WOMEN PHYSICISTS SPEAK

A report from the UK delegation to the first international conference on Women in Physics, held to examine the under-representation of women in Physics and to develop strategies to increase their participation

Preface

In March 2002, the International Union of Pure and Applied Physics (IUPAP) held the first international conference on Women in Physics, devoted to understanding the reasons for the underrepresentation of women in physics worldwide, particularly at the more senior levels.

The conference was attended by a large number of very distinguished women and men who had devoted some considerable time to thinking about the issues. Delegates agreed a number of actions intended to raise the profile of physics among women and to make it easier for women to pursue a career in this area. The delegates came almost exclusively from academia and the topics discussed centered largely on aspects of education and research.

We should like to thank the Institute of Physics for helping to make our visit to Paris possible and also for financial assistance in publishing this report. We should also like to thank the Association of Women in Science and Engineering for hosting this report on its website at ***http://www.awise.org****.*

Professor Gillian Gehring (team leader)	University of Sheffield
Dr Yasmin Andrew	JET project
Dr Joanne Baker	University of Oxford
Professor Sandra Chapman	University of Warwick
Dr Dimitra Darambara	University College London
Dr Helen Heath	University of Bristol
Mrs Ann Marks	Physics teacher

CONTENTS

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Executive Summary

Women are currently under-represented in every area of physics. This report presents in a UK context the resolutions and recommendations from the first IUPAP international conference on Women in Physics. Delegates came almost exclusively from academia, so the topics discussed centred on education and research. Some recommendations are specific to physics; others go much wider. (Note that throughout this report the term physics is intended to also embrace astronomy.) It is important to judge whether gender equality has been achieved by monitoring outcomes, not by inspecting the process.

The following recommendations are directed at UK communities and bodies

Physics and astronomy communities

If there is to be a qualitative change in the participation of women in physics and astronomy, attitudes of mind and procedures in university departments need to change. Both men and women should ensure that all procedures are transparent and that female physicists receive career guidance and support equivalent to that provided for their male colleagues. This support should recognize both the negative peer pressure and the isolation that many women physicists experience.

Departmental structures need to be changed to allow women to combine a career in physics with raising children. The physics community needs good students and should do more to demonstrate to young people the fascination and usefulness of physics and astronomy. It is important to increase the uptake of physics as a degree subject, particularly for women.

The Institute of Physics and the Royal Astronomical Society

The Institute of Physics and the Royal Astronomical Society should each regard the increased participation of women as part of their core strategy and offer an imaginative lead to the community. Their current initiatives are very welcome and they should look to expanding them. These organisations do facilitate women's networks and support mentoring schemes; in cooperation with international organizations, they should support the increased participation of women worldwide. Both institutions should regularly collect and publish statistics relating to both education and employment and should set up a database and make it widely available.

Heads of university physics departments

Departments should strive for higher participation of women at all levels and should ensure that all students work in a supportive environment and receive good career guidance. Particular care needs to be taken over career development advice given to women, recognizing that they are unlikely to have older female colleagues as a source of informal advice. Departments should encourage women to apply for academic posts and should allow part-time working or job shares for all members of staff who want to spend time with their children whilst continuing with their careers.

Examination boards and schools

Examination boards and schools need to give the highest priority to measures that will increase the number of girls studying physics to A level and at university. Attractive career materials are needed to interest girls in the subject from an early age, so that they are drawn in rather than feel pushed.

Vice-Chancellors

University Vice-Chancellors should ensure that at all levels the university appoints women to senior positions in the same proportion as they are represented on university staff, recognizing that women have much to offer that may be different from men. Promotion must be fair to each gender and there should be an established a career path for women who work part-time or return to work after a break; men should also be able to opt for reduced duties in order to undertake childcare. They should ensure that procedures for promotion and salary revision are transparent.

The Higher Education Funding Councils

The UK's Higher Education Funding Councils should recognize that the Research Assessment Exercise (RAE) plays a very important role in all academic appointments in physics and astronomy. The RAE needs a transparent policy, binding on all panels, to ensure fair treatment of women. The Funding Councils should insist that universities either justify the inequalities highlighted by the Bett report or take immediate action to raise the pay of women academics to equal that of men.

Research Councils

The Research Councils must review all funding schemes to ensure that there is no gender discrimination, in particular with respect to age, and must monitor/question the fairness and objectivity of peer review. Workshops on the career development and training of short-contract researchers should be organised and coordinated with universities and industry. The research councils should look to funding the better pay and conditions for all contract research workers recommended by the Roberts' report as this would be of particular benefit to women.

