUATE PhD POST-DOC
Synthetic Organic Chemistry / Medicinal Chemistry ● QNFM	**Very difficult recruiting into manufacturing; difficult for R&D** § Recruiting organic chemists into manufacturing is especially difficult. § Relationships with university chemistry departments greatly assist recruiting. § Likely to be problematic in the future due to the declining popularity of chemistry.	GRADUATE PhD POST-DOC

2.4.8 ENGINEERING

DISCIPLINE	KEY COMMENTS	LEVELS
Chemical and Process Engineering ● QNFM	**Difficult to recruit chemical engineers with industrial experience** § Interdisciplinary approach often lacking. § UK courses would benefit from greater knowledge of other disciplines such as chemistry and biochemistry. § Relationships with universities assist recruiting. § May be strong competition from other industries.	GRADUATE PhD POST-DOC
Mechanical and Electrical Engineering ● QNFM	**Serious quality problems; difficult to find experience** § Pharma may not be seen as natural route for engineers. § Different skills needed for pharmaceuticals – companies need to encourage universities to address these additional skills, or do so themselves with in house training. § Interface between apprenticeships / foundation degrees and honours degrees unclear for all types of engineer. These should be joined up.	GRADUATE **PhD & Post-Doc Not Available**

2.4.9 *IN VIVO* SCIENCES

DISCIPLINE	KEY COMMENTS	LEVELS
***In vivo* Physiology** ● QNF	**Graduate recruiting especially difficult; some skills very hard to find** § Lack of clarity around *in vivo* career within industry § Lack of educational courses, particularly at higher levels. § Difficult to find candidates with experience. § Some skills, e.g. neurophysiology and metabolic physiology, are particularly scarce.	GRADUATE PhD POST-DOC
***In vivo* Pharmacology** ● QNF	**Recruiting very difficult; low and declining interest** § Lack of clarity around *in vivo* career within industry. § Lack of educational courses, particularly at higher levels. § Difficult to find candidates with experience. § Animal rights activists are a deterrent to pursuing this career. § Recruiting good graduates is particularly difficult – those that don't progress to a PhD have very few practical skills.	GRADUATE PhD POST-DOC
Toxicology ● QNF	***In vivo* toxicology very high priority at all levels; particular severe at graduate level** § Some undergraduates lack important skills, particularly biochemistry and chemistry. § Poor understanding of regulatory toxicology. § Genetic toxicology is an important future skill. § Difficult to find individuals who can design toxicology studies. § May require significant training in house due to lack of candidates. § Considerable recruitment overseas necessary.	GRADUATE PhD POST-DOC
Pathology ● QNF	**Need for more courses; veterinary pathology is an important skill need** § Difficult to find candidates with experience. § Clinical pathology should be a recognised course (as in US). § Need to encourage postgraduate study of veterinary pathology in the UK by: o i) Veterinary pathology postgraduate courses (as in US) or, o ii) Courses with an option to study veterinary pathology as an alternative to veterinary medicine.	GraduateN/A PhD POST-DOC
Veterinary Medicine & Veterinary Science ● QNF	**Global recruitment necessary for high quality candidates; lack of career awareness** § Lack of awareness of pharma as a career. § Lack of training of vets in methods, procedures and species relevant to toxicology.	GRADUATE PhD POST-DOC

2.4.10 STATISTICS

DISCIPLINE	KEY COMMENTS	LEVELS
Statistics ● QNFM	**Grounding in stats is needed – and lacking – in a wide range of disciplines** § At graduate level, statistics skills are consistently a high priority. § "Omics" revolution has increased demand, and thereby difficulty of recruiting experienced statisticians at MSc and above. § Communication issues: many people who specialise in these disciplines do not like team work. § Statistical genetics very important future issue: Quality is a major concern and demand will increase as it a critical area for pharmacogenetics and pharmacogenomics. § Very high priority for manufacturing.	**GRADUATE** **PhD** **POST-DOC**

2.5 Emerging Disciplines and Skills

The following disciplines are increasingly important and many present opportunities for the UK to gain a strategic advantage by proactively addressing future demand.

Mathematical Science	There is a growing demand for mathematical scientists who can analyse increasingly large chemical and biological data sets, with a variety of modelling techniques. A general paucity of mathematics skills negatively affects the emerging as well as the core disciplines. The following areas are of particular importance: **Computational Science:** § General need for computational specialists spanning a wide range of technical areas. Currently, it is often necessary to recruit at PhD level or above in order to find candidates with an understanding of chemical structure, structural biology, and the appropriate IT skills. **Computational Chemistry:** § Rapidly increasing demand for computational / structural / theoretical chemists. § Quality issues: many poor-quality candidates; small pool of good applicants. § Requires comprehensive and thoughtful recruiting strategy. § Relationships with universities and academics important for recruiting. **Modelling of Pharmacokinetics (PK) and Pharmacodynamics (PD)** § Requires skills in chemistry, pharmacokinetics, pharmacology and mathematics. § Very few courses and shortages are a worldwide problem.
"Omics"	§ Particularly proteomics and metabonomics. § Need to recruit at PhD level or above. § Pool of candidates small; quality requirements are high. § Negatively impacted by general problems with mathematics.
Molecular & Translational Toxicology	§ Challenging area; requires multidisciplinary skills. § Candidates require the ability to combine knowledge of a broad range of disciplines, in unusual ways. § Increasingly, toxicologists require an understanding of immunology, alternatives to animal testing, genomics, toxicokinetics and biotechnology. § A solid foundation in PK/ADME sciences is invaluable, but this is rare even amongst the best candidates. § Paucity of PhD graduates in UK. **Predictive Toxicology** § Considered to be an increasingly important discipline.
Translational Medicine & Pharmacology	§ Increasing need for a wide range of skills including in *in vivo* pre-clinical models and clinical trials; the development of assays that are applicable and practical in a wide range of pre-clinical studies; and the planning of clinical trials. § Currently these skills are not available from academia.
Highly Complex Process Control & Instrumentation Engineering	§ The increasing complexity of manufacturing control systems and scientific equipment for R&D is raising the level of skill required in this area. § Already difficult to recruit and the level of skills/sophistication is expected to increase in the future.

2.6 Organisation Type and Recruiting

Each of the three types of respondents – big pharma, smaller innovator companies and contract research organisations – experience different pressures and difficulties associated with finding the right skills. Key issues include the following:

2.6.1 Relationships with Universities

These can be critical in facilitating access to a large pool of candidates, as well as access to high quality candidates. Strong relationships are often a mainstay of big pharma's recruiting strategy, and small companies struggle to match these. Large companies have relationships with a wide range of university departments; many of their collaborations are "additive" to their in house skills. Conversely, smaller companies' collaborations tend to be complementary – providing skills they do not possess in house. For smaller companies, relationships with universities are therefore less likely to provide a source of recruitment.

2.6.2 Attractiveness: Smaller Companies versus Big Pharma

Small organisations may be at a disadvantage when competing for candidates. In some instances, big pharma's superior human resources (HR) strength enables them to recruit candidates before they have even been interviewed by smaller organisations. Even when candidates are interviewed by both types of organisation, some are thought to favour larger companies for security reasons. One smaller company experienced particular difficulty recruiting graduate computational chemists as they are highly sought after by big pharma. An important recruitment aid for smaller companies can be successful projects which serve to raise their profile amongst applicants.

2.6.3 Attractiveness: Contract Research Organisations (CROs) versus Big Pharma

A reputation for less favourable pay and employment benefits places CROs at a disadvantage. Other issues such as location and image may also have a negative influence on recruiting. One CRO believes that these issues are perceived rather than real and is attempting to address them through improved marketing of the company. Another CRO takes a different approach, by recruiting predominantly new graduates. This minimises competition with big pharma companies which tend to focus on finding candidates with experience. However, this strategy necessitates intensive in house training programmes. For more senior positions, CROs may have success recruiting from the middle levels of big pharma – often capable people who feel blocked in their current positions or who see potentially greater opportunities in small organisations.

2.6.4 Relative Company Growth Rate

Small companies may experience recruitment difficulties when they have to rapidly hire a large number of staff, relative to their size. Without HR capacity, this can be onerous and difficult. Head hunters are considered too expensive to use for all but the most senior positions.

3 STAKEHOLDER INPUT

3.1 Reports relating to science skills

A full list of reports consulted in the survey is included in Appendix III. A number of these reports relate closely to the work undertaken in this project; and many of their conclusions mirror our own.

It is interesting that reports covering a slightly different sector, such as the NEPIC report into skills for the North East[1] which included non graduate skills and surveyed a number of SME biotech companies which are outside the scope of our study, came up with recommendations which are, in many cases, very similar to our own.

