The Molecular Bioscience PhD and Women's Retention:
A Survey and Comparison with Chemistry

RSC | Advancing the Chemical Sciences
uk resource centre for women in science, engineering & technology
Biochemical Society
Advancing Molecular Bioscience

About

About the Biochemical Society

The Biochemical Society promotes the advancement of the Molecular Biosciences, representing the interests of all those working in the sector. The Society recognises that the discipline of 'Biochemistry' now encompasses the entire breadth of Cellular and Molecular Life Sciences and this is reflected in the range of our activities and our strapline - 'Advancing Molecular Biosciences'. We also believe that we are part of a Bioscience community with a proliferation of learned societies with whom we work to foster a community of Bioscientists, thereby delivering our mission more effectively.

The Biochemical Society is a Registered Charity and this status reflects the nature of our core educational activities. The Society seeks to accomplish its mission and charitable objectives in a variety of ways, including:

- Publishing a range of high quality journals and books
- Organising an excellent programme of scientific meetings
- Organising and supporting educational activities, including those relating to primary and secondary education and the public understanding of science
- Providing grants and bursaries for scientists (including students) to attend scientific meetings in the UK and overseas
- Promoting the importance of Cellular and Molecular Bioscience to the health and wealth of the nation, both to Government and other public agencies

www.biochemistry.org

About the RSC

Since 1841, the RSC has been a leading society and professional body for chemical scientists, and is committed to ensuring that an enthusiastic, innovative and thriving scientific community is in place to face the future. The RSC has a global membership of over 44,000, with a further 300,000 associated chemical scientists internationally, and is actively involved in the spheres of education, qualifications and professional conduct. It runs conferences and meetings for chemical scientists, industrialists and policy makers, at both national and local level. It is a major publisher of scientific books and journals, the majority of which are held in the RSC Library and Information Centre. In all its work, the RSC aims to be objective and impartial, and is recognised throughout the world as an authoritative voice of the chemical sciences.

www.rsc.org

About the UKRC

The UKRC for Women in SET works to significantly improve the participation and position of women in science, engineering and technology occupations in industry, research, academia, and public service to benefit the future productivity of the UK and the lifetime earnings and career aspirations of women. It is the UK's leading Centre providing information and advisory services to employers and organisations in the SET sectors and supporting women entering, returning and progressing in these fields.

www.ukrc4setwomen.org.uk

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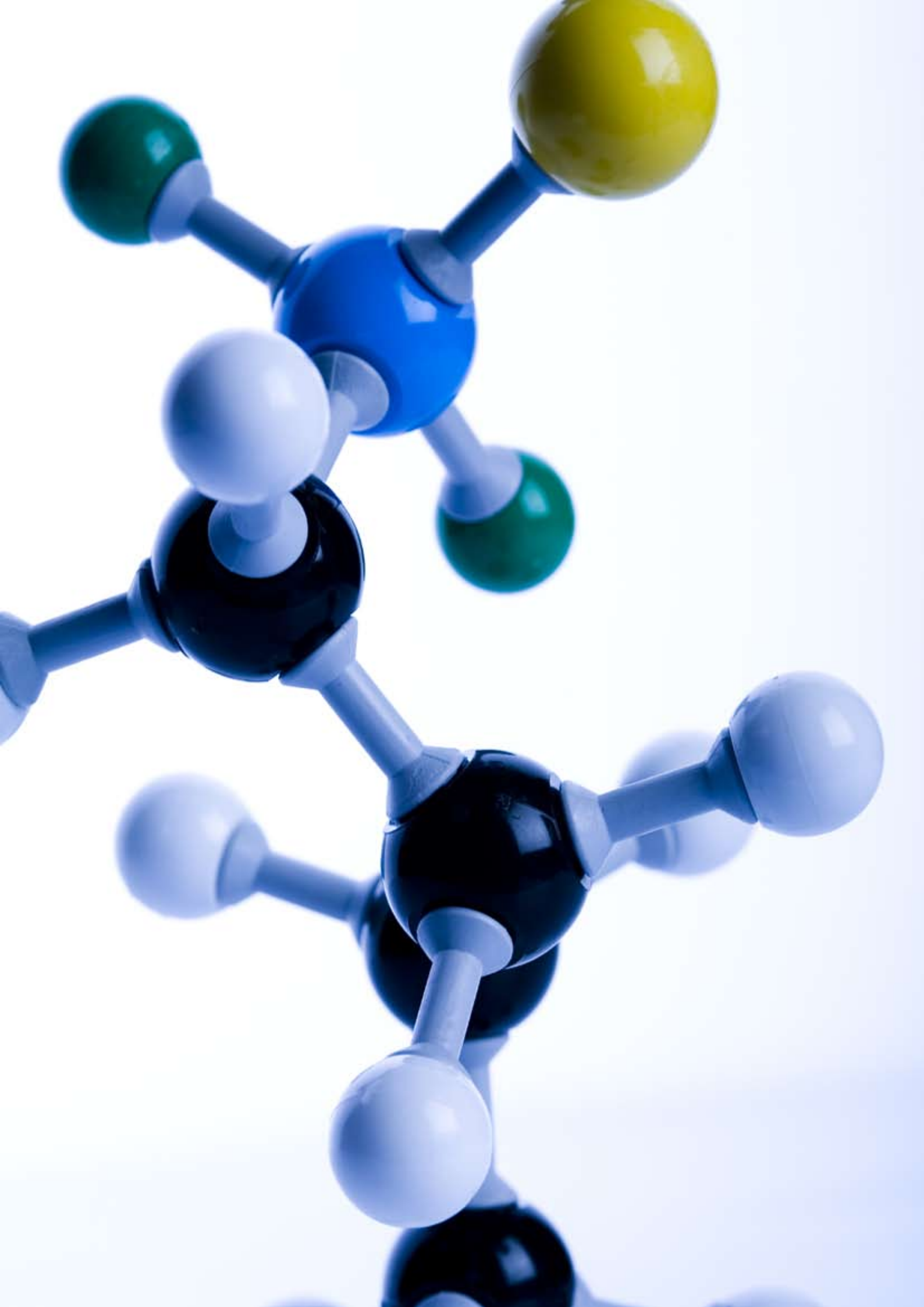

Foreword

As a long-standing member of the Biochemical Society, I am very pleased to have this opportunity to write a foreword to this report, which summarises the findings of an important collaborative research project undertaken with the Royal Society of Chemistry and the UK Resource Centre for Women in Science.

Within the biological sciences, female and male undergraduates are enrolled in roughly equal proportions and this trend continues amongst doctoral students. However once doctoral graduates enter the science sector in a professional capacity a decrease in the number of women occurs such that, amongst the professoriate in UK Universities, less than 10 percent of post-holders are women.

The main aim of this research project was to investigate the career intentions of molecular bioscientists and to obtain data on their experiences of doctoral study. The gendered data analysis applied to the results has increased our understanding of how the experience of doctoral study may affect men and women in different ways. Furthermore, a comparison of these results to those of a preceding research project involving chemistry PhD students indicates that these different disciplines face different challenges.

The Biochemical Society is committed to addressing the issues facing women in science. As a Learned Society, we recognise that a diverse and talented workforce is crucial for both the UK economy and for wider society. In building such a workforce, a solution to the problem of the attrition of women from science after obtaining a PhD must be found. The results of this research project highlight key areas to be addressed, such as the quality of supervision and careers advice.

Of course, the experiences of young scientists undertaking their PhD studies are only one factor contributing to the under-representation of women at the most senior levels of UK science. The partners involved in this project are committed to addressing the causes of this under-representation wherever they may reside.

I congratulate the Biochemical Society, The Royal Society of Chemistry, UK Resource Centre for Women in Science for producing this important piece of work. Special recognition must go to researcher Jessica Lober-Newsome who undertook this project as part of her own PhD studies. I know all three organisations are very grateful for all her hard work.

Sir Tom Blundell FRS, FMedSci
William Dunn Professor of Biochemistry and Chair
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Foreword by the Director of the UK Resource Centre for Women in SET

I am delighted to present the findings of this research which examined the link between doctoral study experiences and career intentions of female and male PhD students in molecular bioscience. The findings were compared with those from a similar survey of chemistry PhD students, which revealed that although a greater proportion of women than men began their PhD studies with the intention of pursuing a research career, but by the end of their studies the proportion of women had halved, while the proportion of men had stayed about the same.

The research was a collaborative research project carried out by the Royal Society of Chemistry (RSC) and the Biochemical Society with the UK Resource Centre for Women in Science Engineering and Technology (UKRC).

The UKRC has a primary objective to foster women's engagement and progression in sciences. Therefore understanding the impact of the experience of doctoral study on the career intentions of female students is particularly important to the UKRC. One way of encouraging the retention of highly qualified women from science, engineering and technology (SET) study and employment, is to find ways for organisations to support women at key life and career transition stages so that talented and qualified women are not lost from SET careers. The UKRC supports research such as this that informs both policy and practice.

This report identifies gender equality and diversity issues at the doctoral level that affect both chemistry and the molecular biosciences (and, it may be safe to presume, other sciences). The report also presents a list of policy recommendations based on the research findings. These suggest ways of improving culture and practice that will benefit doctoral students in molecular biosciences, chemistry and in the sciences in general. I hope that these recommendations will be taken forward by the appropriate stakeholders including Heads of SET university departments, all those who work and/or supervise PhD students, learned societies, and research councils because the changes the report suggests can only be accomplished with their support and enthusiasm.

This report is one of a number that the UKRC has commissioned and funded. More information can be found on our website: www.ukrc4setwomen.org.

Annette Williams
Director, UKRC

Acknowledgements

This project was co-ordinated by Sarah Dickinson, Science Policy and Diversity Specialist, and Sean McWhinnie, Manager, Science Policy, both of the Royal Society of Chemistry. The survey was administered by Rebecca Smith, Parliamentary and Policy Officer, of the Biochemical Society, assisted by Amy Cox. Key advisors to the project were Chris Kirk of the Biochemical Society, Caroline Fox of the Athena Forum, Pat Morton of Sheffield Hallam University, and Louise Ackers of the University of Liverpool. The UK Resource Centre for Women in Science, Engineering and Technology (UKRC) was represented by Anna Zalevski and Leigh Ingham.

Special thanks go to Jessica Lober-Newsome for all her work in both developing the questionnaire and writing the report.

Thanks are also due to the UK Resource Centre for Women in SET (UKRC) who provided the opportunity and funding to carry out this study. Additionally, UKRC's help and advice throughout the project has been greatly appreciated.

This project would not have been possible without the co-operation of the 30 university molecular bioscience departments that kindly distributed survey questionnaires to students. Neither would it have been possible without the 454 molecular bioscience PhD students who took the time to complete the questionnaire, to whom all those involved in the project are most grateful.

Executive Summary

Overview

This report presents the findings of collaborative survey research involving the UK Resource Centre for Women in Science, Engineering and Technology (UKRC), the Biochemical Society, and the Royal Society of Chemistry (RSC).

Women are under-represented in science, engineering and technology (SET) employment; a contributing factor is that SET fails to retain qualified women in similar proportions to men. This project aimed to understand further why this is through a gendered analysis of the doctoral study experiences and career intentions of molecular bioscience PhD students. The findings were compared with those of a similar survey of chemistry PhD students to provide further insight.

The survey was administered as a self-completion, postal questionnaire. A response rate of 20% was achieved. The survey was based on a non-probability sample (statistical significance was calculated as an aid to interpretation only).

Results The key results on the doctoral study experiences of molecular bioscience PhD students are:

- The overwhelming majority of respondents were happy in their role as PhD students: 84% of women and 89% of men;

- Notwithstanding, the 'downsides' to PhD study included:

  - Repetitive, frustrating work (43% of men and 57% of women agreed);
  - Long and irregular work hours (35% of both men and women agreed);
  - Financial worries (35% of men and 25% of women agreed);
  - Feelings of isolation (20% of both men and women agreed);
  - Supervision problems (10% of men and 17% of women agreed).

These results were similar to those found for chemistry PhD students;

- More female than male respondents were networking (i.e. had joined a networking scheme or group) but few belonged to 'women and science' groups.

The project also examined experiences of supervision:

- The majority of respondents were satisfied with their supervision: 94% of men and 81% of women described their relationship with their supervisor as either 'good' or 'excellent';

- However, female respondents were more likely than male respondents to describe their supervisory relationship as poor (note - only a small minority of women did so overall).

Key results about the career intentions of molecular bioscience PhD students are:

- Female respondents were less likely to be planning to pursue research further after completing their PhD: 58% of female respondents compared with 69% of male respondents. Among UK-domiciled students only, 51% of female respondents and 60% of male respondents were planning to continue research further (a similar difference was found among chemistry PhD students);

- However, in contrast to the results for chemistry PhD students, there was no evidence that a significant proportion of women were deterred during their PhD from entering a research career in the molecular biosciences. Rather, many female molecular bioscience respondents had never intended to remain in research (across all disciplines, the decision to undertake PhD study is not necessarily motivated by career plans; for example, the individual may have been motivated by their enjoyment of the research project they undertook in the final year of their first degree);

- Of those molecular bioscience PhD students planning to continue in research after completing their PhD, 90% of both sexes indicated they were likely to remain in academia (amongst chemistry PhD students, women were less likely than men to wish to remain in academia on completion);

- However, only 47% of female respondents compared with 62% of male respondents believed they would have a long term academic career (the finding for chemistry PhD students was similar).

Conclusions

The findings of this survey (and that for chemistry PhD students) show that certain gender equality and diversity issues apply to both chemistry and the molecular biosciences at doctoral level. These issues are evidenced by the tendency for:

- Women to be more likely than men to report finding research repetitive and frustrating;

- Supervision problems to more often affect women than men;

- Women to be less likely than men to consider a career in research on completion of their PhD (although molecular bioscience PhD students were more likely than chemistry PhD students to be planning to continue research in the near term);

- Women to be less likely than men to want to stay in academic science in the long term (a perceived incompatibility between motherhood/maintaining a work-life balance and an academic career were cited).