Industry

Industry should provide gender-specific initiatives and parental advisory and networking services. There should be opportunities for flexible working patterns, part-time working, job sharing or home-working plus family-friendly practices together with childcare facilities, a mix of maternity packages (paid paternity and maternity leave) and other support mechanisms such as crèche facilities. Technical training should also be provided during a transition period back into employment.

Central Government

Central Government, as both a consumer and a sponsor of science, has a clear responsibility to promote gender equity. There should be continued support for all organizations that encourage people to be better informed about science. Institutional discrimination in science, education and technology (SET) employment should be broken down by severing assumed ties between chronological age and experience. Government should remove the financial disincentive to employers of operating a job-share and should provide good statistics that will enable the community to establish the efficacy of any future initiatives. Monitoring and evaluation systems should be embedded in all schemes. There should also be more government support for awareness-raising activities and more women promoted to senior and policy-making positions.

I. Setting the Scene: the IUPAP Conference

The International Conference on Women in Physics was sponsored by the International Union of Pure and Applied Physics (IUPAP) and held in Paris in March 2002. The meeting was attended by over 300 distinguished delegates from 65 countries. In most cases, the team included women who are heads of major laboratories or very large research groups. Men who attended included a number of presidents or ex-presidents of national physics societies, the current president of the European Physical Society (EPS) and representatives from the EU.

The primary purpose of the conference was to understand the severe under-representation of women in physics worldwide and to develop strategies to increase their participation. The conference served as an initial focal point for ongoing activities to implement these strategies. This report was prepared by the UK team who attended; a full report of the conference is available on the web at *http://www.if.ufrgs.br/%7Ebarbosa/conference.html* [(1)].

In UK universities, astronomy is taught and researched within physics departments, so throughout this report "physics" should be read as "physics and astronomy".

The conference passed a number of resolutions that were expected to be binding on all countries plus recommendations that were more area-specific. These are given in Appendix I. Section VI of this report puts these into a UK context.

The conference was organized by academic physics societies and there were very few delegates from industry. The main subject was therefore the participation of women in universities and research institutes. Problems pertaining to career progression for women in industry and the career structure for those who do not take doctorates were not discussed. The meeting's scope was thus very similar to the European Technology Assessment Network (ETAN) report[(2)] which looked at the problems for women in academia in Europe for all the sciences. Employment statistics for universities are readily available and one institution may be easily compared with another within one country; comparable information on industry is less easy to assemble.

Is it of any concern in the UK that women are under-represented in physics and that this under-representation increases with seniority? Or is it a fact of life – like the observation that women can bear children? Certainly, the UK government is concerned. The conference coincided with the government signalling its desire to see a dramatic change in the level of participation of women in science. The Rt Hon Patricia Hewitt, Trade and Industry Minister, has recently said[(3)]: "Whilst we have a number of excellent small initiatives, I am concerned by the lack of significant progress, the low number of women professors and the lack of recognition given to women in science. I believe we must pursue a more aggressive, joined-up strategy to increase the participation of women in science and engineering." The EU has also included gender equality as a major area of concern in the 6th Framework programme.

II. Areas of concern

Four main areas of concern exist for physicists and astronomers:

- The recruitment of girls onto physics and physics-related degree courses.
- The problems in academia for women seeking to obtain their first tenured post.
- Accumulated disadvantage, resulting in women not achieving to their potential.
- Balancing a career in physics with a family, the availability of childcare, part-time working and posts for returners.

There seems to be a genuine desire among the political, scientific and engineering establishments for change. Despite this, change has not been rapid. Problem areas can be summarised as follows:

- The popular view of physics as both hard and dull; physicists stereotyped as boring grey-haired nerd-like males
- The severe shortage of well qualified physics teachers.
- Institutional practices – particularly the long period of unsettled academic apprenticeship (postdoctoral research) that is unattractive to women.
- Many important career steps coincide with a woman's major childbearing years.
- A lack of career structure for women who wish to work part-time or to return to work after a career break.
- Unconscious prejudice in the physics and wider communities, often unrecognised because of the isolation experienced by many women physicists.
- The shortage of visible role models at all levels.
- Flagrant gender discrimination (there a few are well documented examples).

In most cases, the difficulties that women experience arise because institutions have grown up that fit the male pattern of working. Some women have adapted to this environment, obscuring the fact that it poses serious problems for the majority. Gender bias occurs, for the most part, unconsciously and one aim of this report is to raise awareness in the community. The House of Commons Select Committee on Science and Technology 6th Report[4], published in 2001, states "Women remain under-represented within the SET community, particularly in the mathematically based sciences and engineering. And women who are working in SET appear to be less successful than their male colleagues."

As remarked at the conference, no-one knows how to solve all these problems. Some countries are better in some areas than others. This report is intended to help the UK learn from best practice worldwide.