Key findings on the skills and training needs of the biotechnology/bioscience industry in the North East:

- Growth in employment within the bioscience sector in the North East is anticipated; in particular significant numbers of specialist biotechnicians will be required.
- In house training is often required to fill gaps in skills and knowledge amongst recruits into the sector.
- A shortage of graduates who are flexible can adapt from one science base to another and can fit into a manufacturing environment.
- The overall deterioration in the quality of available graduates, particularly analytical and development chemists.
- Practical 'wet chemistry' skills for graduates and technicians are a particular issue.
- The need to elevate the standing of scientists, engineers and manufacturing industry to attract the best.
- Growing shortage of school leaver and process technicians due to the progressive expansion of Higher Education provision.
- Growing shortage of instrument/engineering technicians, particularly those with a knowledge of laboratory and control equipment.

Several reports from SEMTA, the Sector Skills Council for Science, Engineering and Manufacturing Technologies, are also noteworthy. Reports published in 2004 investigate the occupational and functional maps of the bioscience sector; this work is extended in an, as yet unpublished, Stage 1 agreement for a Bioscience Sector Skill Agreement. A second unpublished report scopes the pharmaceutical industry to investigate its relationship with the biotechnology sector which comes within the footprint of SEMTA and its relationship with other Sector Skills Councils.

Key findings from the study *Scoping the Pharmaceutical Sector*:

- Some companies found it more difficult to recruit than others, but all had difficulty in filling places.

[1] *A Market Research Survey into the Training Needs within the Biotechnology/Bioscience Cluster in the North East*, NEPIC, May 2005

- Difficulty in recruiting specialists at higher grades and in recruiting the right calibre of staff in specialist areas.
- Need for scientists who show an appreciation of the science beyond their specialist discipline.
- Issue in recruitment of graduates for research and development with a high quality degree focused in a single discipline.
- Particular issues for R&D around recruitment of chemists, analysts, biologists especially pharmacologists, toxicologists, pathologists, senior veterinary staff and animal technicians, project managers, clinical research associates, clinical pharmacologists, statisticians and regulatory professionals.
- Particular issues for manufacturing around recruitment of vocational staff, process operators with an understanding of chemistry, process engineers with IT competence, quality assurance managers.
- The re-focus of the pharmacy degree into clinical and community aspects is having a deleterious long-term effect on the supply of pharmacists wanting to work in pharmaceutical manufacturing.
- Recruitment of professional engineers (electrical, mechanical and especially IT/electronic) is particularly difficult, as is recruitment of people with multiple skills such as an instrument technician.
- Recruitment and, in particular, retention of 'Qualified Persons' is an issue.
- Particular issues for commercial areas around recruitment of commercial strategists, patent agents and licensing executives.

Some of these studies also considered future skills needs:

- Perceived future shortage of bioprocess technicians at Level 3, need to develop an Advanced Apprenticeship to meet this need.
- The long term fall in the birth rate will eventually start to impinge on recruitment in general, both vocational and graduate.
- IT and informatics is a hugely important growing area.

A further report from the Biosciences Federation, to be published November 2005, looks at study of biology and bioscience throughout the education pipeline[2]. The Biosciences Federation report makes a number of recommendations about the curriculum from early years through to undergraduate education. Amongst their recommendations are:

- Curricula must ensure that bioscience students of all ages develop appropriate skills and study the key concepts of the subject.
- Practical work is an essential element of learning in the biosciences. Valid concerns about health and safety and respect for living organisms must not result in a poorer learning experience for students.
- A level grades should be standardised so that a candidate's expected grade is independent of the subject being taken.

[2] *Enthusing the Next Generation: A Biosciences Federation Report on the Bioscience Curriculum*, Biosciences Federation

- Students should receive quality careers advice before making their subject choices at age 14, age 16 and subsequently.
- Students studying the biosciences in the 16-18 age range should be aware of the implications of studying a biological subject on its own without another science or mathematics.
- Undergraduate courses need to take account of the rapid advances in the biosciences and the requirement for graduates entering industry to have the knowledge and skills needed in an increasingly competitive international market. Funding for teaching must be sufficient to enable universities to provide appropriate facilities and practical training.
- Teachers and lecturers need high quality continued professional development to help them develop their teaching skills and update their subject knowledge.

Many of the recommendations of these reports are in line with our recommendations in Section 4 and indicate a high level of support is likely from pharmaceutical and bioscience companies in taking these forward.

A recent report[3] from the UK Clinical Research Collaboration (UKCRC) also highlights the need to encourage talented young medical and dental professionals to carry out leading edge clinical research.

The report identifies the following barriers to a clinical academic career:

- Lack of both a clear route of entry and a transparent career structure.
- Lack of flexibility in the balance of clinical and academic training and in geographical mobility.
- Shortage of properly structures and support led posts upon completion of training.

The report sets out a number of recommendations including:

- Promoting the attractiveness of a career in academic medicine to medical students.
- Maintaining a limited number of MB-PhD schemes.
- Two year foundation programmes for those who show an aptitude and commitment to a research or educational career.
- Dedicated academic training programmes in partnership universities and local NHS trusts and Deaneries. These would consist of academic clinical fellowships leading to a training fellowship and a higher degree, and a clinical lectureship phase.

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[3] *Medically and dentally qualified academic staff: Recommendations for training the researchers and educators of the future*. Report of the Academic Careers Sub-Committee of Modernising Medical Careers and the UK Clinical Research Collaboration, March 2005

3.2 Stakeholder meetings

The results of the survey into skills issues have been shared with a number of stakeholder organisations in order to gather their views and to discuss working together to overcome the problems identified. A list of the organisations involved in these discussions is given in Appendix II.

Issues arising from the report were discussed in small groups. The first stakeholder session covered the issues under three general areas:

- School level issues
- Undergraduate issues
- Postgraduate education and training issues

The main outcomes of these discussions are presented here.

3.2.1 School level issues

3.2.1.1 *Opportunities for practical work with tissues, organs and animals*

At school level, a number of barriers were identified which may prevent schools from enabling students to carry out practical work. These include confidence of teachers in the use of animal organs, the acceptability of animal research, supply and cost of organs, technician time to support the work, disposal of animal waste and limited time within the curriculum to provide experiences of this type.

It was agreed that the level of practical work of this type could be increased through:

- Providing advice for teachers on opportunities for introducing animal tissue or organs, including the practical issues to consider.
- Providing training for teachers through courses at Science Learning Centres on practical skills and awareness of regulations.
- Support training in initial teacher training institutions on practical skills and ethical issues.

These approaches may best be achieved within an overall UK strategy for *in vivo* sciences from a primary school to a higher education level through a partnership with government and other organisations.

Measures of Success:

- Increased applications to university courses which include *in vivo* work.
- Increased opportunities for teachers and trainee teachers to acquire the skills needed to include practical work involving whole animals and organs/tissues.
- Increased numbers of teachers taking the courses.

3.2.1.2 *Career advice, information and guidance*

The reasons why some young people do not consider a career in science beyond the areas they are most familiar with, such as medicine, pharmacy, dentistry and forensic science were discussed.

The knowledge base of Connexions Personal Advisers is variable and, because of the focus on young people not currently in education, employment or training (or at risk of becoming so), provision of careers advice to all young people is not a priority.

Young people are known to be influenced in their choice of career by a number of different factors[4] including parents, the high visibility of some careers on television, a perception of science careers as low paid and unexciting[5] and poor perception of the status of a career in scientific research or in manufacturing. In response to the latter issue, the DTI has set up an image subgroup of their Manufacturing Forum to work towards making a positive difference to the perception of manufacturing amongst school children further and higher education students, teachers, careers advisers and other groups.

Suggestions to overcome the lack of awareness and student prejudices include training for careers advisers, careers and science teachers, information on the wide range of career opportunities to increase the knowledge base of teachers, students and careers advisers, integrating information of science careers into school science courses and promoting the financial benefits of a career in science. A number of new career information sources have recently been developed, or are being considered; contact with organisations developing these should be made to see what they offer. The Science Council proposal for a 'one stop' careers website and other materials should be supported.

Applied Science qualifications require students to investigate science-based employers, but there is currently little emphasis on jobs within science in other courses. ABPI has submitted a proposal that a Science Diploma should be developed within the 14-19 Framework (attached, Appendix V); one of the advantages of a diploma would be that work experience within science and a consideration of the careers that study of science can lead to would form part of the diploma.

The proposal for career advice to be devolved to schools in the Youth Matters Green Paper provides an opportunity for provision of career information to young people to be improved; however it is also a threat because it will fragment provision of advice, making it more difficult for organisations providing information on careers to ensure that it reaches young people.