- The results of the survey also suggested differences in the career intentions of chemistry and molecular bioscience PhD students:

- A smaller proportion of female molecular bioscience than female chemistry PhD students were deterred from pursuing further research over the course of doctoral study;

- Amongst those with an intention to remain in research, a larger proportion of female molecular bioscience than female chemistry PhD students intended to stay in academia once they had completed their doctoral study.

This suggests that certain equality and diversity issues at the doctoral level operate in chemistry but not in the molecular biosciences.

Policy Recommendations

The policy recommendations are based on the findings from surveys of both chemistry and molecular bioscience PhD students. While the survey results for chemistry and molecular biosciences were different, especially in respect of the intentions of female students to continue in research, improvements in culture and practice will benefit students in both disciplines and therefore the recommendations are designed to apply to both chemistry and molecular biosciences, and indeed are equally applicable to other disciplines. Each recommendation is followed by the names of the key stakeholder(s) considered by the authors the most appropriate to take it forward.

Supervision

- Within molecular bioscience, 17% of female and 10% of male respondents stated that supervision problems had detracted from their PhD experience being a positive one. Good supervision informed by an awareness of all aspects of equality and diversity will help all students, and therefore institutions should provide academic staff with training before they undertake the supervision of PhD students. The training should include elements to enable supervisors to become sensitive to the differing needs of individual students and advice on where to direct students who are having problems. The training should also help institutions meet their obligations under the gender equality duty[1].

  > Universities; Research Councils, UKRC

- The PhD experience should not rest alone with the scientific supervisor. 31% of female and 41% of male molecular bioscience students, felt that their supervision experience could have been enhanced with more adequate mentoring (the mentors might be 'buddies' who are more senior students, and/or advisors outside the supervision team) and more general advice. PhD students should have access to a support team and mentoring should be available to students. Respondents to both questionnaires felt isolated. Mentoring schemes can prevent feelings of isolation and provide networks of support for students. The mentors should receive training which includes gender awareness[2].

  > Universities, UKRC

Student Experience

- The overall assessment of research output should include an element related to the student experience as the training of research personnel is an important part of the research process.

  > Funding Councils; Research Councils; DIUS; QAA

- There is a lack of understanding about PhD study among potential students, which is shown by some responses to open ended questions in the molecular bioscience questionnaire. Universities should ensure that appropriate and timely guidance is provided for potential doctoral students, including access to existing students and online case studies. Potential students should also be made aware of the need to actively seek information on the realities of the doctoral experience prior to accepting a place in a department[3]. Such information may be gained through contact with existing students and internet research e.g. forums. The

UKRC's website includes information and contacts which can help inform potential women students.

> Universities; PhD Students; Learned Societies

Careers Advice

- PhD students are still unaware of the career pathways beyond PhD study. A third of all respondents (both sexes) to the molecular bioscience questionnaire and a quarter of all respondents (both sexes) to the chemistry questionnaire rated their awareness of career options outside academia as either 'poor' or very 'poor'. Careers information and advice targeted specifically at PhD students is needed to demonstrate alternative career routes as well as research careers. Students need to be aware of where a PhD can lead, especially as a number of PhD students do not want research careers. Therefore to improve careers advice, learned societies should consider the production of careers information for PhD students to make them aware of the career opportunities in areas of speciality.

  > Learned Societies; Industry; University Careers Services; Association of Graduate Careers Advisory Services; University Science Departments; Vitae

- Additional training in gender and diversity awareness and careers in Science, Engineering and Technology (SET) should be offered to those giving information, advice and guidance to PhD students, to ensure understanding of issues faced in different areas of SET and the different career paths open to both men and women.

  > Learned Societies, Science Departments; University Careers Services, UKRC

Good Practice and Work Life Balance

- Comments were also made by both sexes about the all consuming nature of science, and the difficulties in balancing an academic career with having a family. Therefore academic institutions should ensure that departments consider work-life balance in all aspects of departmental activity, building on the information which is available in publications such as the RSC's report Planning for Success: Good Practice in University Science Departments and the UK Resource Centre's Good Practice Guide on work Life Balance, and implementing their own policies where necessary.

  > Universities; Athena SWAN

Dissemination and Further Research

- The results of projects such as this one should be disseminated to members of learned societies through networks such as the Athena Partnership and organisations such as the UKRC since a number of the issues identified will apply to other SET subjects.

  > Learned Societies

- Learned Societies should continue to work collaboratively on the improvement of working practices so that sector-wide recommendations can be made and action taken. Such cooperation may be facilitated through the SPIDER (STEM

Professional Institutes Diversity and Equality Resources) network and the Athena Partnership.

> Learned Societies

- Larger and long term research projects, including longitudinal studies, should be carried out to enable a deeper understanding of why and when women leave specific science areas and what can be done to reduce attrition rates.

- Research Funders; Learned Societies; DIUS

Notes

1. See also the Quality Assurance Agency for Higher Education (QAA) Code of Practice, section 1: Postgraduate research programmes, QAA 2004, ISBN 1 84482 168 4, precepts 11 to 14.

2. ibid, precepts 12 and 13

3. ibid, precepts 6 to 10

1

Introduction

'Molecular bioscience has a much shorter history as a discipline than chemistry and so it was interesting to ask whether molecular bioscience has developed the same cultural identity and way of doing things as chemistry.'

This report presents the findings of a collaborative research project between the UK Resource Centre for Women in Science, Engineering and Technology (UKRC), the Biochemical Society and the Royal Society of Chemistry (RSC). The research comprised a survey of molecular bioscience PhD students which was carried out during Winter 2007/08.

1.1 Research Drivers

Women constitute only 14% of science, engineering and ICT professionals (ONS 2007). Women are better represented in science than in engineering and technology and female participation in the biological sciences is higher than in the physical sciences. Within UK universities the proportions of female researchers, lecturers, senior lecturers, and professors in bioscience are 49%, 38%, 26% and 13% respectively, whilst in chemistry the respective proportions are 30%, 23%, 12% and 6% (HESA 2006-07). One factor contributing to the under-representation of women in SET careers is that appropriately qualified women are not retained in similar proportions to similarly qualified men. This is true of all SET disciplines, though the proportions of women at undergraduate level do vary greatly with the biosciences having one of the highest proportions of female undergraduate students.

This project was designed to compare the results of a survey of chemistry PhD students with those from molecular biosciences PhD students to assess the generality of the issues identified. The molecular biosciences were chosen because within the biological sciences academic "pipeline" women are better represented than in chemistry, both at the first stage (undergraduate) and at the last (professor). For the most part, research in both chemistry and molecular biosciences is carried out in laboratories, and therefore the question arose whether the PhD experience affects both men and women in terms of their career aspirations the same in both subjects. Molecular bioscience has a much shorter history as a discipline than chemistry and so it was interesting to ask whether molecular bioscience has developed the same cultural identity and way of doing things as chemistry.

To learn more about factors which account for significant loss of women from science careers at the PhD-contract research worker (CRW) (EC 2002) transition, the UKRC is interested in whether the doctoral study experience is less positive for women than for men. This project provides insight into the doctoral study experiences of one group of doctoral science students: molecular bioscientists. The Biochemical Society was also interested whether the postgraduate experience was a contributory factor to the loss of women bioscientists from a research/academic career. The RSC had previously undertaken a survey of chemistry PhD students in 2006 and saw value in comparing their earlier findings with those of doctoral molecular bioscience students. The comparison has, (a), helped to further explain the trends the RSC

found and, (b), determined that certain policy measures to improve gender equality and diversity have relevance beyond chemistry.

1.2 Definition of Molecular Bioscience

Molecular bioscience in the current report is taken to encompass all those areas of biology and biomedicine that rely significantly on biochemical, biophysical or molecular biological research techniques. 10,000 PhDs are awarded in molecular bioscience across the world each year (IUBMB 1999).

1.3 Research Aims

The aims of the survey were to, (a), generate data on the PhD study experiences and career intentions of molecular bioscience doctoral students and to uncover any gender differences; and, (b), compare findings concerning gender differences with those of a survey of doctoral chemistry students carried out in 2006 by the RSC.

1.4 Research Question

The research question was:

To what extent are there gender differences in the study experiences and career intentions of molecular bioscience doctoral students?

To investigate the doctoral study experiences of molecular bioscience PhD students, respondents were asked open and closed questions about what they perceived to be the positive and negative aspects of PhD study, about their experience of supervision, including the quality of their supervisory relationship, and about their networking activity.

To establish what respondents intended to do after their doctoral studies, they were asked a series of closed questions to distinguish between research and non-research pathways and to determine industrial sector preferences. Respondents were also questioned on their experiences of career advice and longer term career plans.

1.5 An Important Objective

One reason for carrying out the survey was to find out whether a trend observed amongst chemistry PhD students also is observed for molecular bioscience PhD students.

The RSC 2006 survey of doctoral chemistry students found that the proportion of female students who intended to pursue a research career after their doctoral studies falls during the course of PhD study. Whilst 72% of first year female chemistry PhD students indicated an intention to stay in research after their PhD, this was true of only 37% of third year female chemistry PhD students. In other words around half of the women who begin a PhD in chemistry intending to pursue a research career change their minds by the end of their third year of study.

This suggests that many female chemistry PhD students reconsider their plans to take up a career in research after their initial experience of doctoral study and/or research science.

This change was not found amongst male chemistry PhD students. The proportion of male chemistry PhD students intending to pursue a career in research after completing their PhD fell by only 2%, from 61% amongst first year students to 59% amongst third year students.

Moreover, a higher proportion of male second year students (73%) than first year students wished to stay in laboratory science, although this does mean that men were also put off research as they approached the end of their PhDs.

The 'stage' results relating to molecular bioscience PhD students are detailed from page 29 onwards of this report (for more details on the results of the chemistry survey please refer to the full report available at www.rsc.org/diversity).

1.6 Background

1.6.1 First Destinations of Science PhD Graduates

The publication 'What Do PhDs Do?' (CRAC 2007) presents analysis of 'First Destinations' data recently (2003-2005) collected by the Destinations of Leaver of Higher Education survey (administered by the Higher Education Statistics Agency). Tables 1 and 2 reproduce selected analysis relating to biological science PhD graduates and Tables 3 and 4 reproduce selected analysis relating to physical science and engineering PhD graduates (combined).

Table 1: Employment Circumstances of UK-Domiciled Biological Science PhD Graduates (2003-2005), Six Months after Graduation (percentages)

	Entered work in the UK	Work and studying in the UK	Entered study or training in the UK	Working or studying overseas	Not available for work or study	Believed unemployed	Other
2005	64.5	9.4	2.8	9.5	4.8	2.4	1.9
2004	70.9	7.5	2.5	9.0	4.7	3.4	2.1
2003	17.0	607	3.4	12.3	2.4	2.9	1.4

Table 2: Employment Sectors Entered by UK-Domiciled Biological Science PhD Graduates (2003-2005), based on Standard Industrial Classifications (SIC) (Percentages)

	Education	Finance, business and IT	Health and social work	Manufacturing	Public Administration	Other sectors
2005	50.6	5.6	11.9	21.2	6.6	4.1
2004	49.2	6.5	11.9	21.4	4.5	6.6
2003	47.7	5.9	9.2	24.7	6.1	6.4

Table 3: Employment Circumstances of UK-Domiciled Physical Science and Engineering PhD Graduates (2003-2005), Six Months after Graduation (Percentages)

	Entered work in the UK	Work and studying in the UK	Entered study or training in the UK	Working or studying overseas	Not available for work or study	Believed unemployed	Other
2005	69.2	9.4	2.8	9.5	4.8	2.4	1.9
2004	65.6	10.7	3.1	10.6	5.0	2.5	2.5
2003	73.0	6.0	1.8	10.2	4.7	2.3	2.0

Table 4: Employment Sectors entered by UK-Domiciled Physical Science and Engineering PhD Graduates (2003-2005), based on Standard Industrial Classifications (SIC) (percentages)

	Education	Finance, business and IT	Health and social work	Manu-facturing	Public Admini-stration	Other sectors
2005	43.5	18.9	2.2	27.9	7.1	5.8
2004	42.7	18.5	2.3	25.2	6.7	4.7
2003	39.2	17.8	2.2	27.9	7.1	5.8

1.6.2 Women in Bioscience

Historically women have comprised a minority of the scientific labour force. To this day, women remain under-represented in the physical sciences. Women still only account for 18% of professional physicists and 23% of professional chemists (ONS 2007).

Women are far better represented in bioscience, constituting 51% of biological scientists and biochemists across levels (ONS 2007). However, whilst the biosciences have a greater proportion of females than other SET subjects, inequalities between the careers of women and men bioscientists persist. There are three main ways in which the career outcomes of male and female biological scientists prove unequal.

First, male bioscientists are much more likely to occupy the top positions whereas female bioscientists tend to populate the lower grades. This is termed 'vertical occupational segregation' and is at a fairly high level amongst bioscientists in the university setting: 49% of researchers but only 13% of university professors in biosciences are female (HESA 2006-07). This situation has not improved significantly for some time, which challenges the notion that a 'critical mass' of women in the lower ranks of a profession will lead to a greater gender balance in the upper ranks.

Research at the Faculty of Biological Sciences, University of Leeds suggested women are failing to progress as far as their male colleagues either because they tend to be on short-term contracts or simply because they do not apply for promotion (University of Leeds 2002). Analysis of applications to the European Molecular Biology Organisation's Long-Term Fellowships and Young Investors Programme found that women were consistently less successful than men, but ruled out gender bias in the selection process as the explanation (Ledin et al 2007). Taking a contrary perspective, Anderson and Connolly (2006) utilised Athena's ASSET survey data to support claims that gender discrimination reinforces a glass ceiling in science. Research by Smith-Doerr (2004) on the careers of life scientists highlights the importance of the organisational setting on success. It reveals that women have better progression opportunities in networking rather than in hierarchically organised biotechnology firms.

Second, there is evidence of a gender pay gap in bioscience. Median hourly pay for biological scientists and biochemists (excluding overtime for full-time employees) stands at £16.38 for men but only £15.08 for women (ONS 2006). This represents an 8% pay gap.

'Science fails to retain qualified women in the same proportions it retains men (DTI 2002) with women 'leaking out' along the science pipeline.'

A third gender equality issue relates to retention rates. Science fails to retain qualified women in the same proportions it retains men (DTI 2002) with women 'leaking out' along the science pipeline (the notional conduit along which scientists flow as they train and advance). Poor rates of female retention matter for several reasons:

- For diversity reasons: diversity enriches scientific enquiry, promotes excellence, opening up new markets and ensures the agenda of science reflects the interests of the population.

- For equality reasons: gender inequality in scientific careers undermines the principles of fairness, equality of opportunity, and social justice to which liberal democracies such as the UK subscribe.

- For economic reasons: female attrition has the potential to compromise the ability of the UK to successfully compete in the global economy, particularly in growth areas where a boost to numbers of skilled personnel is required.

The latest data on the UK indicate that only 28% of female SET graduates are employed in SET occupations compared with 48% of men (UKRC 2006). Female attrition in the biosciences, especially in the university setting, is evidenced by the fact that women represent only a third of permanent academic staff (Athena Project 2005) but dominate the student body. It is also illustrated by the membership profiles of the Biochemical Society (see Table 5) which show female members in the majority amongst the under thirties but outnumbered six-fold amongst the over sixties.

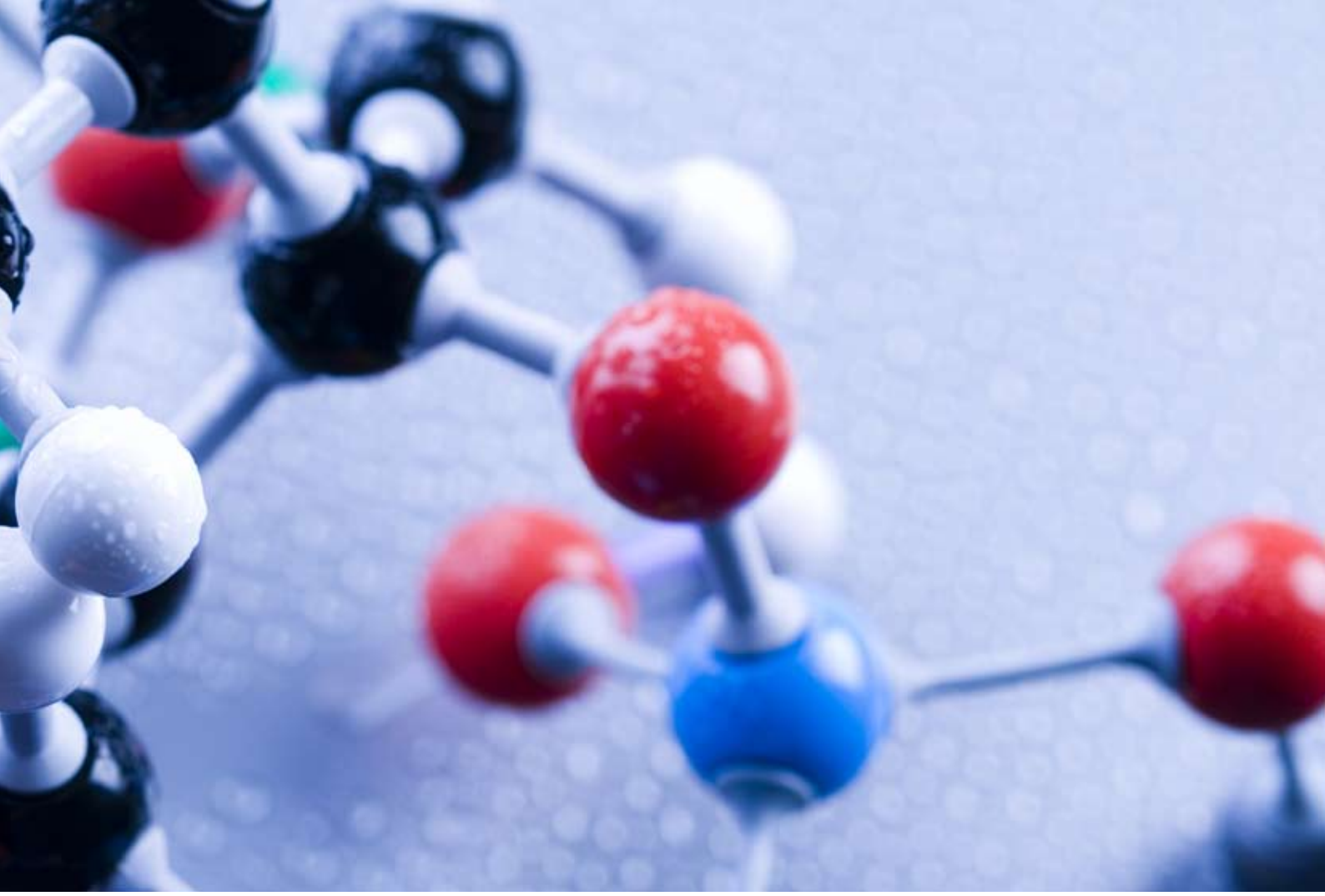
Table 5: Membership Profile of the Biochemical Society, by Age Group (2007)

Age Group (Years)	Ratio (Men to Women)
20 to 29	0.72
30 to 39	1.06
40 to 49	1.64
50 to 59	2.60
60 and over	6.16

1.6.3 Female Attrition and this Report

Female attrition from science occurs in two main ways, (a), when women scientists exit scientific employment and, (b), when newly qualified women do not translate their newly acquired science qualification into a science job (Glover, 2001).

The survey reported here was concerned with the latter. Will the proportion of newly qualified women lost to the molecular biosciences be higher than the proportion of newly qualified men, and if so by how much? What insights can be gleaned as to what factors underlie leaks from the pipeline at the PhD-CRW transition? Do women molecular bioscientists become deterred from pursuing research over the course of doctoral study, as is the case among chemists?



2 Methodology

The methodology employed in this research replicated that used to carry out the RSC survey of chemistry PhD students in 2006. This had proved successful and had generated a high response rate.

2.1 Target Population

The target population for the survey was students studying for a molecular bioscience (or related) PhD at UK Higher Education Institutions (HEIs). Due to the difficulties of robustly sampling this population, the objective was to enable and encourage as many individuals as possible from this target population[1] to take part. Questionnaires were distributed to students through university departments known to have a large population of molecular bioscience PhD students.

2.2 Mode

The survey was administered as a self-completion, return-by-post, paper questionnaire. Recipients were encouraged to participate with a prize draw. Consent was informed by introductory paragraphs which stated the aims of the survey and who was responsible for it. Assurances about the anonymity of responses were provided. It was made clear to recipients that it was important they responded to the questionnaire regardless of whether or not they wished to pursue a career as a scientist.

2.3 Research Tool

To permit a comparison between chemistry and molecular bioscience PhD students, the questionnaire was very similar to the one used in the RSC 2006 survey of chemistry PhD students. Question wording was kept the same throughout but some additional questions were included in the molecular bioscience questionnaire and a small number of redundant questions were removed. Both closed questions (requesting respondents to choose a response from a list) and open questions (requesting respondents to write comments freely) featured in the questionnaire.

2.4 Administration and Response and Coverage Rates

Questionnaires were distributed to students through their university departments by the Biochemical Society. 34 departments were approached and 30 took part (anonymised information about the departments that took part is included in Appendix 4). 2304 questionnaires were distributed and 454 completed questionnaires were returned, representing a 20% response rate. Using Higher Education Statistics Agency (HESA) data it is possible to estimate that 7% of the eligible population took part in this survey[2].

2.5 Data Entry and Analysis

Returned questionnaires were computerised and the computerised data validated to verify the accuracy of the data entry. The quantitative data (responses to the closed questions) were analysed with the aid of the software package SPSS and the qualitative data (responses to the open questions) were analysed with the aid of the software package NVivo.

More information on the methodology is included in the Appendix 1.

Notes

1. Due to the non-disclosure provisions of the Data Protection Act (1998), UK universities are not in a position to disclose the demographic and contact details of their students to a third party (and it was thought impracticable to ask universities to seek the informed consent of all students in order for research exemptions to the non-disclosure provisions to apply). Thus it was concluded that producing a sampling frame of all PhD chemistry students from which to select a sample was not feasible.

2. According to HESA Student data relating to the year 2006/07, c. 6500 students are studying for a doctoral qualification in Biological Science (defined as students registered as studying Biology; Botany; Broadly-based programmes within biological sciences; Genetics; Microbiology; Molecular biology, biophysics & biochemistry; and Other in biological sciences) in UK HEI. The actual percentage is likely to be higher than 5% given this includes those studying for any postgraduate qualification and the target population was those undertaking PhD study only.

3 Profile of Respondents

3.1 Universities

Responses to the questionnaire came from PhD students studying at 30 Higher Education Institutions located across the UK (see Appendix 4 for more details).

3.2 Sex

63% of respondents were female and 37% male.

3.3 Age

Over 50% of respondents were under 25 years old; nearly 90% were under 30. The oldest respondents were in their early fifties.

3.4 Domicile

60% of respondents described themselves as Home Students with approximately 20% describing themselves as Overseas Students and 20% as EU Students.

3.5 Stage

Respondents were spread fairly evenly in terms of the year of their doctoral study. Around 30% of respondents were in the first year, around 30% were in their second year, and around 30% were in their third year. The remaining 10% or so were in their fourth or fifth year.

3.6 Status

Only 3% of respondents indicated they were studying on a part-time basis, however, part-time students were under-represented in the sample (see Appendix 3).

3.7 Funding

Nearly 95% of respondents were in receipt of PhD funding. Over a third of those in receipt of funding were supported by a research council. 1 in 5 was financially assisted via a university scheme. The remainder were funded by either an industrial sponsor, the third sector, a British or overseas government department, or by the European Union.

3.8 Industrial Experience

72% of respondents had never been on an industrial placement and 55% of respondents had no experience of industry at all. Of those who had some experience of industry, around three quarters of both men and women reported they had enjoyed it. 70% had acquired their experience on an industrial placement as an undergraduate.

3.9 First Degree Subject

The first degree (usually BSc) subjects of respondents spanned a wide variety of disciplines. No one discipline stood out as the most commonly read. First degree subjects included agriculture, anatomy, animal science, biological science, biochemistry, biomedical science, botany, chemistry, environmental studies, food/nutrition, genetics, plant science, mathematics, medicine, pharmacology, physiology and zoology.

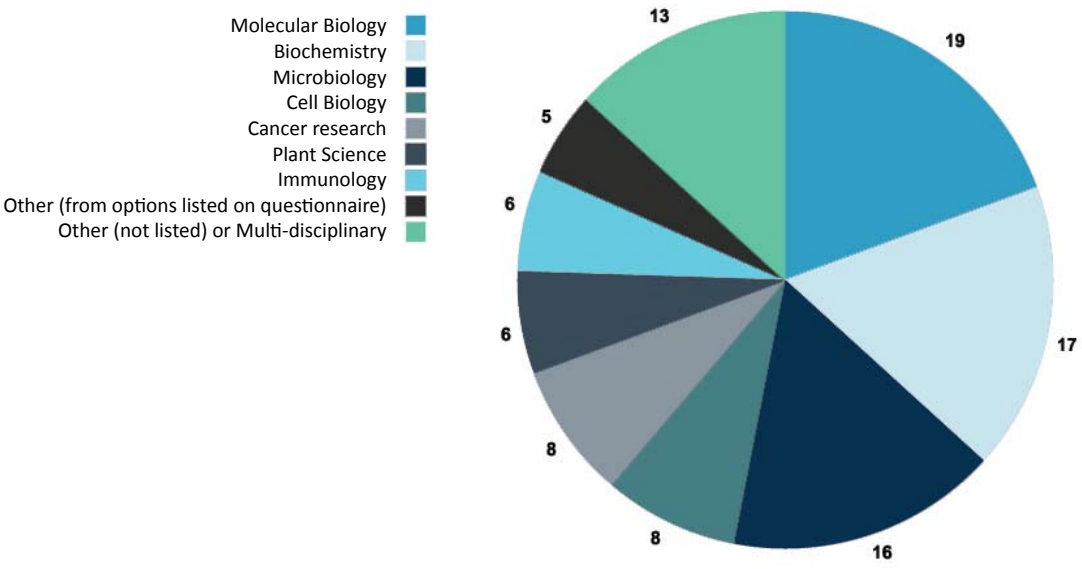
3.10 First Degree Class

41% of respondents possessed a first class honours degree. The rate was higher amongst women (45%) than men (35%).

3.11 PhD Discipline

Respondents were asked to select the discipline from a list which most accurately described their PhD research topic. The results are shown in Figure 1 (the total does not add up to 100% due to rounding). Nearly 20% of respondents indicated their research was either multi-disciplinary or outside the discipline options listed on the questionnaire (which in addition to the disciplines listed in Figure 1 included bioinformatics, biotechnology, environmental biology, molecular genetics and toxicology). Unlisted disciplines, as specified by respondents, included computational biology, developmental biology, food science, neuroscience and structural biology.

Figure 1: PhD Disciplines of Respondents (percentages)




4

Doctoral Study Experiences

'The majority of respondents (70%) indicated that it was their interest and enthusiasm for science more than any other factor that had led to them undertaking PhD study.'

4.1 The Impetus

The majority of respondents (70%) indicated that it was their interest and enthusiasm for science more than any other factor that had led to them undertaking PhD study. Men were more likely than women to indicate that their own intrinsic aptitude for understanding and practising science also featured: 26% of male respondents but only 15% of female respondents[1]. However, both men and women revealed in their responses to open-ended questions that they had to some extent come to doubt their ability to be a laboratory scientist[2]. One woman, for example, admits that since starting her PhD she feels;

"like the aptitude I thought I had for science has disappeared."