Measures of success:

- Creation of a science career website and a high level of use by students.
- Significant increase in number of visits to ABPI careers website.
- Increased awareness of the variety of science courses by young people (difficult to measure).

[4] *The formation of science choices in secondary schools*, Cleaves, A. International Journal of Science Education 18 Mar 2005 27 (4) 471-486

[5] *A Market Research Survey into the Training Needs within the Biotechnology/Bioscience Cluster in the North East*, NEPIC, May 2005

3.2.2 Undergraduate level issues

At undergraduate level, the main issues raised were:

Demand - How to manage student led demand to ensure that students make sensible decisions regarding the type of degree they do and the choices of modules they make within the course.

Course content/work based learning - A partnership model involving funding bodies, HE and industry was suggested to ensure that all have agreed what is offered. A high level of interaction between these key players is very important.

SME engagement with industry and HE - A high number of science graduates go into this area, hence the need to ensure that SMEs have the opportunity to contribute to this discussion.

Vocational courses - Awareness of the opportunities for those with vocational qualifications (HNC, HND, Foundation degree) should to be raised and engagement with industry should be sought.

Biology – As a subject, biology is not seen as threatened, due to high overall numbers taking biology related courses. However, this masks reducing numbers taking some of the courses that industry values. Some disciplines need as much support as the physical sciences. A proposal for key core content is being made by the Biosciences Federation to address this. Biologists also need an understanding of chemistry and physics to enable them to work effectively in multi-disciplinary teams; however, strong knowledge of their subject area is the most important factor for employers.

Measures of Success:

- Increased application (differential application) to STEM subjects, including foundation degrees.
- Decreasing percentage of employers with recruitment issues.
- Improved relevant guidance to students/HE/FE/employers/government.

3.2.3 Postgraduate issues

There was significant enthusiasm for industry/funders/academia/professional societies working together on skills issues and sustainability of the UK science base. It is possible that the money to support the training we need is in the system (e.g. Doctoral Training Accounts and Collaborative Training Accounts), but funding may need to be redirected.

An over-arching government strategy for sustaining key skills merits further consideration. Linking research and training funding, targeting CASE studentships to strategic areas, and working with universities that we favour to use their doctoral training accounts to support PhD and MSc studentships of relevance to industry was considered to be a useful approach. It was agreed that it is particularly important to feedback success to funders, such as the Research Councils and to ensure that universities are aware of what we feel are the most successful schemes. Additionally, it was suggested that work placements in industry could be offered as part of a PhD.

To improve the attractiveness of careers in the industry, and to support recruitment from universities, it was suggested that industry could provide more information, higher salaries (to compete with the city) and more opportunities for visits and placements in industry. It was noted, however, that this would require some financial incentives from Government to encourage greater industry involvement.

It was felt useful to collect and provide data from companies to provide to funders and universities on where we recruit from. It was noted that HESA data is not very useful in this respect.

There was recognition that SMEs may have a different perspective and are less able to engage because of smaller numbers of staff coupled with business pressures.

Measures of success:

- Increased number of partnerships between academia and industry.
- Increased number of suitable interviewees.
- Reduced time to fill vacancies.

The second meeting with stakeholders was wide-ranging and resulted a long list of potential issues to tackle. However, in further discussions, the following three potential practical actions were identified as proposals to be taken forward:

- A survey of industry activities at both primary and secondary education levels; to identify their geographical coverage, goals and approach and to share perspectives on the appropriate metrics for such programmes. The goal would be to supplement the DfES STEM mapping currently under way for (mainly) public sector activities for science education, and to propose ways of rationalising activities and working together to maximise the effectiveness of industry interaction with schools.
- The development of a sharper set of output requirements from the educational pipeline for us to share with Government. As we agreed in discussion, Government tends to look at total numbers rather than the quality of graduates and the content of their courses. In particular, we agreed that articulating clear measures of practical content (both laboratory and in vivo) would highlight important gaps in the current output. The goal would be to sit down with senior Government policy makers to discuss this gap analysis.
- The HEFCE factors applied to the funding method for teaching and full economic costing were agreed to be significant issues in the types of courses that are available and in research collaboration. It was proposed that, by working together to collect as much data as possible on the impact of the current arrangements, a strong case could be made to Ministers and others on the need for an urgent review.

3.2.4 Moving towards concordance with the “Bologna Agreement” across Europe

In 1999, in the Bologna agreement, the UK signed up to the creation of a common model for Higher Education in Europe. This will include a three or four year first Bachelor degree, a second, 2 year, stage leading to a Masters degree, and a third stage leading to a Doctoral degree. It is unclear how the UK Government intends to fit the current system of 3 year BSc, or 4 year MSci/ MChem degrees, with the opportunity to progress onto a one year Masters, or 3 or 4 year PhD, to this model.

4 CONCLUSIONS, RECOMMENDATIONS AND IMPLEMENTATION

The analysis that provides the core of this report and the discussions with stakeholders indicates that further action is needed by all stakeholders to enhance the pipeline of skills that are a cornerstone of UK R&D competitiveness. Clearly the Government has a strong commitment to improving education and on creating a knowledge driven economy. In order to achieve these aspirations, the UK requires skills at many different levels – from vocational, technical support to academic research skills.

If the UK is to sustain its skills pipeline and respond to the increasing competitive pressures from emerging countries, action needs to be taken along the entire length of the skills pipeline. No single stakeholder, whether Government department, education funder or institute or company, can achieve significant change individually and it is essential that stakeholders work together.

During the preparation of this report we actively engaged stakeholders; both to seek their views and understand what similar initiatives and activities were taking place (see Section 3). The various stakeholders engaged are listed in Appendix II. The critical issue is not to try to remove or restrict existing activity, but rather to identify good practice, where gaps exist and identify an action plan and targets for success.

We hope that the recommendations, targets and actions identified below, will be viewed as a constructive contribution to taking the process forward. Challenges have been identified for all the stakeholders who have influence, either direct or indirect, on the education skills pipeline.

TABLE 1: KEY PARTNERS AND LEVERS

Who are the key partners?	**What are the levers?**
Ø Government Ø Professional bodies Ø Education institutions Ø Funding bodies Ø Pharmaceutical industry Ø Charities Ø Patient groups	Ø Policy (and targets) Ø Funding mechanisms Ø Curriculum Ø Teachers Ø Specific initiatives Ø Careers advice Ø Aspirations for STEM

4.1 Cross-cutting issues to address

4.1.1 An *in vivo* science strategy for UK

The UK has a long history of successful pharmaceutical R&D built on a strong science base. Critically the UK had strength especially in the *in vivo* sciences, along with pharmacology and translational medicine – all areas that were identified as "red light" recruitment disciplines in Section 2.

Historically, the UK has had a strong foundation of *in vivo* and pharmacology skills with good practical experience – this is no longer the case. The supply, both in terms of number and quality, of graduates with *in vivo* skills is of great concern.

The cause of the decline in *in vivo* skills is complex, but critically, the time spent on practical science activities, and the range of activities used, is decreasing in schools and in undergraduate courses. Students are rarely exposed to animal tissues and organs, partly due to safety concerns, although dissection of animals or animal parts obtained from a butcher is not subject to any national restriction[6], there are pressures on schools not to perform dissections from various animal rights organisations, some students and sometimes the staff within a school. No syllabus specification at GCE A level now requires dissection of a whole rat, hence most schools are no longer willing to invest the time or money to allow students to have the opportunity to do this, and, as many younger teachers may never have experienced dissection themselves, they might not have the skills required.

The feedback received on *in vivo* sciences indicated that issues exist at multiple levels – from animal technicians to research scientists and support staff in toxicology, pharmacology and physiology, the pipeline is constricting. An ageing cohort of staff, coupled with a decline in practical skills and bad press from animal rights extremists have resulted in a reduction in *in vivo* science careers.

ABPI members led by Pfizer, AstraZeneca and GSK have started to respond through an *in vivo* pharmacology initiative being managed by the British Pharmacology Society. In addition HEFCE, BBSRC and MRC have committed funds to invest in UK centres of excellence and the Institute of Animal Technology has initiatives to enhance recruitment and bolster continuous professional development. These are encouraging developments which need building on with significant further increases in funding from Government

Problems also exist earlier in the pipeline – critically practical experience in schools is in decline. There are multiple reasons for this, for example:

- New graduate teachers themselves have less experience of practical classes and are therefore less confident and less likely to provide the right practical experience.
- Health and safety regulations have meant it is more difficult or impossible to get tissue by-products from the meat industry: for example lamb lungs have been used to explore function, but this is no longer possible as they have to be cut open for health and safety reasons.
- The anti-vivisection lobby has had a significant impact on the attitudes of students. A strong welfare policy well implemented, coupled with effective communication on the

[6] *Are we allowed to ….?*, CLEAPSS School Science Service, PS64 JAT 12/04

benefits and regulation of research would assist in changing this perception in some pupils at least.

RECOMMENDATION 1: Government should facilitate the establishment of a UK *In Vivo* Sciences Task Force that would:

i. **Consist of key stakeholders across employers and the education sector, along with appropriate welfare organisations such as the National Centre for the 3Rs;**

ii. **consolidate information from all stakeholders on the current provision of skills; and**

iii. **identify existing initiatives; gaps; and develop an action plan with earmarked funding for the next five to ten years.**

TARGET 1: Key stakeholders, facilitated by Government, to establish an *In Vivo* Sciences Task Force to report by the end of July 2006.

4.1.2 Practical skills

Practical skills and capability are an essential skill for scientists and it is not only *in vivo* skills that are of concern. Feedback from members in the ABPI survey clearly indicated deterioration in these capabilities in new employees in the UK compared to other countries. The fact that companies are increasingly recruiting chemists from other European countries, especially France, typifies this trend.

Other factors in the decline of practical work in schools are due to the high level of content in current exam specifications and the fact that, many teachers cover all three science subjects up to GCSE level, and far fewer chemistry and physics teachers have been trained since the late 1980s, compared to biological scientists[7]. Hence many teachers may not feel sufficiently confident to allow students to carry out experiments outside their speciality which involve any degree of risk, particularly if there are class management issues.

The cost of supporting practical work is also an issue in Higher Education, leading to reduced laboratory time for students, with many no longer carrying out a substantial practical project as part of their degree. Despite this, research by the Royal Society of Chemistry found that chemistry is an expensive subject to teach because of the amount of laboratory work that undergraduates undertake; requiring maintenance of properly ventilated laboratories and supervision by academic staff.[8]

RECOMMENDATION 2: The Science Learning Centre network, industry and teacher training institutes, should work together to develop and support courses to update the practical skills of teachers, and those training to be teachers, and help them update their knowledge of cutting-edge scientific research. ABPI and other stakeholders should review how they can support recruitment of specialist science teachers for 14-16 education in critical subjects.

[7] *Chemistry Teachers, a report for the Royal Society of Chemistry*, Alan Smithers and Pamela Robinson, Centre for Education and Employment Research, University of Liverpool. March 2004

[8] *Study of the Costs of Chemistry departments in UK Universities*, Royal Society of Chemistry, personal communication.

TARGET 2: Develop action plan on practical skills with teacher training institutes and Science Learning Centre network for implementation during the 2006-7 academic year.

4.1.3 Curriculum

The main issues identified from the survey relating to Higher Education were numbers and quality of undergraduate and graduate students in specific disciplines, availability of Masters' courses in specific areas, and students choosing not to select the options within their degree course that are of most relevance to their subject and to industry.

Many of the general skills identified in the analysis as being an issue for graduates and postgraduates are believed to have their origins in school education. For example, the high level numeracy and literacy skills that are demanded of employees; rely on building a sound foundation in these subjects from primary school through to GCSE.

Primary schools generally expect the class teacher to teach most, or all, subjects. A recent survey has shown that many teachers feel inadequately trained to cover the science curriculum with confidence. Although children generally enjoy science at this stage, the curriculum content, focus on assessment, together with, in some cases, lack of confidence of the teacher, may lead to restrictions on open-ended practical work and opportunities to make the science topics relevant to children's lives[9].

The exam specifications for GCSE are determined by the programme of study for Key Stage 4, although individual exam boards are able to add additional topics, they must cover the programme of study within their GCSE specifications. From September 2006 the programme of study for science Key Stage 4 is being reduced to enable exam boards and teachers to introduce more flexibility into the curriculum, it will be tested in a single science GCSE, but the expectation is that about 80% of students will continue to take two science GCSEs.

The changes to GCSE science courses provide an opportunity for teachers to introduce more discussions, practical work and coverage of topical issues into their lessons than has been possible before due to the heavy content of GCSE science courses. Many teachers will need professional development to increase their confidence to use a different approach and may need additional technical support to increase the practical content of their lessons.

The programme of study for Key Stage 3 and criteria for GCE (A level) courses are also being reviewed at present.

A single maths GCSE is compulsory, as is English Language. The Key Stage 4 programme of study for these, and all other subjects, is currently being reviewed. Changes to the requirements for GCSE, and anticipated changes to GCE A level, provide an opportunity for industry and higher education to influence what is covered within the specification and, for maths GCE, to comment on whether having optional modules causes difficulties when students move on to higher education courses.

In its February 2005 Education and Skills White Paper the government announced plans for Specialised Diplomas in 14 occupational lines. However no diploma is planned for the science sector. ABPI has submitted a proposal for a science diploma to offer students high quality vocational and general pathways into further and higher education science courses and employment in science.

[9] *Primary Horizons; Starting out in science*, Wellcome Trust, September 2005

At undergraduate level, the curriculum to be covered, both compulsory and optional modules, should be agreed with all partners; funding bodies, industry (including SMEs) and Higher Education Institutions. Input from industry could encourage students to select appropriate modules.

In some disciplines, although companies have few issues with recruiting people with the skills they need now, they foresee significant problems for the future. Additionally, an expansion of some disciplines is anticipated, which is likely to lead to a shortage of people with the right knowledge and skills.

RECOMMENDATION 3: A 14-19 Diploma in Science should be developed, with appropriate support from industry, to support science skills and careers. The relevant Sector Skills Council (SEMTA) should lead the development of the Science Diploma, working with other Skills Councils, industry and other stakeholders as appropriate.

TARGET 3: SEMTA to develop a proposal for a Science Diploma, working with relevant stakeholders to establish a diploma development partnership by January 2006 for introduction of the diploma in September 2009.

RECOMMENDATION 4: The ABPI will develop clear profiles, including expectations on practical skills, for priority areas to share with stakeholders and initiate dialogue to fill the skills gaps. Stakeholders encompass the Research Councils, Higher Education Funding Councils, Professional Bodies, Government and academia in Higher Education.

TARGET 4: ABPI to develop profiles, including practical capabilities, on priority skills areas – and complete all "red light" priority profiles by end 2006.

RECOMMENDATION 5: ABPI will support Royal Society of Chemistry initiatives to encourage continued dialogue between industry employers and university chemistry departments to promote understanding of the needs of industry and to encourage implementation of measures within undergraduate and postgraduate courses to meet these needs.

TARGET 5: Support RSC in preparing a report of workshops held with industry and academic representatives in 2004 and arranging follow on meetings to be held 1st quarter 2006.

RECOMMENDATION 6: ABPI will build on the liaison with Research Councils and universities to target CASE awards to strategic areas and doctoral training accounts to support PhD and MSc studentships of relevance to industry. ABPI will review provision of work placements as part of PhDs.

TARGET 6: By end of 2nd quarter 2006, ABPI to complete paper after consultation with member companies and key stakeholders on proposals to target studentships more strategically in line with priority skills areas and to review and expand opportunities for work placements for undergraduate and postgraduate students.

4.1.4 Stimulating interest in and demand for science

The UK Government cannot be criticised for its support for science and technology, especially in relation to the pharmaceutical and biomedical sciences sector. Nevertheless, since first coming to power, the number of graduates in chemistry and physics has declined (Table 2), although there are indications of an improvement with the number of applications for chemistry increasing in 2005/6. Yet is this enough? The trend in graduate numbers is important as it indicates an exit route from the skills pipeline for many students and one of the recruiting streams for companies.

TABLE 2: NUMBER OF FIRST DEGREE QUALIFICATIONS OBTAINED BY UNIVERSITY STUDENTS IN THE SCIENCES AND MATHEMATICS (source: Higher Education Statistics Agency)

Year	Physics	Mathematics	Chemistry	Biology
1994-95	2551	3435	4110	3712
1995-96	2070	3383	4144	4066
1996-97	2530	3114	3753	4398
1997-98	2428	3372	3393	4104
1998-99	2439	3638	3624	4035
1990-00	2400	3550	3420	4230
2000-01	2600	3720	3285	4405
2001-02	2230	3725	3215	3915
2002-03	2480	4390	2955	4430

There are complex reasons for the decline in physics and chemistry, possible factors include:

- reduction in funding of laboratory-based courses compared to non-laboratory courses;
- perception of high student debt coupled with poor salary and career expectations; and
- students being ‘turned-off’ off to science for a variety of reasons, including restricted practical experience, comparative difficulty of subjects and restrained curriculum.

Without a doubt the Government has moved to address some of these issues. However, we remain concerned that these measures are not enough and the timelines unclear.