4.2 Positive Aspects

The majority of respondents indicated they did not regret their decision to undertake PhD study in very similar proportions to the chemistry survey respondents. 84% of women and 89% of men were happy in their role as a PhD student ($p>0.05$). Of those respondents, half reported they were pleased they had decided to do a PhD because they enjoyed researching their topic. This female respondent speaks for many;

"I am really enjoying this. I'm learning a lot whilst already making a difference."

A further fifth were glad to be accruing the experience they needed for the career they wanted. The majority of those respondents who admitted that they did regret their decision to do a PhD said this was because they no longer want to work in science (therefore completing a high level qualification in science felt like a poor use of time).

4.3 Negative Aspects

Considering the downsides to doing a PhD, 35% of respondents cited long and irregular work hours. One respondent commented;

"Its constant stress – you can't forget about it at the end of the day."

And another confessed;

"I didn't realise how much I would have to sacrifice in terms of free time and feeling constantly under pressure."

20% of respondents indicated they had felt isolated.

"Carrying out research in a lab with the same people day after day can make you feel isolated and detached from the real world."

This respondent was not alone;

"I've felt very isolated with no mentor, colleague or supervisor with expertise in my field."

Another wrote;

"I am the only home student in my lab so I have felt isolated."

Women were more likely (57%) than men (43%) to say they have found the work repetitive and frustrating. One female student commented;

"I find lab work tedious, repetitive and disheartening. I just don't think I could do it forever."

One female respondent wrote;

"Regardless of how hard you work, it very often doesn't feel like you have made progress!"

Another woman expressed how;

"Doing a PhD is more difficult than I expected…it's difficult to do an experiment 10 times and for it not to work."[3]

Male molecular bioscience PhD students were more likely to say money was an issue (35%) than women (25%).

A similar, albeit small, proportion of men (9%) as women (7%) felt they lacked a role model ($p>0.05$).

4.4 Supervision

Most respondents were satisfied with the supervision they were receiving. 94% of men reported that the relationship they had with their supervisor was either 'good' or 'excellent'. One man, for example, praised his supervisor and research group as follows;

"My doctoral experience so far has been wonderful because of the excellent supervision I have been enjoying from my supervisor coupled with the friendly environment I have found myself in."

The corresponding figure amongst women was lower at 81%, with the majority of these women saying the relationship was on 'good' rather than 'excellent' terms. 15 women but only one man described their supervisory relationship as either 'poor' or 'very poor'. He confides;

"My supervisor doesn't seem to value my opinion on things and treats me like a child. She also sets unrealistic goals…I will apply for a job in industry where I think things will be run more professionally."

Moreover, female respondents were over one and a half times more likely than male respondents to state supervision problems had detracted from their PhD study experience being a positive one: 17% of women and 10% of men selected this option. The supervision problems female respondents had experienced (as revealed in responses to open-ended questions) tended to relate to students not receiving the level of supervision they had expected, or to the approach of the supervisor, which in turn affected the student/supervisor relationship. The gender

With regards to supervision:

'Moreover, female respondents were over one and a half times more likely than male respondents to state supervision problems had detracted from their PhD study experience being a positive one.'

of each of the supervisors mentioned in the following quotations is not known unless inferred.

One female respondent articulated how;

"My supervisors have made me doubt my abilities as a scientist even though I love my subject and work hard. It seems academics can treat people terribly and get away with it. If I wasn't so strong willed and determined to succeed, academia would have made me leave by now."

For this woman, the manner of her supervisor led her to revise her career intention;

"Generally I enjoy my work but the whole experience has been over-shadowed by the very poor supervision I have received and the reluctance for any of the other academic staff to intervene. My supervisor is both over-bearing and rude! I have always wanted to be a scientist but my experiences at PhD level have made me realise it's not the route for me."

These two women were not the only ones to report having an unsatisfactory supervision experience. These three women also took the opportunity to share their supervision problems.

"So far my doctoral study experience has been poor. The science so far has been poor and unorganised by my supervisor. The project I agreed to undertake during the interview stages is not the project I am working on now so my relationship with my supervisor is constantly strained."

"My experience has been quite negative. So much so that I am looking to finish early and submit for MPhil. I have received little to no help from my supervisor in the lab, having to rely on other PhD students for help getting used to techniques."

"During the first year of my PhD I received no lab based supervision and therefore fell behind with practical work. In the second year my second supervisor began work on another project so I was given a new supervisor. He apparently became bored of my project and proceeded to ignore me, going for months without speaking to me and this once again left me with no lab supervision."

Nonetheless it is worth reiterating that only 19% of women PhD students in the molecular biosciences rated their supervision as less than 'good'. Indeed, some female respondents could not have been more positive about their doctoral study experience. One woman, for example said,

"I love working in science. I have a fantastic project, the most supportive supervisor ever and a brilliant working environment."

Another woman remarked;

"My experience of doing a PhD has been second to none so far. I have a first rate supervisor and I feel very lucky to have his support and encouragement. And I work in a brand new lab!"

4.5 Enhancing Supervision

When asked if and how the supervision experience could be enhanced, the most popular response was that students should be more adequately mentored and given more general advice. More men than women were keen on having their supervision experience enhanced in this way (31% of women compared with 41% of men). There were no differences between men and women with respect to the other suggestions listed on the questionnaire. 27% of both sexes wanted to receive greater support in their research, 17% wanted their supervisor to more readily provide them with careers advice, and 27% indicated their supervision experience could not be enhanced at all.

4.6 Networking

During the course of their PhD study, 63% of all respondents had joined at least one mentoring scheme or networking group related to their studies. 35% had joined a well known internet-based social networking group. 16% had joined a university-based networking group. Only a fraction (4%) of students was participating in a mentoring scheme. Overall, women were more likely than men to be networking: 66% of women had joined a scheme or group compared with 56% of men. This is positive, (a), because networking is one way in which women scientists can avoid feeling isolated and, (b), because networking is important for maximising future career prospects. Only 3% of female respondents belonged to a 'women in science' group. 51% of respondents indicated they are a member of a learned society, with women more likely than men to be members (56% of women and 43% of men). This correlates with the membership profiles of learned societies (see Table 5).

Notes

1. The same tendency was found amongst chemistry PhD students where the comparative figures from the RSC survey were 19% of male respondents and 9% of female respondents.

2. This was not the case amongst chemistry PhD students where it was exclusively women who admitted their self-confidence had been eroded.

3. Qualitative data from the RSC survey found that these are sentiments chemistry PhD students, especially women, share.

5

Career Intentions

'10% of respondents (typically third or fourth years) had already accepted an offer of work or further study. 7 out of 10 of these were posts in academia.'

5.1 Employed Respondents

10% of respondents (typically third or fourth years) had already accepted an offer of work or further study. 7 out of 10 of these were posts in academia.

5.2 Desirable Job Characteristics

Respondents were asked to indicate how important a range of job characteristics would be to them in deciding their next career steps. The results are shown in Table 6. This portrays a 'wish list' of what the majority of respondents were looking for in a career. The features are ranked according to the proportion of women and men who indicated this feature will be 'very important' to them; only the top 5 are shown.

Table 6: Desirable Job Characteristics

Rank	Men (% of the total)	Women (% of the total)
1	Making a positive difference (46)	Making a positive difference (46) =
2	Variety in the work (40)	-
3	Job security (39)	Job security (43)
4	Pleasant locations (36)	Pleasant locations (40)
5	Good health and safety (32)	Good health and safety (29)

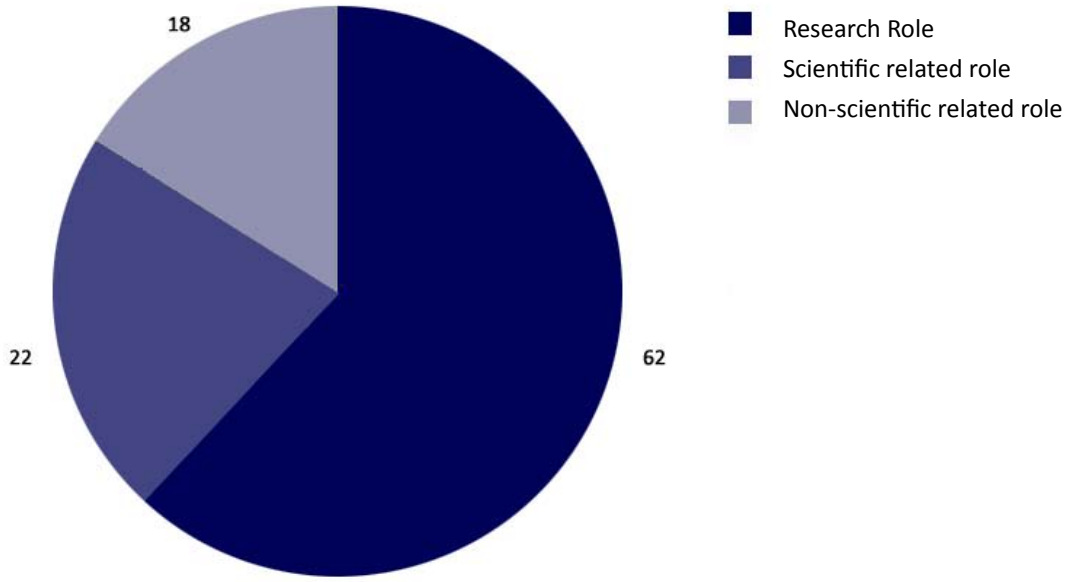
Table 6 shows there were no significant differences between the responses of men and women. A career with the potential for flexible working ranked as the 6th most important factor amongst women and 8th amongst men.

5.3 Intentions to Pursue Research

Respondents (who had not already accepted a job offer or a place on a further study or training course) were asked whether they intended to pursue a research career after completing their doctoral study programme.

Figure 2 shows the career intentions of respondents. 62% indicated they did want to pursue research further.[1] Although the majority of molecular bioscience respondents said they did have the general non-science skills employers were looking for, they were a little less confident of this than chemistry PhD students (molecular bioscience PhD students: 86% of women, 81% of men; chemistry PhD students: 88% of women and 86% of men ($p>0.05$)).

Figure 2: Key Career Intentions (All eligible respondents: percentage)



A further 22% of molecular bioscience PhD students said their intention was to look for a role which made use of their scientific background but one which did not involve research directly. For example, one respondent explained,

"I enjoy the PhD I am studying for and would like to get a job related to science though not in research …continuous highs and lows are hard to deal with on a day to day basis."

Another commented,

"I don't think I would like to continue working as a research scientist. It's often more about who you know and how much luck you have – so not very rewarding."

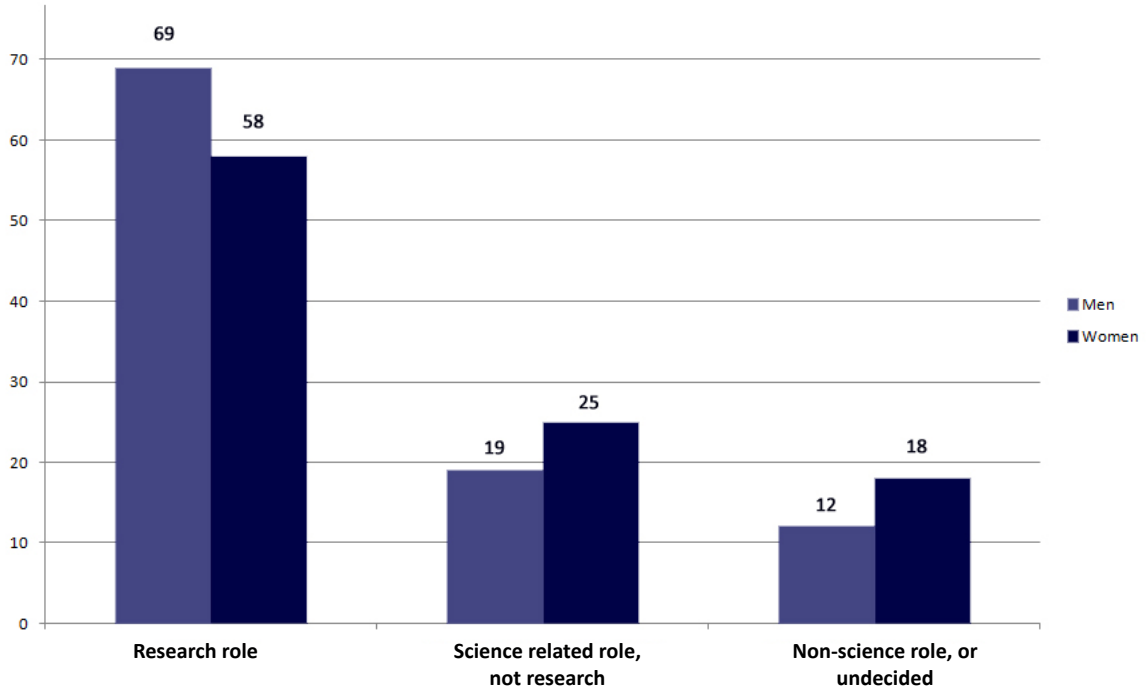
Typical non-research career intentions included teaching, patent work, science policy and science journalism. 16% reported they would be looking for a role entirely unrelated to science or were as yet undecided about what they would do next.

"I enjoy the PhD I am studying for and would like to get a job related to science though not in research … continuous highs and lows are hard to deal with on a day to day basis."

Gender Differences

The differences between the career intentions of men and women can be seen in Figure 3. 69% of men were committed to continuing in research. By contrast the comparative figure amongst women was 58%; thus female respondents were less likely than their male counterparts to be planning on pursuing a research science career. Correspondingly, more female than male respondents were considering leaving science, or at least leaving the research environment, after completing their PhD.

Figure 3: Key Career Intentions, by Gender



Consistent with this finding, women were more likely than men to have sought careers advice. Nearly twice the proportion of female than male respondents (33% compared with 19%) reported they had sought careers advice since beginning their doctoral studies. Nearly 20% of female PhD students but only 10% of male PhD students had visited a career or recruitment fair.

Domicile Differences

The proportion of respondents with an intention to pursue research further was higher amongst international students than amongst home students (as might be expected given the commitment these students have already demonstrated by seeking a placement outside their country of domicile). 72% of female international students and 78% of male international students were intent on seeking a research role after finishing their PhD ($p>0.05$).

Amongst home students the proportions were lower. 60% of UK-domiciled male students reported they wanted to continue in research science whereas a significantly lower proportion of UK-domiciled female students (51%) said the same ($p<0.1, >0.05$).

Stage Differences

An aim of the survey was to establish whether a trend in career intentions found amongst female doctoral chemistry students was also to be found amongst female doctoral molecular bioscience students.

Figure 4 illustrates the trend observed among chemistry PhD students. Female students in their third year of study were much less likely than females in their first year to report that they intended to pursue a research career after completing their PhD. Further analysis showed that this was particularly true in relation to research science in academia (for more details please refer to the full report on the chemistry survey on www.rsc.org). This suggests that, during the course of doctoral

study, female PhD students become dissatisfied or disillusioned with research science and are deterred from staying in academia to do postdoctoral work. By contrast, the intentions of male respondents changed very little over the course of PhD study, save for a surge of enthusiasm for research amongst second year students.

Figure 4: Research Intentions of Chemistry PhD Students by Gender & Stage (percentages)

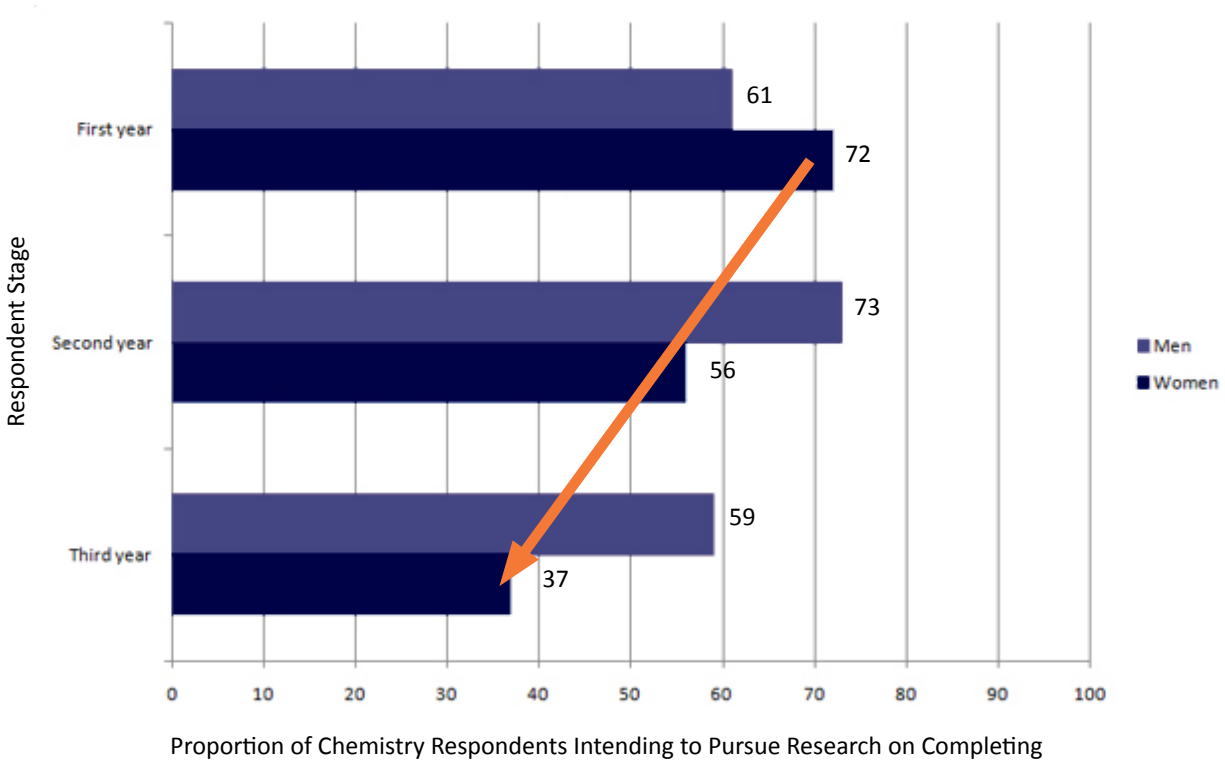
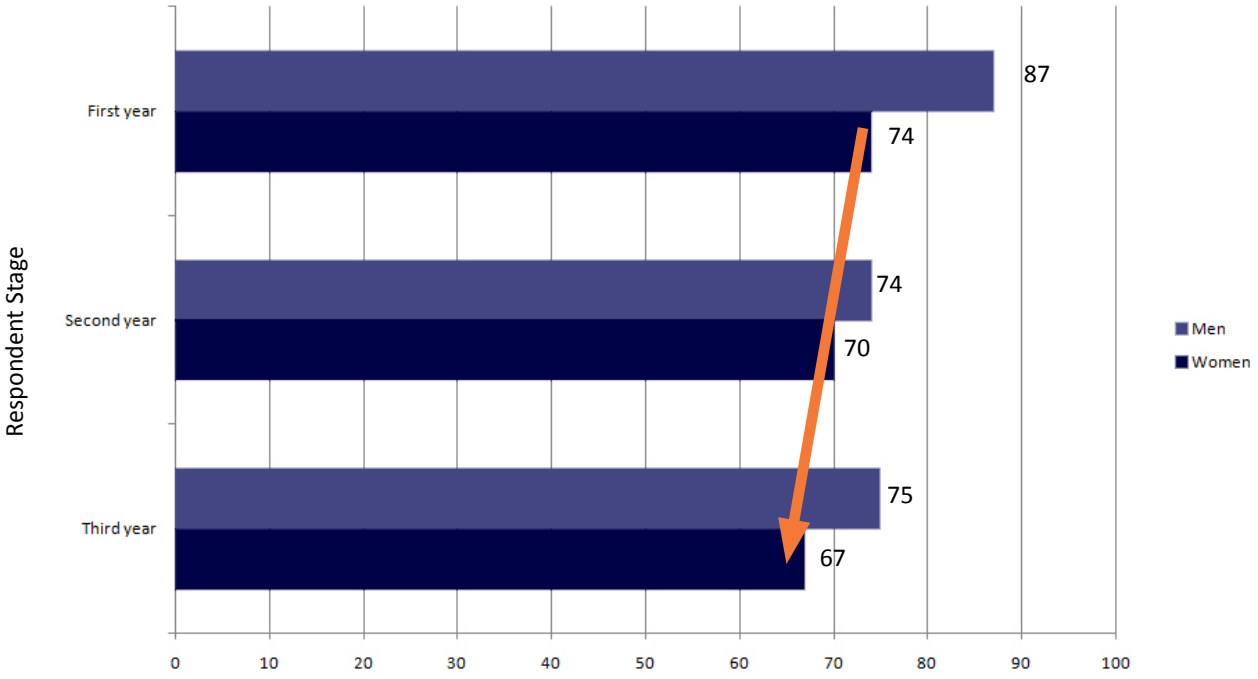


Figure 5 shows the comparable results from the molecular bioscience survey. It can be seen that the trend found amongst chemistry PhD students is not reproduced for molecular bioscience PhD students to the same extent (NB please see 'Discipline Comparisons' p32).

The proportion of female molecular bioscience PhD students wanting to follow a research career did fall during the course of PhD study, from 74% to 67%. However this represents only a 10% drop, when the comparative fall amongst chemistry PhD students was 49%.

Moreover, the proportion of male molecular bioscience respondents wanting to pursue a research career fell more over the course of the PhD than it did amongst women: by 14% between the first and third year (compared with 10% for women). The comparative figure amongst chemistry PhD students was only 3%, and furthermore the surge amongst male chemists in their second year was not in evidence amongst molecular bioscientists. That said, male molecular bioscientists in their third year were more likely than male chemists in their third year to report an intention to continue in a research role.

Figure 5: Research Intentions of Molecular Bioscience PhD Students by Gender & Stage (percentages)



Proportion of Molecular Bioscience Respondents Intending to Pursue Research on Completing

Nevertheless, even amongst those respondents planning to stay in research, 18% of women but only 8% of men said they had developed misgivings since beginning their doctoral study.

The results of this survey suggest that a smaller proportion of molecular bioscientists than chemists change their mind about pursuing research as a career after experiencing it as a doctoral student.

However, more than 1 in 10 molecular bioscience respondents (men as well as women) did re-think their intention to continue research.

'The results of this survey suggest that a smaller proportion of molecular bioscientists than chemists change their mind about pursuing research as a career after experiencing it as a doctoral student.'

The qualitative data provided useful insights as to why career intentions change. Interestingly, there were no discernible differences between the attitudes expressed by female and male respondents. A handful of people said it was down to their negative supervision experiences (see above). Other respondents were dissuaded by what they described as the political side of science and university life.

A large number of people had developed concerns about the labour market for molecular bioscientists. Their worries included competition levels, remuneration levels, and the prevalence of short-term contract positions rather than permanent positions.

The following were additional reasons:

- Some people had found that research just does not excite them personally:

"I am not enjoying my PhD. It is an excellent project with good supervisors and budget but I don't enjoy the research as much as I thought I would – I haven't the passion/dedication for it which I think is important for a research scientist. It's just not for me."

- Some people had become perturbed by the sometimes protracted pace of research work:

"I was aware that research can be slow and frustrating and felt equipped to deal with it. However after 3 years of it, my morale and motivation are low. There has been little support for how to deal with this. Consequently my love for science is starting to dwindle. I hope to find a job which requires my science background but with no research. I want a job in which I feel I am making progress on a day to day level."

- Some had been put off by the all-consuming nature of research:

"It completely takes over your life. I love it completely but think I would have a breakdown if I did it much longer!"

- Others had found the working conditions unappealing:

"What has made me want to leave research? Working in a basement with no windows doing the same thing over and over again!"

- Some had found the culture of science unattractive:

"I am a bit disappointed by the realities of working in science. I have realised most scientists either don't have families or put their personal lives second. Although I work hard I would like to have a good work-life balance which I feel is unachievable in science."

- Some people would simply rather pursue a positive alternative instead:

"I may start a medical degree and combine my experience as a research scientist with new studies."

'A large number of people had developed concerns about the labour market for molecular bioscientists. Their worries included competition levels, remuneration levels, and the prevalence of short-term contract positions rather than permanent positions.'

5.4 Brain Drain

A little under half of UK-domiciled respondents indicated they would consider employment abroad[2]. Of UK-domiciled respondents intending to enter research, the proportion prepared to work outside the UK was slightly higher. 49% of women and 53% of men in this category would consider non-UK based employment ($p>0.05$). 5% of respondents said they would definitely be seeking work abroad on completion.

5.5 Sector Preferences

Table 7 shows that amongst respondents wishing to continue in research after completing their PhD, 90% stated they were likely to remain within academia[3].

The qualitative data revealed that although respondents have concerns about working in academia (relating to the downsides of working on short-term contracts, the fierce competition for more permanent posts, the very long and irregular work hours in return for what they regard as non-commensurate financial reward, and a great deal of pressure to secure funding and publish), most still favour the academic option. According to respondents opportunities for professional freedom and flexibility are far greater in academia than in alternative sectors.

However female respondents frequently expressed how they felt they may have to choose between having a career and having a family if they stayed in academia:

"I enjoy my PhD and love working in science but have concerns for my future career because it feels as if women must choose between their career and having a family."

Some women appear to have internalised this idea:

"Science within academia totally consumes you. In the future I would love to be a mum and I don't believe you can be a good scientist and a good mum! Or at least, I don't think I can!"

This woman does not even question it:

"It is noticeable that there are few senior women in biochemistry/ biology. It is a difficult field for women to climb up in if they decide to have a family."

Another woman mentioned the source of her concerns:

"Other women academics have warned me that working as a research scientist is not compatible with good parenting."

Table 7: Probable Destinations amongst Respondents with an Intention to Pursue Research[4]

Destination	Men (%)	Women (%)
Academia	90	90
Pharmaceutical industry	45	45
University spin-off R&D	48	32
Public sector	23	23
Commercial research	36	26

45% of members of both sexes regarded the pharmaceutical industry as an alternative sector within which they might pursue research. 23% thought the same of the public sector. There were gender differences with respect to the proportion of women and men who regarded university spin-off R&D and commercial research/services as career possibilities. Whilst 48% of male molecular bioscience PhD students saw university spin-off R&D as a potential option, the comparative figure amongst women was only 32%. In addition, 36% of male respondents but only 26% of female respondents indicated they were considering the commercial research/services sector. Very few respondents selected the 4 other sectors provided as options on the questionnaire (the chemical industry, the defence industry, the utilities sector and medical services).

It is worth noting that a third of all respondents (both sexes) rated their awareness of career options outside academia as either 'poor' or 'very poor'.

5.6 Academic Futures

Respondents wishing to take up a research career were asked in which sector they see themselves working, (a), 3-5 years after completing their PhD and, (b), 6-10 years after completing their PhD. Table 8 shows the

results. 59% of female and 66% of male respondents saw themselves as likely to remain as university scientists 3-5 years after finishing their PhD. The proportion intending to stay in academia for 6-10 years was smaller, with 47% of female and 62% of male respondents planning to do so. This means that female respondents were less likely than male respondents to be considering pursuing a longer term research career in an academic setting.[5]

Table 8: Respondents with an Intention to stay in Academia for the Foreseeable Future Pursue Research

	Proportion of respondents intending to stay in academia*	
Years after completion in academia	Men (%)	Women (%)
3-5 years	66	59
6-10 years	62	47

* Proportions are given as the percentage of those who indicated their intention to remain in research.