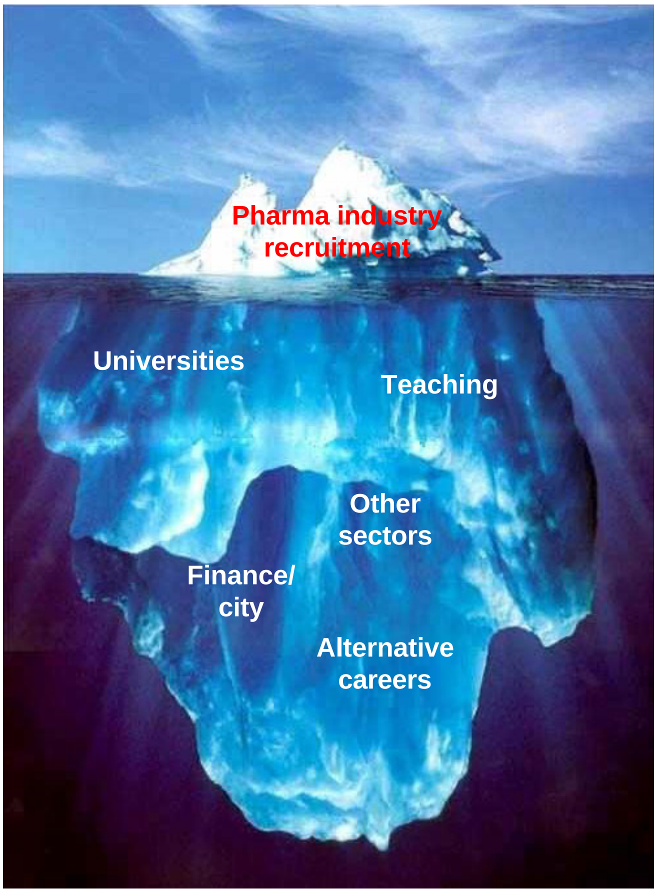
For chemists, despite a 9% expansion of Higher Education intake, we have seen a reduction in chemistry graduates from 4,110 in 1994/5 to 2,955 in 2002/3 (Table 2). The total number of chemistry full time undergraduates has decreased from 13,714 in 1997/8 to 11,625 in 2002/3, a decrease of 15%; if the number had increased in line with the overall increase in numbers of students in Higher Education this would have increased to nearly 15,000[10].

[10] *The economic benefits of Higher Education Qualifications*, a report produced for the Royal Society of Chemistry and Institute of Physics by Pricewaterhouse Coopers LLP, January 2005

Taking 1997/8 as a base year for expansion, this means that in 2002/3, we should have observed 2,647 and 3,698 physics and chemistry graduates respectively, if they had remained in step with expansion of total graduate numbers.

It is essential that Government re-visit and set targets for science graduates for 2010 and 2015. These should not be developed on a simple numerical basis – if the UK wants to compete globally there needs to be a large enough pool of all core science disciplines upon which employers, whether from the public or private sector, can draw.

FIGURE 1: Recruitment of scientists can be compared to an iceberg – although Pharmaceutical companies do not employ every graduate, there needs to be a large enough pool from which they can recruit.



This pool of scientific talent can be considered akin to an iceberg. While companies employ those individuals ‘above the water’, it is critical that the pool of talent that is recruited by other employers – whether scientifically oriented or not – is large enough.

RECOMMENDATION 7: The Government should set targets for HE funding councils to expand physics and chemistry courses in line with UK strategy on science and innovation

TARGET 7: To expand numbers of chemistry and physics undergraduates, in line with total expansion of HE using a baseline of 1997/8.

Awareness of the wide variety of opportunities within science is an issue at secondary school and within undergraduate training. In particular, vocational options are often less well known. These are issues which should be tackled through improved awareness and availability of career information, advice and guidance.

At all stages of education science role models are important. In many instances, when young children have been asked to draw a scientist, they almost invariably draw a man in a white coat. However it has been shown that opportunities to meet real scientists can have a significant impact on this perception[11].

A number of initiatives, by individual companies, industry sectors, and industry supported bodies such as the Chemical Industry Education Centre, enable school pupils to meet scientists and, often, to visit an industrial site. A more widespread programme is the Science

[11] *Children Challenging Industry Project*, Chemical Industry Education Centre

and Engineering Ambassadors (SEAs) which encourages scientists to develop a link with a particular school, providing a role model for students, and supporting teaching and learning.

Currently there are few links between the study of a scientific topic and information on what degree(s) would lead to further study of that topic, and what jobs this could lead to. This type of information is embedded into vocational GCSE and A level courses, but not into their academic equivalents.

The current arrangements for providing careers education, advice and guidance to young people through Connexions Personal Advisers are inadequate. Their targets encourage a focus on young people not in education, employment or training and those with personal issues that are likely to affect their attendance at school or college.

Opportunities for young people to undertake work experience and work placements, or even to visit a research or manufacturing site, are very limited. Work-related learning is now a compulsory part of the secondary school curriculum. However, if we are to excite young people about the opportunities science offers, we will need to encourage them with inspiring experiences showing that a career in science can be both intellectually stimulating and financially rewarding.

Examples of current activities include: school visits to sites (including ‘young scientist’ days); scientist visits to schools to talk about careers and science in industry (for example through the Science & Engineering Ambassadors Scheme); and work placement opportunities (for example, Nuffield Bursary placements)

RECOMMENDATION 8: Industry should work more effectively with key stakeholders to co-ordinate liaison with schools through carrying out survey of industry activities at both primary and secondary education levels to:

- **Identify their geographical coverage, approach and goals, to complement the DfES STEM Mapping Review; and**
- **Develop appropriate metrics to evaluate the impact of engagement.**

TARGET 8: Complete a survey of primary initiatives by mid-2006 and secondary initiatives by end 2006, then identify areas for cooperation and collaboration.

RECOMMENDATION 9: ABPI, with member companies, will review current activities with schools to identify new opportunities and share best practice to stimulate awareness of the pharmaceutical industry and facilitate good course selection to achieve career goals.

TARGET 9: Over the next two years, to benchmark and improve effectiveness of industry engagement with schools.

RECOMMENDATION 10: The QCA should include relevant information on scientific careers within course content to ensure appropriate selection of scientific subjects at Key Stage 3 and in 14-19 education.

TARGET 10: QCA, following work with relevant industry sectors, to specify information on careers in scientific subjects at Key Stage 3, GCSE and in all post-16 courses.

RECOMMENDATION 11: The STEM community, including ABPI, should work together to coordinate and enhance delivery of careers information in schools. Advice should portray opportunities, not just in terms of high-level research skills, but also vocational and technical support opportunities across R&D, manufacturing and engineering. In particular:

- **ABPI to re-launch our careers website in a format that will attract greater interest and use amongst students.**
- **The Science Council and the Engineering Training Board, should work together with stakeholders to develop a one-stop portal for STEM skills covering: information for students at various stages of the skills pipeline and support for careers advisors and science teachers**
- **Enhance portrayal of science careers in the media, both in terms of the range of skills and positive portrayal of STEM careers.**

TARGET 11: To make a measurable difference in information flow to pupils and enhance teachers' knowledge on careers to increase demand for foundation and honours STEM degrees, including:

- **ABPI to re-launch new-look careers website by September 2006 and monitor impact on an annual basis.**
- **The Science Council and ETB to work together with stakeholders to create a single portal on careers.**

Develop a media communications strategy to broaden the positive portrayals of the range of STEM careers (using an approach akin to the Coalition for Medical Progress).

4.2 Areas for Further Development

4.2.1 Vocational/technical skill provision in Higher Education

The UK is one of few countries in Europe not to have clear technical or vocational higher education pathways. However, there are real opportunities for the UK to consider re-establishing this in line with Government actions to:

- develop a 10-year strategy to support science and innovation;
- support progression from vocational courses at 14-19 years into higher education; and
- promote the role of RDAs and Learning and Skills Councils.

The Government, especially the Department for Education and Skills, HM Treasury and Department for Trade & Industry, should review the funding mechanism in Higher Education. While academic skills could continue to be funded through national funding councils to ensure global competitiveness of research skills, vocational and technical funding streams should be more clearly fed through RDAs and LSCs. This would ensure these capabilities are focused on regional needs and provide clear mechanisms to deliver the “hub and spoke” model being discussed in Government.

Such a mechanism would have clear advantages:

- clarity and differentiation of universities – not all 120+ institutions can be globally competitive in terms of research;
- align local technical and vocational provision with local industry and employer needs; and
- provide a logical flow from vocational courses in specialist schools and colleges into Higher Education to enhance participation, especially to drive social inclusion.

Some progress is already being made in terms of universities addressing local needs.

Research by the North East Pharmaceutical Industry Cluster has identified a number of Higher Education Institutions which are actively developing new vocational courses of relevance to the industry, or which are considering doing so. The willingness of universities to proactively tailor their output to the growing needs of the bioscience sector should be encouraged and contact made with universities outside this area to identify their plans to develop similar courses.

All nine of the Regional Development Agencies have identified bioscience/pharmaceuticals clusters within their regions, and, in addition, the three Northern English RDAs have identified chemicals clusters[12].

The same report reveals that their research indicates that there are likely to be approximately 1000 new jobs created within the sector in the region over the next three years. Of these, 450 are predicted to be at technician level and of these, 300 will occupy specialist biotechnician roles. If this pattern is mirrored throughout the regions, the need for non-graduate and foundation degree technical training courses is substantial. Government pressure for 50% of

[12] *A Market Research Survey into the Training Needs within the Biotechnology/Bioscience Cluster in the North East*, NEPIC, May 2005

18 to 35 year olds to enter higher education has decreased the pool of potential entrants to technician level jobs and is leading to a growing shortage of technicians with practical laboratory skills.

SEMTA's draft report 'Scoping the Pharmaceutical Sector' finds that some companies have difficulty in recruiting into roles such as laboratory technicians, and that animal technicians are also difficult to recruit and retain. Retention of technical staff, along with others that have skills which are easily transferable to other industries, such as administrative, IT, personnel and marketing staff, is a issue for some pharmaceutical companies. Contract research organizations were found to have difficulty retaining staff following training for particular jobs, such as clinical research associates.

The BIA is taking forward the recommendation from the BIGT report[13] for skills training in biotechnology and development of leadership skills for bioprocessing.

Although this survey did not specifically ask about the recruitment with technical skills, we recognise that this is an area that needs to be followed up.

RECOMMENDATION 12: DfES and Government to consider establishing Technical and Vocational University Funding streams through the RDAs/LSCs, with appropriate engagement with the Funding Councils.

4.2.2 Full economic costing of teaching science subjects

Research by the Royal Society of Chemistry into the full economic costs of teaching chemistry and carrying out research at eight university chemistry departments indicates that all departments in the sample were operating with budget deficits in 2002-03, based on current funding allocation models. These deficits are usually covered by subsidies from across the university[14]. Where the data was analysed for the five activities each carried out: publicly and non-publicly funded teaching, publicly and non-publicly funded research and other activities, analysis shows that most of the departments had deficits in 2002-03 in all five areas.

RECOMMENDATION 13: DfES to move teaching towards a full economic costing model to ensure appropriate funding of all subjects and reflect regional variation in the cost of HE provision.

[13] *Bioscience 2015, a report to Government by the Bioscience Industry and Growth Team*, November 2003
[14] *Study of the Costs of Chemistry departments in UK Universities*, Royal Society of Chemistry, personal communication.

5 APPENDICES

5.1 Appendix I: Members of the Taskforce

Dr Aileen Allsop	AstraZeneca (Chair)
Mr Mike Best	Wyeth
Dr Paul Brooker	Huntingdon Life Sciences
Dr Mike Collis	Pfizer
Professor Bill Dawson	Bionet
Dr Pablo Fernandez	Pharmanet
Professor Graham McClelland	Roche
Mrs Kay Roberts	GlaxoSmithKline
Dr Keith Suckling	GlaxoSmithKline
Mrs Jackie Wilbraham	AstraZeneca
Mrs Sarah Jones	Head of Education ABPI
Dr Philip Wright	Director of Science & Technology ABPI

5.2 Appendix II: Stakeholders Consulted

Academy of Medical Sciences
Advisory Committee on Mathematics Education (ACME)
Association for Science Education (ASE)
Biochemical Society
BioIndustry Association (BIA)
Biotechnology and Biological Sciences Research Council (BBSRC)
Biosciences Federation
British Association for the Advancement of Science (the BA)
British Pharmacological Society (BPS)
British Toxicology Society (BTS)
Chemical Industries Association (CIA)
Chemical Industry Education Centre (CIEC)
Confederation of British Industry (CBI)
Council for Industry and Higher Education (CIHE)
Department for Education and Skills (DfES)
Department of Health (DoH)
Department of Trade and Industry (DTI)
East of England Development Agency (EEDA)
Engineering and Physical Sciences Research Council (EPSRC)
Engineering Technology Board (etb)
Eastern Region Biotechnology Initiative (ERBI)
Faculty of Pharmaceutical Medicine
Higher Education Funding Council for England (HEFCE)
Imperial College, London
Institute of Animal Technology (IAT)
Institute of Clinical Research (ICR)
Institute of Biology (IOB)
Institute of Physics (IoP)
Learning and Skills Council (LSC)
Medical Research Council (MRC)
National Science Learning Centre
Office of Science and Technology (OST)
Physiological Society
Qualifications and Curriculum Authority (QCA)
Research Councils UK (RCUK)
Royal Society
Royal Society of Chemistry (RSC)
Science Council
Sector Skills Council for Science, Engineering, Manufacturing Technologies (SEMTA)
Statisticians in the Pharmaceutical Industry (PSI)
Teacher Development Agency (was Teacher Training Agency) (TDA)
Treasury
UK Grad Programme
Universities UK

5.3 Appendix III: Bibliography

5.3.1 Reports, ongoing surveys and consultations

5.3.1.1 *General*

- *Mapping of STEM initiatives:* DfES, 2004

5.3.1.2 *Education – Primary and secondary*

- *Enthusing the Next Generation,* Bioscience Federation, November 2005
- *Improving Achievement in Science in Primary and Secondary schools,* HMIe, Scotland
- *Science Education for the Future: Liberate teachers, engage pupils,* Project funded by Scottish Executive May 2005
- *Science in Primary Schools: Ofsted subject reports (Annual Report 2003/04)* HMI 2345, February 2005
- *Assessment of Science Learning 14-19,* Kings College for the Royal Society, March 2004
- *Primary Horizons – starting out in science,* Wellcome Trust, September 2005
- *Research into the deployment of mathematics and science teachers,* National Foundation for Educational research, report January 2006

5.3.1.3 *Higher Education*

- *Report of a survey of the teaching of integrative physiology/pharmacology in UK universities.* Survey undertaken by the British Pharmacology Society, Spring 2004
- *Physics – building a flourishing future. Report of the Inquiry into Undergraduate Physics,* Institute of Physics, October 2001
- *Strategic Science Provision in English Universities,* House of Commons Science and Technology Select Committee Inquiry, Report April 2005
- *Strategic Science Provision in English Universities,* Government Response to the Committee's Eighth Report of Session 2004-05, 25 July 2005
- *The freedom to succeed: a review of research fellowships in the biomolecular sciences,* Academy of Medical Sciences, July 2005
- *Academic Medical Bacteriology in the 21st century,* Academy of Medical Sciences, July 2001
- *Royal Society project on supply of and demand for scientifically and technically trained people to underpin the UK economy,* The Royal Society, on-going
- *Reproductive toxicology training,* Article from European Teratology Society to be published September 2005 in *Reproductive Toxicology*
- *HEFCE consultation on the funding method for teaching*, November 2003
- *Proposal for postgraduate training of drug safety scientists in the UK,* BTS, AstraZeneca and potentially other organizations
- *Review of the competitiveness of UK Higher Education,* Centre for Industry and Higher Education (CIHE), project completion expected April 2006
- *Industry needs and university supply of chemists,* Project initiated by SEMTA in 2004, to be taken forward by RSC. Currently no timescale set.