5.7 Career Intentions Among those with an Intention to Leave Research

A third of women who did not wish to continue in research after completing their PhD were considering a scientific publishing role. A quarter of women indicated they were considering seeking employment related to science policy and a further quarter regarded a role in the governmental sector as a possibility. Men responded to all the 'next step' options provided on the questionnaire fairly evenly. The most common selection was 'travel' with a quarter of male respondents hoping to see the world once they had submitting their theses.

NOTES

1. Chemistry PhD students were less likely to want to pursue research: only 55% of respondents to the RSC 2006 survey were intent on a research career.

2. The figure was notably higher amongst chemistry PhD students at 65%.

3. Considerably fewer chemistry PhD students overall, only 40%, and a greater proportion of female than male chemistry PhD students (for example only 29% of female compared with 53% of male second year respondents) saw their immediate career prospects in academia.

4. Respondents were asked 'Do you intend to seek employment in any of the following sectors?' and were instructed to mark all that applied from this list: university, public sector, pharmaceutical industry, chemical industry, food or drink industry, defence, water electricity oil or gas, medical services, university spin-off R&D, other.

5. The same trend was found amongst chemistry PhD students where, according to the results of the RSC 2006 survey, 70% of women with an intention to pursue research do not see themselves in academia 6-10 years after completion of their PhD.

6

Discussion

'Certain policies may be applicable to all disciplines but in addition, some disciplines will require action on one issue whilst other disciplines would be better advised to concentrate on a different issue.'

6.1 Discipline Comparisons

There is increasing evidence that, in order to make progress on improving gender equality and diversity in science, the individual sciences should not be conflated (Glover and Fielding 1999). Whilst there are similarities between the sciences in terms of certain 'women and science' issues (e.g. women are poorly represented in the higher grades of all scientific professions) there are also differences (e.g. women are more poorly represented in physical science than in biological science).

It is therefore arguable that each scientific discipline requires a different mix of equality and diversity policies. Certain policies may be applicable to all disciplines but in addition, some disciplines will require action on one issue whilst other disciplines would be better advised to concentrate on a different issue. This discussion aims to highlight and summarise the gender-based similarities and differences between the molecular biosciences and chemistry that have been revealed by the two surveys with the aim of informing equality and diversity policy.

Furthermore, when a phenomenon is observed in one context but not in another, this in itself often leads to useful insights about the roots and causes of that phenomenon. When a phenomenon is observed universally, context-specific roots and causes can be considered less likely. The following discussion attempts to draw on this.

6.2 Gender and the PhD Study Experience

The surveys show that male and female molecular bioscience PhD students have much in common in their attitudes towards doctoral study. Despite acknowledging that PhD study involves working long and unsociable hours and feelings of isolation and pressure, the majority of respondents reported that they do not regret their decision to do a PhD.

However, the survey revealed two important gender differences between the doctoral study experiences of molecular bioscience PhD students.

First, female respondents were more likely than their male colleagues to indicate they had been surprised by the reality of the nature of research work. More women than men disclosed finding research repetitive and frustrating.

Similarly, qualitative data gathered from the RSC survey of doctoral chemistry students exposed a tendency for women to be deterred from pursuing research by aspects of the nature of the work.

A perception (more widely held amongst women than men) that research

is repetitive and frustrating is therefore the first similarity between the molecular biosciences and chemistry. It is unclear what underpins this perception. Explanations which suggest that women are generally less interested in science as it is currently constructed as masculine, or as a result of socialisation processes, may provide some insights. Perhaps the overall level of discomfort women can tolerate is lowered by the cumulative effect of other negative PhD study experiences (such as supervision difficulties). Or, is it possibly a symptom of the unease women feel towards the ('masculine') environmental and cultural context they must research in? Alternatively, perhaps women begin doctoral study with higher expectations than men, and consequently suffer greater disappointment when the drawbacks become apparent. Indeed, since it might be considered surprising that some 50% of all PhD students feel somewhat downbeat about the nature of research work, perhaps there is a case for all potential PhD science students being better informed about what doctoral study involves prior to embarking on the three or four year undertaking. By the same token, perhaps there is also a need to improve the attractiveness of research careers.

It is important to note that progression in science usually takes the scientist away from the bench and into a strategic and leadership role. Yet if women are deterred from science in the early stages of career, because they cannot see themselves in a career at the bench, they will never reach such a position (thereby contributing to vertical occupational segregation). This suggests that there is a need to bring progression routes in science to the attention of all science students to raise awareness that a career in science is not necessarily a career in a laboratory. A similar point is made below.

Second, female respondents were more likely than male respondents to be affected by supervision problems, especially significant supervision problems. Although most men and women believed they had a good relationship with their supervisor, and a quarter said their supervision experience could not be enhanced at all, a significant minority of female respondents reported how supervision problems had adversely affected their overall doctoral study experience. A number of female respondents reported that they had encountered profound difficulties.

Interview and focus group research with current chemistry PhD students and recently qualified doctoral chemists suggests a similar theme in chemistry (see "The Contribution of the Doctoral Study Experience to Female Attrition from Chemistry" (UKRC/RSC, 2008)). In that study, women reported experiencing severe supervision problems that men did not report. The data also indicated that male chemistry PhD students encountered the same standard supervision problems described by their female colleagues, but that women tended to be more affected by these than men.

The experiences of women in relation to supervision are therefore the second similarity between the molecular biosciences and chemistry although it should be emphasised problems were not as widespread in the molecular biosciences. Policy relating to supervision in science is discussed further in "The Contribution of the Doctoral Study Experience to Female Attrition from Chemistry".

6.3 Gender and Research Intentions

Around two-thirds of male and female respondents were planning a research career on completion of their PhD: all things being equal there should not be a gender difference in intentions. However, supported by the finding that women are more likely than men to seek careers advice, the survey found female respondents were less likely to be intending to pursue an academic career than male respondents. This suggests that women qualified to doctoral level continue to be lost to the molecular biosciences at the PhD-CRW transition to a greater extent than men (although women are lost from a higher base than men)[1]. This is also the case in chemistry so a higher female than male attrition rate represents the third similarity between the two disciplines.

'What is it about molecular bioscience that repels a smaller proportion of women PhD students than chemistry?'

However, as mentioned above, the female attrition rate at the PhD-CRW transition in the molecular biosciences does not seem to be due to significant numbers being deterred from research during doctoral study (as is the case in chemistry). Rather, the survey suggests that many female molecular bioscience PhD students (approximately 25%) did not intend to stay in research beyond their PhD study from the outset (the same is true of chemists but in addition chemistry loses many women during doctoral study).

This represents the first contrast between chemistry and the molecular biosciences. What might explain this difference? What is it about molecular bioscience that repels a smaller proportion of women PhD students than chemistry? It is not possible to answer that question definitively but two possible explanations may be considered, though there are undoubtedly many others and it is likely that a combination of factors contribute.

Could the reason be related to cultural factors? Does chemistry offer a less attractive and/or hospitable culture for women than the molecular biosciences? As an emerging field, perhaps 'molecular bioscience' has yet to develop a discernable "masculine" culture for women to find unattractive or inhospitable. Indeed it is interesting to speculate whether molecular bioscience will ever develop a specific culture, let alone a masculine one, as, in contrast to chemistry, PhD molecular bioscientists derive from a wide range of different disciplines and undertake diverse research topics (as shown in the 'Respondent Profile' section). Is the critical mass of women at the bottom of the molecular biosciences helping to retain women at the PhD-CRW transition (even though it appears to have little effect on improving the numbers of women in the top grades) because it renders the general culture more agreeable to women? Perhaps the contrast at PhD level is related to the molecular biosciences being a more female-dominated environment compared to chemistry. Alternatively, perhaps the fact that the molecular biosciences are a more female-dominated environment than chemistry is a factor contributing to the decline in the proportion of male molecular bioscience students over the course of the PhD wishing to carry on in research, something which is not seen to the same extent in chemistry. Or is this because many men come to realise they have considerably more lucrative career options outside research? It is also possible that some male PhD students may be "supporting" a family (NB men were more likely than women to state that financial worries were a drawback of doctoral study). Or perhaps broad socialisation processes render men more motivated by money regardless.

In a similar vein, could it be that female chemists are more likely to be deterred from pursuing research during their doctoral study than female molecular bioscientists as a result of being more aware of alternative career paths. A similar question was posed above. Unlike chemistry respondents, a third of molecular bioscience respondents rated their awareness of their job options outside academia as poor or very poor: the equivalent proportion amongst chemistry PhD students was notably smaller. Molecular bioscience PhD students were also less likely than chemistry PhD students to say they had the general skills employers were looking for. RSC campaigns in schools which seek to ingrain into the culture of chemistry education the fact that chemistry can lead to other things and that "not all chemists wear white coats" (RSC slogan) could be a factor here in persuading students that they are valued outside chemistry. If this is the case then it might be sensible to ensure those molecular bioscientists who begun doctoral study with the intention of entering research are aware that their skills are also in demand in the wider labour market. The revised "Concordat to Support the Career Development of Researchers" (due to be published in June 2008 by the Research Councils UK), states "There are a wide variety of career paths open to researchers and the ability to move between different paths is key to a successful career. It is recognised that this mobility brings great benefit to the UK economy…Researchers should be empowered by having a realistic understanding of, and information about, their own career development and career direction options as well as taking personal responsibility…"

'Unlike chemistry respondents, a third of molecular bioscience respondents rated their awareness of their job options outside academia as poor or very poor.'

The second contrast between the molecular biosciences and chemistry is that amongst those female PhD students with an intention to stay in research, molecular bioscience respondents were more likely to have an intention to remain in academia than chemistry respondents. In chemistry, a significant proportion of women are lost at the transition between PhD student and post-doc (RSC 1999) whereas, in the molecular biosciences this appears not to be the case.

However, the survey findings suggested that whilst female attrition from academia in the molecular biosciences does not happen at the PhD-CRW transition, it will happen later on. The majority of female molecular bioscience respondents (53%) with an intention to stay in research did not see themselves remaining in academia long term. Chemistry is also likely to lose women (though from a lower base) beyond the PhD-CRW transition, although perhaps to a lesser extent. This marks the fourth similarity between the molecular biosciences and chemistry.

It seems reasonable to speculate that academia fails to retain many female molecular bioscientists and chemists later on in career as a result of the perceived/real difficulties of balancing science with family commitments (PhD students are unlikely to have caring responsibilities). Indeed the perception that motherhood and academia are incompatible was found in responses to open-ended questions in both surveys. In terms of the way forward, the situation may well be 'catch-22'. Women 'returners' (i.e. women who have taken a career break but come back) are arguably needed to demonstrate to younger scientists that it is possible to combine an academic career with motherhood. However such role models may continue to be thin on the ground until it is perceived that a better work-life balance in scientific work is possible. Consideration of work-life balance is becoming an increasingly important issue in the employment of both men and

women. However, as the revised Research Councils UK concordat seeks to emphasise, "the demanding nature of research careers has a disproportionate effect on certain groups, for example women hoping to start families". The concordat recommends "all members of the UK research community actively address the disincentives and indirect obstacles to retention and progression in research careers which may disproportionately impact on some groups more than others."

The final point is that the indication that considerably more women chemists than women molecular bioscientists are deterred from remaining in academia in the near term as well as in the long term, implies there is something else going on in chemistry in addition to the work-life balance issue. One possibility is that whilst women chemists may face similar work-life balance issues to those faced by their molecular bioscience colleagues, they also have to cope with a single-gender culture (Bagilhole et al 2007) which makes it difficult to stay in the field as a female (and not merely difficult to stay in the field whilst responsible for caring and domestic duties).

6.4 Explanations for Female Attrition

What might account for poor retention rates of women in science?
The argument that women are under-represented in, and lost from, science as a result of being intrinsically less capable of understanding, practising and furthering science than men has been scientifically discredited (Spelke 2005) and abandoned in mainstream public debate for some time (American Sociological Association 2005). Testament to this is that in 2005, comments which questioned women's intrinsic aptitude for high-level science made by Professor Lawrence Summers (President of Harvard) (Summers 2005) in a speech to a conference on diversifying the science and engineering workforce, captured the attention of the international press and caused widespread outrage.

A debate continues as to whether women are less interested in science than men (Curran 1980). There is evidence that female children are less interested in science than male children (e.g. Weinburg's 1995 quantitative study and Baker and Leary's (1995) qualitative study cited in Blickenstaff 2005). This is relevant because interest and attachment to a science related career has been shown to form in early life, often by the end of primary education (Schoon, Ross and Martin 2007). Thomas (1990) describes how boys tend to choose the masculine gendered science, whilst girls tend to choose the feminine gendered humanities. Lightbody and Durndell (1996) highlight how girls are less likely to select physical sciences at school and more likely to select languages. There is, however, some recent evidence that boys and girls are beginning to make less 'stereotypical' subject choices (Francis 2000, Wikeley and Stables 1999). Notwithstanding this, two possible explanations have been put forward to explain why girls may continue to be less interested in science than boys. Neither posits that subject choices are biologically determined.

6.4.1 Socialisation Processes

The first explanation is that socialisation processes are at work. The most relevant socialisation processes relate to the assigned gender appropriateness of a given field. It has been argued that fewer women than men choose science as a result of exposure to rigid gender role stereotypes concerning scientists and science. Messages (mainly from parents and teachers) about enjoying science or becoming scientists are said to be absent in girls' socialisation whilst negative messages

about science and the inappropriateness of becoming a scientist are abundant (with the reverse true for boys) (Beyer 1995; Potts and Martinez 1994; Jussim and Eccles 1992). Science pedagogy contributes to the overall message, with science packaged in such as way as to be less appealing to girls than boys (Kelly 1985). Mead and Metraux (1957) and more recently Barman (1999) found children consistently draw scientists as white males. Wajcman (1991:3) explains "If science is seen as an activity appropriate for men, then it is hardly surprising that girls do not want to develop the skills and behaviours considered necessary for success in science." Where women leave science careers, it could be argued that this is because the socialisation which prescribes science as more suitable for boys than girls continues to have an influence in later life, perhaps because those messages have been internalised.

Socialisation processes are also thought to contribute to levels of 'science confidence'. The suggestion is that women are under-represented in science because they lack self-confidence when it comes to science (Trankina 1993; Lips 1992) and/or display science 'anxiety' (Mallow 1994), as a result of the socialisation processes they underwent in their youth. According to this perspective, girls are thought to be socialised to think they are not suited to science or capable of high scientific attainment. In addition, the existence of a 'mathematics filter' has been put forward, whereby girls are said doubt their mathematical abilities from an early age, and as a result de-select themselves from a scientific or engineering career (Byrne 1993). Once girls have internalised the message that girls are weaker at science than boys, they may find it very hard to overcome. McIlwee and Robinson (1992) conclude that poor self-confidence amongst female scientists and engineers is the main reason why women have less success in the scientific and engineering workplace than men; in addition, they say women become less self-confident through daily exposure to a hostile culture in addition to entering the workplace already less confident than their male colleagues.

6.4.2 Science and Masculinity

The second explanation as to why girls may be less interested in science than boys draws on the constructivist sociological understanding of science as influenced by struggles for power, and is rooted in radical feminist critiques of science and technology which see these as a mechanism for dominating women and for justifying this domination (Wajcman 1991: 4). The contention is that modern Western science is a masculine construction; the idea that science, as we know it, is modelled on the masculine way of seeing and interacting with the world and driven by masculine experiences and interests (Harding and Hintikka 1983). In short, the suggestion is that science is and has been defined in terms of masculine identity (Harding 1991: 63).

'The contention is that modern Western science is a masculine construction; the idea that science, as we know it, is modelled on the masculine way of seeing and interacting with the world and driven by masculine experiences and interests (Harding and Hintikka 1983).'

It is argued that as science is masculine in nature it unlikely women will be attracted to it and those women who do enter science will find themselves exposed to a 'chilly climate' where their femininity puts them at a disadvantage. Harding (1986) furthermore contends that science has been slower to feminise than the other professions because it has been guarded most fiercely on account of helping to shape what masculinity is. Murray (1993: 78) explains "To 'take the toys from the boys' threatens those boys with one of the symbols that makes them feel like boys, and significantly, not girls. Without those 'toys' the boys would no longer be boys as they and we know them." Noble (1992) provides one account as to why science may have evolved as masculine.

Noble charts how science mimicked Christian clerical culture, a culture characterised by celibacy, where women were feared and distrusted (1992: 244). Noble writes (1992: xiv), "In recent years, there have been important pioneering attempts to understand the nature and origins of this 'masculine' scientific tradition…but for the most part the exclusive identification of science with men has been taken as a given, some thing to be overcome, but never really explained…the male identity of science is no mere artefact of sexist history; throughout most of its evolution, the culture of science has not simply excluded women, it has been defined in defiance of women and in their absence. Thus, predictably, the world of science has remained an alien world for women, and a hostile one, a world where women are not merely marginalised but anathematised [cursed/denounced], where they face not just discrimination, but dread." According to proponents of the masculine science perspective, science can be thought of as modelled on masculinity in a number of respects (e.g. Lowe 1994; Rose 1994). The first is the idea that modern Western science is based on masculine methods, specifically the method of positivist objective rationality which arose out of the Enlightenment. The second is that science is based on masculine values and masculine epistemology, both seeking to further a masculine agenda. The third is that science is based on a masculine culture. An important aspect of this masculine culture is said to be the aggressive and competitive nature of science.

6.4.3 Domestic Responsibility

A further explanation for women's under-representation and attrition in science is liberal feminist in origin and hinges on the 'domestic responsibilities' model (Bebbington 2002).

For liberal feminists, men and women display different outcomes when it comes to scientific employment, not because they are essentially different in any way, but rather as a consequence of the different roles each plays in society. Gender inequality between female and male scientists' careers is seen as due to the structure of scientific work being incompatible with women's caring and domestic role. Rossi (1965) represented one of the first liberal feminist inspired discussions of why women are not better represented in science, and fare less well than men. She talks about the effect of marriage and motherhood on a scientific career. Since then, various specific structural barriers, said to make academia and science an un-level playing field have been identified (Bailyn 2003). These include the following:

- Scientific organisations have been described as 'greedy' to denote the way scientific careers very often involve long and irregular hours which women with caring responsibilities may find it difficult to plan around (Grant et al 2000). Ellis (2003) contends that scientific work does not lend itself to a fixed hour regime posing an obstacle to people who need a predictable timetable. Kubanek and Waller (1995) found young women deterred from pursing science because they thought women scientists would need to be 'superwomen' to succeed.

- Scientific occupations offer little opportunity for flexible working (McRae, Devine and Lakey 1991) and part-time employment opportunities are unusual on the premise that science is rarely successfully practised on a less than full-time basis (Rayman and Burbage 1989).

- Building a successful scientific career entails being most active and productive between the ages of 25 and 35 when researchers have few management responsibilities (Mason 1991; Warrior 1997). However, these are the prime child-bearing years so many women take time out from employment during this crucial time and therefore fail to build the weighty research portfolio they need to progress.

- During researchers' early careers there is an expectation of geographical mobility and without international experience, promotion prospects are limited (Kulis and Sicotte 2002; Stalford 2005).

6.4.4 Gendered Organisations

The final perspective as to why scientifically qualified women leave science in larger proportions to scientifically qualified men starts from the position that organisations are not gender neutral institutions (Acker 1990). Rather, gender is held to be a fundamental structuring element of organisations, "present in processes, practices, images and ideologies and distributions of power" (Acker 1992). Various recently published European level documents on women and science draw on the gendered organisations approach. Notably the European Commission report on women and science policy, known as the ETAN report (European Commission 2000), refers to gender as a key organisation principle in scientific institutions. Two other European Commission reports provide a specific example to illustrate how scientific organisations are infused with gendered processes (European Commission 2004; European Commission 2005). Both reports present evidence to support the claim that the systems for identifying and evaluating excellence in scientific work conspire to disadvantage women scientists. Similarly, in the academic literature, Benschop and Browns (2003) discuss how the social construction of scientific quality is one mechanism by which gender is 'done' and women disadvantaged, in academia. Eisenhart (1994) conducted an ethnographic study of a biological science-based not-for-profit organisation. She found that the organisation had developed a reputation for being a good place for women to work by appearing gender neutral. However under the surface, a taken for granted male way of doing things actually makes it more difficult for women to 'measure up', surreptitiously hampering women's careers. Etzkowitz (2000) argues more generally that women are not easily assimilated into academic science communities of practice which are masculine in nature. Etzkowitz (2001) also believes that the two-track research system (i.e. either being a lecturer or a contract research worker) represents a gender-related hierarchical structure which prevents women from owning an independent scientific career.

NOTES

1. It would be useful to confirm this indication via analysis of molecular bioscience students First Destinations (HESA collect information about graduates' SIC and SOC employment destinations six months after graduating). The CRAC publication 'What Do PhDs Do? - Trends' does not distinguish between men and women.

7 Conclusions

The findings of this survey were that certain gender equality and diversity issues at the doctoral level affect both chemistry and the molecular biosciences (and more than likely other bioscience disciplines). These issues are evidenced by the apparent tendency:

- For women to more be likely than men to report finding research repetitive and frustrating;
- For supervision problems to more often affect women than men;
- For women to be less likely than men to express the intention to pursue a research career on completion of their PhD (although molecular bioscience PhD students were more likely to be planning to pursue research in the near term than chemistry PhD students);
- For women to be less likely than men to want to stay in science in the university sector in the longer term (a perceived incompatibility between motherhood and the academic career was cited to account for this).

However, the results of the survey also suggested that the career intentions of chemistry and molecular bioscience PhD students differ in that it would appear that:

- A significantly smaller proportion of female molecular bioscience PhD students, compared to female chemistry PhD students, become deterred from pursuing research further over the course of their doctoral study;

- Amongst those with an intention to pursue research, a larger proportion of female molecular bioscience PhD students than female chemistry PhD students intend to stay in academia on completion of their doctoral study.

This suggests that certain equality and diversity issues at the doctoral level operate in chemistry but not in the molecular biosciences.

8 Recommendations for Further Study

A number of opportunities for further research work arise from the surveys of both molecular bioscience and chemistry.

- The survey should be repeated for other disciplines to examine how career intentions of PhD students vary throughout their PhD studies. With data on a more disciplines it may be possible to suggest concrete reasons for the different attitudes to research that have between observed for chemistry and molecular bioscience PhD students, and in particular females.

- The survey should also be repeated in other European countries perhaps with support from the European Commission.

- A similar survey tool should be developed for contract research workers. It will be interesting to see how the attitudes of men and women towards research careers change with time during work

as a contract research worker, and whether there are variations between subjects. Alternatively, questions could be added to the Athena Survey of Science, Engineering and Technology (ASSET) aimed specifically at contract research workers, and/or an ASSET survey specifically aimed at contract research workers could be developed.

- Qualitative research is needed to explore the important cultural differences between the scientific disciplines and the influence these have on gender equality and diversity.

- It may appropriate to undertake a broad evaluation of, or research on, the quality of careers guidance that PhD students receive.

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Appendix 1

Methodology (continued)

Generalising the Results Had recipients of the survey been selected using a probability sampling technique it would have been possible to generalise the results of the survey to the entire doctoral molecular bioscience population (with estimates of statistical confidence). However, it was necessary to assess the likelihood that the results of this survey could be safely generalised, using other means. There are three principal means by which this was done:

(a) The characteristics of the students who were sent a questionnaire were compared with the characteristics of the biological science PhD student population (See Appendix 2);

(b) The demographic characteristics of the students who were sent a questionnaire were compared with the characteristics of those who responded (See Appendix 3);

(c) The chi-squared test statistic was used to assess whether observed gender differences were likely to have been due to chance or sufficiently large to be considered 'statistically significant'. The results in this report are statistically significant at the 5% level unless otherwise stated.

Based on the results of the first two procedures it was considered that the students who responded to the survey were broadly representative of the target population as a whole. Whilst the third check should strictly speaking only have been performed if the data were collected using a probability sampling technique (whereby all members of the target population would have equal probability of being selected), it was carried out to aid interpretation, and in the knowledge that major bias was unlikely to be present in either the sample or responses. The favourable outcomes of the three checks, on balance, suggested it would be reasonable to generalise the results to the wider molecular bioscience PhD population, with the caveat that the results be treated as indicative only (i.e. a degree of caution should be maintained).

Drawing Comparisons Throughout this report, where appropriate, comparisons are made between the findings of the 2006 RSC survey of chemistry PhD students and those of the molecular bioscience survey. However, where analysis by respondent stage is presented, the reader should bear in mind that an exact comparison between chemistry PhD students and molecular bioscience PhD students was not possible for the following reason. The RSC surveyed chemistry PhD students in the summer whereas the survey of molecular bioscience PhD students took place in the winter. Therefore, at the time of the survey, if it is assumed that most PhD students begin in the autumn (at the start of the academic year), then molecular bioscience respondents in their first year of study would have only just begun their PhD whereas chemistry respondents would have been working on their PhD for some months. In the same way, molecular bioscience respondents in their final year would not have been as close to finishing as chemistry respondents would have been. This is of consequence because as demonstrated by the findings of the RSC survey, the attitudes of respondents towards their doctoral student experience and their career intentions can change over the course of their doctoral journey.

Cohort Effects It is important for the reader to be aware that the trends observed in relation to the career intentions of chemistry PhD students over the course of their doctoral studies, may have been spurious rather than due to cohort effects. Although a quasi-panel analytical approach was taken, the 2006 RSC survey was cross-sectional and did not have a panel/longitudinal design (the present survey shared this design). In reality it is highly improbable that the trend was spurious.

Appendix 2

The Biological Science PhD Student Population

Table 9 provides a comparison between the demographic characteristics of the students who were sent a questionnaire and the characteristics of the biological science PhD student population. The source of the latter figures is Higher Education Statistics Agency Student Data relating to the year 2006-07.

Table 9: Number of Questionnaires Distributed Compared with the Number of Biological Science* PhD Students Registered at UK HEIs

	UK Domiciled		EU/Overseas Domicile		
	Yr 1	Yr 2 Onwards+	Yr 1	Yr 2 Onwards+	Total
Men	114/428	391/1938	112/260	263/868	**880/3494**
Women	163/316	486/1593	121/270	265/860	**1035/3039**
Total	277/744	877/3531	233/530	528/1728	**1915/6533**

*Biological Science is defined as students registered as studying Biology; Botany; Broadly-based programmes within biological sciences; Genetics; Microbiology; Molecular biology, biophysics & biochemistry; and Other in biological sciences.

+ HESA Student Data only distinguishes first year students.

Table 10: Proportion of Biological Science PhD Students to whom the Survey Questionnaire was Distributed

	UK Domiciled		EU/Overseas Domicile		
	Yr 1	Yr 2 Onwards+	Yr 1	Yr 2 Onwards+	Total
Men	27%	20%	43%	30%	**25%**
Women	52%	31%	45%	31%	**34%**
Total	37%	25%	43%	31%	**29%**

Appendix 3

The Response/Recipient Population
Table 11 shows a comparison between the demographic characteristics of the students who were sent a questionnaire and the characteristics of those who responded.

The disaggregated response rates are slightly elevated above the overall response rate because 6 institutions did not provide demographic data relating to their students. A little over 10% of the questionnaires distributed are excluded from Table 12.