- *Strategically important and vulnerable subjects,* HEFCE Chief Executive's Strategically Important Subjects Advisory Group report, June 2005

5.3.1.4 *Education – policy*

- *14–19 White Paper*, DfES, February 2005
- *Science and Innovation Investment Framework 2004 -2014, Annual report and progress against indicators July 2005*, HM Treasury, DTI, DfES, July 2004
- *Development of Government science funding policies between 1998 and 2004*, Bioscience Federation (BSF), 2004
- *The impact of Government science funding policies on the health of biosciences: results of a questionnaire survey on the views of university Heads of Department,* BSF 2004
- *Youth Matters Green Paper*, DfES, July 2005 (open for consultation until 4 November 2005)

5.3.1.5 *Skills*

- *Sectors Matter: the skills case,* Institute for Employment Studies (IES) for SSDA, report expected October 2005
- *National Employers Skills Survey 2004*, Learning and Skills Council, July 2005
- *Leitch Review of Skills*, HM Treasury, report due Spring 2006
- *A Framework for Achievement, report to DfES on the outcomes of stakeholder consultation*, QCA, May 2005

5.3.1.6 *Teaching*

- *Chemistry Teachers*, Centre for Education and Employment Research, report for the Royal Society of Chemistry, March 2004
- *Results of the newly qualified teacher survey 2005*, Teacher Training Agency, 2005
- *Review of Financial Incentives to enter teacher training and teaching*, Teacher Training Agency, 2005

5.3.1.7 *Career information and Employment*

- *Destinations of Leavers from Higher Education in the UK for academic year 2003/04,* Higher Educations Statistics Agency, SFR 89, 5 July 2005
- *Fishing for Talent in a Wider Pool*, IES report 421, 2005
- *National Management Salary Survey 2005*, Chartered Management Institute
- *The economic benefits of Higher Education qualifications,* PriceWaterhouseCoopers for RSC and IOP, January 2005
- *The right chemistry? The choice of chemistry courses and careers*, Institute for Employment Studies for RSC, April 2004
- *Survey of Pharmacology Graduate Employment,* PS, July 2005
- *Update on recruitment of new graduates into the pharmaceutical industry (statistics),* PSI, 2003

- *Key considerations for developing and supporting career management skills in young people in England (Signposter)*, FeDS, February 2005
- *Report of the end to end review of careers education and guidance*, DfES, July 2005

5.3.1.8 *Science based Industry*

- *Scoping Study of the Pharmaceutical industry*, SEMTA, report imminent
- *Developing Technicians in the workplace*, ETB, February 2004
- *Skills for a Competitive Future: a survey for the Pharmaceutical Industry NTO*, IES report 366, 2000
- *Bioscience 2015: Improving national health, increasing national wealth*, BIA, DTI, DoH, November 2003
- *Project to study demand for chemists within industry over the next 10 years and make recommendations on how UK university chemistry can help to meet this demand*, The Royal Society of Chemistry, on-going, report expected end 2005
- *Report on safety assessment of medicine*, Academy of Medical Sciences, due Autumn 2005
- Institute of Animal Technology, Animal Technician Education and Training Stakeholders meeting, 27 May 2005.

5.4 Appendix IV: Map of Skills Needs within Education

5.4.1 Concerns raised by survey

Schools	Undergraduate	Post Graduate
Animal technician **Laboratory analyst** **Laboratory technician**	**Biological and Medical sciences** Clinical pharmacology/ experimental medicine Pharmacokinetics/ ADME Biochemistry In vitro pharmacology Pharmaceutical formulation Pharmacy Bioscience/ molecular biology Medicine **Biotechnology** Biotechnology & biopharmaceuticals **Chemical sciences** Analytical & Physical Chemistry Synthetic organic chemistry/ medicinal chemistry **Engineering** Chemical and process engineering Mechanical and electrical engineering ***In vivo* subjects** In vivo physiology In vivo pharmacology Toxicology Veterinary medicine/ veterinary science **Mathematics** Statistics	**Biological and Medical sciences** Clinical pharmacology/ experimental medicine Pharmacokinetics/ ADME Pharmacy Biochemistry In vitro pharmacology Biomedical imaging/ physical sciences Pharmaceutical formulation Bioscience/ molecular biology Medicine **Biotechnology** Biotechnology & biopharmaceuticals **Chemical sciences** Analytical & Physical Chemistry Synthetic organic chemistry/ medicinal chemistry **Engineering** Chemical and process engineering ***In vivo* subjects** In vivo physiology In vivo pharmacology Pathology Toxicology Veterinary medicine/ veterinary science **Mathematics** Statistics

5.4.2 Core skills and issues to be addressed

SCHOOL/COLLEGE				UNIVERSITY		
Key Stage 1	**Key Stage 2**	**Key Stage 3**	**Key Stage 4**	**Post - 16**	**Undergraduate**	**Post graduate**
			Maths,encourage higher level achievement	Maths (to support science courses)	Maths (components of science courses)	
Practical science	Practical science	Practical science	Practical science	Practical science Written and oral communication – include extended writing exercises in all post-16 science qualifications	Practical science – especially animal and laboratory skills High level literacy and communication skills	High level literacy and communication skills
Use of ICT should be encouraged	ICT skills taught across the curriculum	ICT skills as a subject and within curriculum	ICT skills - encourage all to obtain a level 2 qualification	IT within Key Skills - aim minimum level 2	Computational skills	Computational skills
Encourage hands on study of living animals	Encourage study of animals within ‘Living things in their environment’	Encourage study of living organisms within ‘Living things in their environment’	Encourage dissection of organs and fieldwork	Use of organs/tissue	Practical *in vivo* skills	*In vivo* skills development
Fragmented support from industry	Fragmented support from industry	Fragmented support from industry	Multiple industry initiatives supporting science and career information	Multiple industry initiatives supporting science and career information	Promote important modules Link assessment to valued skills	
Introduce ‘world of work’	Links with ‘world of work’	Careers education	Work related learning, work experience and careers education. Encourage career advice and guidance	Work placements Career advice and guidance	Career advice and guidance	Career advice and guidance

5.4.3 Issues for subject areas (disciplines) to be addressed

SCHOOL/COLLEGE					UNIVERSITY		INDUSTRY
Key Stage 1	**Key Stage 2**	**Key Stage 3**	**Key Stage 4**	**Post - 16**	**Under graduate**	**Post graduate**	**In company training**
Science Change assessment to test understanding and skills Improve funding of science Make science more relevant to everyday life Provide creative contexts for teaching of science Career long CPD for teachers Improve science within ITT SEAS support	**Science** Change assessment to test understanding and skills Improve funding of science Make science more relevant to everyday life Provide creative contexts for teaching of science Career long CPD for teachers Improve science within ITT Encourage interest in science and enquiry SEAS support	**Science** Change assessment to test understanding and skills Engage industry in QCA review of Key Stage 3; encourage discussion, consideration of ethical issues and topics of current interest. Support BA 'Science week' and other engagement with schools	**Science** Support topics on medicines in new courses (first examination 2007) Encourage assessment to promote understanding above recall Support variety in coursework Develop 14-19 Diploma in Science	**General** Promote comparability in degree of difficulty of subjects Promote understanding and skills above factual recall Engage with QCA review of science GCE specifications Develop 14-19 Diploma in Science **Biology** Biology A level - include more physiology, kinetics and pharmacology **Chemistry** Chemistry A level – include modules on medicines (cf Salters) **Apprenticeships** Attractiveness of apprenticeships over HE Appropriate part time courses to support science apprenticeships and other technician training (BTEC National, HNC, FDs)	**General** Engage with BLC, CLC and Sector Skills Councils to take forward the recommendations of Bioscience 2015 report Provide support for students on difficult modules Increase summer placement opportunities (science and engineering) Increase industrial placement opportunities (science, engineering and pharmacy) Funding of science courses **Biological subjects** Training for modelling and simulation PK/PD skills Better grounding for biologists in analytical techniques required Include fermentation/cell physiology/engineering in biotechnology courses	**General** Target strategic areas with CASE awards and DTAs Review work placement opportunities **Biological subjects** Increase support for In vivo pharmacology initiative More MSc courses developed with industry like Kings Drug Discovery Skills Quality MSc courses for PK/ADME and PK/PD modelling Additional centres for PhD ADME/PDM training Take forward proposal for postgraduate training of drug safety scientists in the UK **Medical training** Clinical pharmacologists need knowledge of drug development process Expand opportunities for experimental medicine specialist training	Offer studentships in all areas IOB or RCP diploma in toxicology On the job and In house training in regulatory toxicology for vets and safety scientists In house training in communication and literacy skills Skills and discipline related CPD

SCHOOL/COLLEGE					UNIVERSITY		INDUSTRY
Key Stage 1	**Key Stage 2**	**Key Stage 3**	**Key Stage 4**	**Post - 16**	**Under graduate**	**Post graduate**	**In company training**
					Chemistry Work with RSC on project to look at industry needs and university supply of chemists Analytical chemistry method development training **Pharmacy** Increase focus on industry within pharmacy degrees **Engineering subjects** Collaboration between chemical engineering, chemistry and biochemistry departments Courses to include concepts of importance to industry (e.g. total quality, Business process mapping) **Technical skills** Widen opportunities for vocational training	**Veterinary science** National initiative to increase animal model development and other concerns under discussion	
Maths	**Maths**	**Maths**	**Maths** Involve industry in development of functional mathematics units and new GCSE specifications	**Maths** Statistics/maths for science students	**Maths** Increase mathematical knowledge of life science graduates to enable them to appreciate quantitative methods	**Maths** Training programme in maths/statistics to meet industry needs to include pre-clinical/clinical stats awareness	

Key
Blue Recommendations of Wellcome Trust Report 'Primary Horizons – starting out in science'
Pink Initiative ongoing

5.4.4 Career guidance and related issues

SCHOOL/COLLEGE					UNIVERSITY	
Key Stage 1	**Key Stage 2**	**Key Stage 3**	**Key Stage 4**	**Post - 16**	**Undergraduate**	**Post Graduate**
ABPI 'Making medicines' story Encourage SEAS support	ABPI 'Making medicines' story and slideshow plus animations Encourage SEAS support	Embed information on careers in science in subject study Support career education with information on opportunities and routes into industry Provide information to support subject choice at key stage 4 Encourage SEAS support CPD for careers teachers within schools Provide information on career opportunities in science to science teachers and school careers advisors Support Science Council development of a single source for information on careers in science	Embed information on careers in science in subject study Support work related learning in science Support career education with information on opportunities and routes into industry Provide opportunities for work experience and 'Young Scientist' days Provide information to support subject choice at post-16 Encourage SEAS support CPD for careers teachers within schools Provide information on career opportunities in science to science teachers and school careers advisors Support Science Council development of a single source for information on careers in science Enhance portrayal of science careers in the media	Opportunities for work experience and placements (e.g. Nuffield bursaries) Support work related learning in science Support career education with information on opportunities and routes into industry CPD for careers teachers within schools Provide information on career opportunities in science to science teachers and school/college career advisors Encourage able candidates to consider apprenticeships instead of HE Input into UCAS career conference for science teachers and career advisors Support Science Council development of a single source for information on careers in science Royal Statistical Society career DVD Enhance portrayal of science careers in the media	Royal Statistical Society career DVD Support Bioscience Federation career events Provide information to university careers advisors on opportunities within the pharmaceutical industry Promote industrial career option to pharmacy undergraduates Promote opportunities in industry vs academia, particularly for pathology Enhance portrayal of science careers in the media	UK GRAD Careers in Focus event RCUK – Career paths working group Provide information to university careers advisors on opportunities within the pharmaceutical industry

5.5 Appendix V: The Case for a 14-19 Science Diploma

5.5.1 THE NEED FOR A 14-19 SCIENCE DIPLOMA: A PROPOSAL FROM THE ASSOCIATION OF THE BRITISH PHARMACEUTICAL INDUSTRY

5.5.1.1 *Key Points*

A science diploma would:

- Secure the science base by ensuring that young people are equipped and encouraged to work in science.
- Provide clear vocational and academic pathways into careers in science.
- Encourage more young people to consider studying and working in science.
- Provide information on the wide variety of career opportunities for those with science qualifications.
- Encourage study of appropriate supporting units such as ‘communicating in science’ and ‘maths for scientists’.

5.5.1.2 *Employment in science in the UK*

The UK science and engineering base, which includes higher education and Research Council institutions, performs most of the basic and strategic research undertaken in the UK.

Over 245,000 people are engaged in R&D in the UK and the total number of people employed on R&D in business enterprise in 2002 (167,000) increased by 10% from 2001 (Source: DTI OST SET Statistics October 2004).

5.5.1.3 *UK pharmaceutical industry*

The pharmaceutical sector is the leading private funder of research in the UK. In 2003 the industry invested nearly £10 million per day (£3.2 billion per annum). This equates to a quarter of all industrial R&D funding in the UK.

The pharmaceutical industry employs 83,000 people directly, of which 25% are graduates. Over 300,000 overall are associated with the industry.

The industry employs substantial numbers of people whose backgrounds are in science, in particular chemistry and biology. These individuals are employed in a range of roles encompassing the research, development, manufacture, marketing and sale of pharmaceuticals.

The Association of the British Pharmaceutical Industry (ABPI) is the trade association for the pharmaceutical and biopharmaceutical industry in the UK.

5.5.1.4 *The case for a 14-19 science diploma*

The pharmaceutical industry recruits young people with degrees and PhDs in science from higher education into its R&D, manufacturing, sales and other business support operations. The industry also recruits young people from school and further education into apprenticeships for laboratory work, in both R&D and manufacturing, as animal technicians, and into engineering and operator roles in manufacturing.

As such, it is important that young people are equipped and motivated to progress onto relevant science courses in further and higher education. This will then prepare them for employment in the pharmaceutical and other science-based industries, and organisations including the research institutions, higher education research departments and science teaching, which make up and support the UK science base.

At the 14-19 level schools and colleges need to equip students with the knowledge, skills and understanding to pursue relevant courses in further and higher education, make informed choices about their future careers, and prepare them for employment in science related fields.

In its February 2005 Education and Skills White Paper, the government announced plans for Specialised Diplomas in 14 occupational lines. However no diploma is planned for the science sector.

It is the industry's view that a science diploma would help to address a number of issues relating to employment of people in science. These include:

- the lack of clear vocational pathways into careers in science;
- applied science GCSE courses in science at school and college are apparently being taken mainly by lower achieving students;
- the lack of opportunities for students to take BTEC National courses locally to support vocational pathways into careers in science;
- the poor understanding of some applications of science, which contributes to young people not considering a career in science;
- the long-term downward trend in the number of young people pursuing physical science courses at Advanced level and in higher education. Recent indications that this trend may be reversing are welcome, and we believe that the opportunity to undertake a science diploma may further encourage the study of physical science;
- a lack of knowledge amongst young people about career opportunities in science beyond higher profile careers such as medicine, dentistry and forensic science;
- a lack of higher level numeracy and communication skills at Level 3 and above amongst Year 12/13 students, science undergraduates and graduates.

A science diploma would help to overcome these issues by:

- offering a variety of learning pathways into careers in science, including vocational pathways;
- show young people the full range of employment/career opportunities that exist in science;
- encourage uptake of relevant supporting qualification units, such as a Level 3 and Level 4 'communicating in science' and 'maths for scientists' units which could be

taken by school and college students, as well as by undergraduates and science graduates in employment.

5.5.1.5 *Designing a 14-19 science diploma*

A science diploma should offer students high quality vocational and general pathways into further and higher education science courses and employment in science. In common with the currently proposed 14 diplomas, the diploma would need to be available at Levels 2 and 3, and be designed so that students did not over-specialise at Level 2, cutting off learning pathways into areas other than science.

In addition, the diploma would need to provide challenge; for example by enabling more able learners to study additional units at higher levels. For instance, an able student taking the Level 2 diploma would be able to study further units at this level and some from Level 3, to broaden and deepen their knowledge and understanding. More able students taking the Level 3 diploma would be able to study units from further and higher education courses, to increase their depth of subject knowledge.

As with the other proposed diplomas, links of progression would need to be built to the Apprenticeship system.

As suggested in the guidance for Diploma Development Partnerships for the first tranche of diplomas currently being developed, we would envisage that the science diploma would incorporate existing qualifications, such as GCSE Science or Applied Science at Level 2, and would have a core comprising functional skills in maths, English and ICT, personal employability, learning and thinking skills and, at Level 3, and an extended project.

The diploma could therefore include the following components at Levels 2 and 3:

Level 2:

- Units from the new GCSE science courses being introduced in September 2006, and the Applied Science GCSE. Content covered would need to be equivalent to a double award GCSE.
- Units from BTEC First courses and OCR National Level 2 in science
- Units equivalent to existing higher level Mathematics GCSE, including functional maths.
- English.
- ICT.
- Learning and thinking skills
- Work-related learning.
- Careers education and guidance on careers in science and on progression to other diplomas within further education.

Level 3:

- Units from AS and A2 Advanced level or Applied Advanced level science courses. Content covered at Level 3 would need to be equivalent to the current 12 units (equivalent to 2 Science A levels, or 1 Applied A level).
- Units from level 3 BTEC National courses.
- Maths for scientists units at Level 3.
- Communicating in science at Level 3.
- Learning and thinking skills.

- Work-related learning.
- Extended project.
- Careers education and guidance on careers in science. Progression to further and higher education courses, including Foundation Degrees and Honours Degrees.

The above outlines our initial suggestions. Consultation on the design of the diploma would be needed, supported by the Qualifications and Curriculum Authority and relevant Sector Skills Councils. Organisations to be consulted should include other science-based employers and trade organisations, higher education institutions, research councils, and a range of other organisations including the Science Council, Royal Society of Chemistry, Institute of Biology and Institute of Physics, the Engineering and Technology Board, and Association for Science Education.

5.5.1.6 *Support for a 14-19 science diploma*

We have had preliminary discussions with the professional bodies representing chemistry, physics and biology and with other organisations. All have expressed an interest in principle in exploring the opportunities a science diploma may offer.

A report by:

The Association of the British Pharmaceutical Industry

November 2005