Table 11: Number of Respondents Compared with Number of Questionnaires Distributed (full-time students only)

	UK Domiciled (number returned/number sent)			EU/Overseas Domicile (number returned/number sent)			
	Yr 1	**Yr 2**	**Yr 3/4+**	**Yr 1**	**Yr 2**	**Yr 3/4+**	**Total**
Men	34/114	20/139	39/252	29/112	25/117	18/146	**165/880**
Women	39/163	44/172	86/314	35/121	33/123	36/142	**273/1035**
Total	73/277	64/311	125/566	64/233	58/240	56/288	**440/1915**

Table 12: Disaggregated Response Rates

	UK Domiciled (number returned/number sent)			EU/Overseas Domicile (number returned/number sent)			
	Yr 1	**Yr 2**	**Yr 3/4+**	**Yr 1**	**Yr 2**	**Yr 3/4+**	**Total**
Men	30%	14%	15%	26%	21%	12%	**19%**
Women	24%	26%	27%	29%	27%	25%	**26%**
Total	26%	21%	22%	27%	24%	19%	**23%**

Part-time students: 148 questionnaires were distributed and 14 were returned which is a 9% response rate.

Appendix 4

Participating University Departments

30 university molecular bioscience departments participated in this project by disseminating the survey questionnaire to their doctoral students. Tables 13 and 14 provide anonymised information about those departments.

Table 13 concerns the size of participating molecular bioscience departments and Table 14 provides information about how many of the participating universities were 'new' universities. The information is banded by where in the UK the participating departments were located.

Table 13: Participating Departments, by Size

	Total Number of PhD Students in participating Biomolecular Science Departments		
Location	**<50**	**50-100**	**>100**
Scotland	-	2	2
Wales	-	-	-
Northern Ireland	-	1	-
Southern England	4	3	1
London	1	1	-
Midlands	5	1	2
Northern England	1	1	3
Eastern England	1	-	-

Table 14: Participating Departments, by Type

	University Type	
Location	Pre-1992	Post-1992
Scotland	4	-
Wales	-	-
Northern Ireland	1	-
Southern England	7	1
London	2	-
Midlands	6	2
Northern England	5	-
Eastern England	1	-

Appendix 5: The Questionnaire

DOCTORAL STUDENTS' CAREER INTENTIONS SURVEY

The Biochemical Society is very keen to find out more about doctoral students' study and placement experiences and their career intentions.

We would be grateful if you could complete and return the attached questionnaire, in the freepost envelope provided, by Friday 14th December 2007.

The Royal Society of Chemistry is assisting with the administration of the questionnaire and is handling the freepost envelopes on behalf of the Biochemical Society.

The questionnaire should take you no longer than 20 minutes to complete. It is unlikely that you will need to answer all the questions. Your responses will be anonymous.

Please note, we are interested in your responses regardless of whether you intend to pursue a career as a scientist.

Fill in your contact details on the enclosed postcard and return it together with your completed questionnaire, and you will be entered into a prize draw to have a chance of winning one of the 12 following prizes:

First Prize:	£100 Amazon token
Second Prize:	£50 Amazon token
Third Prizes:	10 x £10 Amazon tokens

Your contact details will be retained separately to your completed questionnaire to ensure your responses remain anonymous. The prize draw will take place in early January so be sure to have responded to the survey by the deadline (14th December 2007).

We would like to thank you in advance for helping.

For enquiries about this survey please contact Rebecca Smith (rebecca.smith@biochemistry.org).

- Please write in BLOCK CAPITALS, in black or blue ink.
- Answer multiple choice questions using a cross:

Section A: About You

A1. Age: …… years

A2. Sex: Male Female

A3. At which university are you registered as a PhD/DPhil student?

A4. Are you registered as a Home student, EU student or Overseas student?
Home student EU student Overseas student

A5. Are you a member of a learned society (professional organisation) e.g. Biochemical Society?
Yes (please specify) No

Section B: Your First Degree

B1. What is the title of your first degree (e.g. Biochemistry, Biochemistry and Medicinal Chemistry)?

B2. Which qualification did you obtain?
BSc/BA Other (please specify)

B3. Which degree classification did you obtain?
First (1) Upper Second (2i) Lower Second (2ii) Third (3) Other

B4. At which university did you obtain your first degree?

Section C: Your PhD or DPhil

C1. Are you registered as a full-time or part-time PhD/DPhil student?
Full-time Part-time

C2. Which year of your PhD/DPhil studies are you in (e.g. 2)?
Year

C3. Which of the following statements best describe the main reason(s) you decided to do a PhD/DPhil? Please mark no more than two boxes.

Out of interest and enthusiasm for science
I have an aptitude for science
I was inspired/encouraged by a tutor
A PhD is a pre-requisite for the career I want
To enhance my earning potential
To give myself time to think about what to do next
For financial reasons
Don't know
Other (please specify)

C4. Have you had financial support during your PhD/DPhil? (e.g. from a research council or via a university scholarship)

Yes – Go to Question C5 No – Go to Question C6

C5. What was/is the source of this financial support? Please mark all that apply.

Research Council
CASE Award
Charity e.g. Wellcome
University
Other (please specify)

C6. Are you pleased you decided to do a PhD/DPhil?

Yes – Go to Question C7
No, I somewhat regret my decision – Go to Question C8
Don't know – Go to Question C9

C7. Which of the following statements, best describe the main reason why you are pleased with your decision to do a PhD/DPhil? Please mark only one box.

I enjoy researching my topic
I will have the experience I need for the career I want
I will have a better understanding of a scientist's work
I will have a better idea about my career plans
Don't know
Other (please specify)

If you have answered Question C7, please now go to Question C9

C8. Which of the following statements best describe the main reason why you somewhat regret deciding to do a PhD/DPhil? Please mark only one box.

It's hard academically
Financial worries
I've felt isolated
I no longer want to work in science
Don't know
Other (please specify)

C9. What, if any, are the main 'downsides' (i.e. negatives aspects) of doing PhD/DPhil research? Please mark all that apply.

Working long and irregular hours
Repetitive and/or frustrating
Loneliness
Financial/funding issues
Other (please specify)
Working environment
Few role models
Supervision problems
No downsides

C10. In which discipline is your PhD/DPhil research? Please mark the most appropriate box.

Biochemistry	Molecular Biology	Molecular Genetics	Cell Biology
Bioinformatics	Cancer research	Biotechnology	Immunology
Toxicology	Environmental Biology	Plant Science	Microbiology

Other (please specify)

C11. How would you describe your relationship with your main supervisor?
Excellent Good Fair / Average Poor Very poor

C12. How could your experience of supervision be enhanced, if at all? Please mark all that apply.

Could not be enhanced
More general advice & mentoring
Other (please specify)
More research support
More careers advice

C13. Would you say you possess the majority of general skills that employers often look for?
Note: 'General skills' refers to non-technical skills e.g. communication, team-working and problem-solving skills

Yes No Don't know

C14. During the course of your PhD/DPhil, have you joined any social networking groups or any societies related to your PhD/DPhil studies? Please mark all that apply.

Facebook group University-run group Women in Science group
Mentoring scheme Learned society (professional organisation) (please specify)
Other (please specify)

Section D: Industrial Placements and Your Experiences

D1. Have you been on an industrial placement as part of your studies? Please mark all that apply.

Yes as an undergraduate Yes as a postgraduate No never

D2. Are you expecting to spend any time working in industry before the end of your PhD/DPhil studies?

Yes No Don't know

D3. Have you had experience of science-based industry, apart from as part of your studies (e.g. as an intern)?

Yes No

D4. Overall, have you enjoyed your experiences of industry?

Yes No Neutral Not applicable

Section E: Your Next Steps

E1. How much have you planned your next (i.e. once you've completed your PhD/DPhil studies) career steps?

Fully A little Not at all

E2. Have you already accepted a job offer or already been accepted on a programme of further study or training, due to start on or near completion of your PhD/DPhil studies?

Yes – Go to Question E3 No – Go to Question E4

E3. Which of the following best describes the job or study/training offer you have accepted? Please mark one box.

Further Study: scientific	Further Study: non-scientific
Teacher Training	Academic: post doc
Academic: lecturer	Scientific Publishing
Scientist: industry/commerce	Scientist: public sector
Manager/Consultant	IT Professional or Technician
Writer/Journalist/Broadcaster	Human Resources/Recruitment
Sales (inc. technical)	Marketing/PR Officer
Financial Professional	Administrator
Government/Civil Service	Other (please specify)

If you have answered Question E3, please now go to Question F1

The remaining questions in this section are about your career intentions on completing your PhD/DPhil studies

E4. On (or shortly after) completion of your PhD/DPhil studies, do you intend to seek paid employment?

Yes – Go to Question E5 No – Go to Question E12

E5. Do you intend to seek employment in the UK or abroad?

UK Abroad Would consider either Undecided

E6. Do you intend to seek employment in role which requires a scientific background?

Yes - Go to Question E7
No - Go to Question E12
Don't know - Go to Question E12

E7. Do you intend to seek employment as a research scientist?

Yes – Go to Question E8
No – Go to Question E12
Don't know – Go to Question E12

E8. Do you intend to seek employment as a research scientist in any of the following sectors? Please mark all that apply.

University (post doc/lecturer)	Public Sector
Pharmaceutical Industry	Chemical Industry
Food or Drink Industry	Defence
Water, Electricity, Oil or Gas	Medical Services
University spin-off R&D	Commercial Research or Services
Don't know	Other (please specify)

E9. What appeals to you about working in the sector(s) you have marked/specified?

E10. What is unappealing to you about working in the other sectors?

E11. My experience of research science as a PhD/DPhil student has…Please mark the most appropriate statement

... made me more intent on pursuing a career as a research scientist
... given me doubts about pursuing a career as a research scientist
… at present had no influence my career intentions

If you have answered Question E11, please now go to Question F1

E12. Did you begin your doctoral studies thinking you would have a career as a research scientist?

Yes – Go to Question E13
No - Go to Question E14
Don't know – Go to Question E14

E13. What has made you change your mind about pursing a career as a research scientist?

E14. Do you any of the following options describe what you intend to do on completion of your PhD/DPhil studies? Please mark all that apply.

Further Study: scientific	Further Study: non-scientific
Teacher Training	Scientific Publishing
Manager/Consultant	IT Professional or Technician
Patent Work	Writer/Journalist/Broadcaster
Science Policy	Human Resources/Recruitment
Sales (inc. technical)	Marketing/PR Officer
Financial Professional	Administrator
Government/Civil Service	Career Break
Travel	Voluntary Work
Other (please specify)	

Section F: Your Career Plans

F1. In the short-term future (i.e. in 3-5 years time), which of these job(s) do you think you are most likely to be doing? Please mark no more than two boxes.

Academic	Scientist: industry/commerce
Scientist: public sector	Scientific Publishing
Manager/Consultant	IT Professional or Technician
Patent Work	Writer/Journalist/Broadcaster
Science Policy	Human Resources/Recruitment
Sales (inc. technical)	Marketing/PR Officer
Financial Professional	Administrator
Government/Civil Service	Teacher
Don't know	Other (please specify)

F2. In the longer-term future (i.e. in 6-10 years time), which of these job(s) do you think you are most likely to be doing? Please mark no more than two boxes.

Academic	Scientist: industry/commerce
Scientist: public sector	Scientific Publishing
Manager/Consultant	IT Professional or Technician
Patent Work	Writer/Journalist/Broadcaster
Science Policy	Human Resources/Recruitment
Sales (inc. technical)	Marketing/PR Officer
Financial Professional	Administrator
Government/Civil Service	Teacher
Don't know	Other (please specify)

F3. How important to you is it to have a career which involves the following?
Please mark one box in each row.

	Very important	Important	Somewhat Important	Not Important
Lots of variety in the work				
Prospects for receiving a high salary				
Access to state-of-the-art equipment/resources				
Making a positive difference				
Prospects for a leadership role				
Flexible working options				
Good 'health and safety'				
Diversity of roles				
Job security				
Extensive benefits packages and/or bonuses				
Living in a pleasant area				
Autonomy at work				
Working at an unhurried pace				
Working at a fast pace				
Holding a respected position				

Section G: Careers Guidance

G1. How would you rate your awareness of career options within academia?

Very Good Good Adequate Poor Very Poor

G2. How would you rate your awareness of career options outside academia?

Very Good Good Adequate Poor Very Poor

G3. Prior to undertaking your postgraduate studies did you receive careers advice from any of the following sources? Please mark all that apply.

University careers service	Industrial placement supervisors
Careers/recruitment fairs	Your supervisor
Other academic staff	Research council
Family or friends	None of the above – Go to Question G6

G4. What was the topic of the careers advice you received (prior to undertaking postgraduate studies)? Please mark all that apply.

Types of jobs available and/or where to look for jobs
Filling out application forms and writing a CV
Insights into working in particular jobs e.g. pay, conditions
Interview techniques
Don't know
Other (please specify)

G5. On the whole, did you seek out this careers advice or was it offered to you unsolicited (prior to undertaking postgraduate studies)? Please mark only one box.

I sought the advice	The advice was offered to me unsolicited
Both	Don't know

G6. During your postgraduate studies have you received careers advice from any of the following sources? Please mark all that apply.

University careers service
Industrial placement supervisors
Careers/recruitment fairs
Your supervisor
Other academic staff
Research council
Family or friends
None of the above – Go to Section H

G7. What was the topic of the careers advice you've received (during your postgraduate studies)? Please mark all that apply.

Types of jobs available and/or where to look for jobs
Filling out application forms and writing a CV
Insights into working in particular jobs e.g. pay, conditions
Interview techniques
Don't know
Other (please specify)

G8. On the whole, did you seek out this careers advice (during your postgraduate studies) or was it offered to you unsolicited? Please mark only one box.

I sought the advice	The advice was offered to me unsolicited
Both	Don't know

Section H: Your Comments

In the space below (or on a separate sheet) we would be grateful for your comments on all or some of the following:

- your doctoral study experience
- your perceptions/experiences of working as a scientist
- your perceptions/experiences of working in the university sector versus working in industry/commerce
- your career plans
- the level/nature of careers advice you have received

END OF QUESTIONNAIRE

May we contact you?

If you would not mind being contacted by the researcher to discuss your responses to this questionnaire, please fill in your name and best contact telephone number. This is entirely optional.

If you would prefer that your responses to the questionnaire remain anonymous, please do not fill in your details.

Name: Tel. No:

Please now return this questionnaire to us in the freepost envelope provided.

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