III. Physics

3.1 The importance of physics

Physics plays a key role in understanding the world in which we live, and physicists contribute strongly to the welfare and economic development of nations. The knowledge and problem-solving skills of physicists are essential in many professions and industries and to society at large.

To thrive in today's fast-changing, technological world, every country must achieve a highly educated population of both women and men, fully engaged in making decisions important to their well being. Many interdisciplinary teams working on engineering problems contain a good proportion of physicists. In a recent Institute of Physics members' survey, approximately 15% (16% men and 6% women) reported that they regarded themselves as an engineer or have obtained chartered engineering (CEng) status.

A knowledge of physics is an important part of general literacy for every citizen. In addition, advancing physics understanding is an exciting intellectual challenge that benefits from the diverse and complementary approaches taken by both women and men from many cultures. Women currently can and do contribute to this quest and, through physics, to the welfare of humankind – but only in small numbers; women are an underused "intellectual reserve". Only when women participate fully as researchers in the laboratory, as scientific leaders and teachers, and as policy makers will they feel equal partners in a technological society.

3.2 Physics in the UK

The UK is justly proud of the contribution that its physicists and astronomers have made to the advancement of knowledge and technology. In the last century, 20 Nobel Prizes were awarded to UK physicists.

A recent international panel assessed research in the UK and found it to be world- leading in many areas. Over the last century the number of women able to make a career in science has increased markedly and there have been a number of very distinguished women – for example, the crystallographer Dame Kathleen Lonsdale, the astronomer Margaret Burbidge, the theoretical physicist Elizabeth Gardner and the nuclear and medical physicist Daphne Jackson. There are currently 15 women professors of physics of whom two (Carole Jordan, Oxford University, and Athene Donald, Cambridge University) are Fellows of the Royal Society. They are in universities with a strong research departments (seven are working in grade 5* departments, six in grade 5 and two in grade 4).

There are also other very distinguished academic women who obtained their first degree in physics before moving into other areas of science, including Dame Julia Higgins FRS, Professor of Polymer Science at Imperial College London, Janet Thornton FRS, Director of the European Bioinformatics Institute and Dr Janet Thompson who was, until recently, Head of the Home Office's Forensic Science Service (also Chair of the ST&M Council and Deputy Chair of EMTA), and Professor Julia Goodfellow, Chief Executive of the BBSRC.

The percentage of girls taking physics at A level has been 21(+/-1)% since 1993. Other sciences have seen an increase in female participation over a comparable period. The expansion in student numbers in recent years has passed physics by[5]. The total number of physics undergraduates has remained static and the number of women gaining physics degrees has since 1995 stayed at 500 – approximately 20% of the total number of physics degrees awarded.

This implies that once a girl has chosen to study A level physics she is as likely to take a physics degree as is a boy studying A level physics. Since all boys and girls have studied some physics to GCSE, the girls' pre-A level experience of physics is discouraging them from studying the subject. It is very possible that an initiative taken primarily with the aim of increasing the attractiveness of physics to women might also result in more men finding it attractive.

A recent study of Oxford undergraduates[7] found that a higher percentage of women at Oxford have A level physics than DTI figures show for any other UK university. This perhaps suggests that clever girls are persuaded to take A level physics to show that they have the brains to do it – confirming the view that physics is a hard subject at A level. However, the percentage of girls studying physics at Oxford is only slightly higher than the average.

The Oxford study also found that over half the girls studying physics had a close relative with science qualifications, probably giving them an insight into possible careers and possibly inspiring them. There is a clear challenge to inspire those who do not get encouragement from their home environment to study science.

Physics degrees allow entry to careers in many areas but a great number of girls who take A level think there are few job openings which would use their physics knowledge rather than their analysis skills. This may be partly because many physicists work in applied physics with "engineer" in their job title. As a physics degree is perceived as difficult, girls who do not have direct personal contact with physicists are perhaps unlikely to choose physics.

There are many views on when promotional activities are the most effective and a common view is that age 13-14 is optimum. Liz Whitelegg has commented on this[8]: "The Girls into Science and Technology (GIST) project, which took place in schools in Manchester, England, between 1979 and 1984, monitored the effectiveness of positive action programmes on girls' achievements in science. The findings were disappointing. The researchers felt that the interventions took place too late; by 13 or 14 many girls had already formed negative attitudes toward science (Kelly et al[9])".

The situation is exacerbated by the shortage of well qualified physics teachers. Only 200 per year are entering physics PGCE courses – insufficient to replace those retiring. At present about two-thirds of physics teachers do not have a degree in physics and one-third of those teaching physics have not even passed A level physics. This point was highlighted by the Institute of Physics Inquiry into Undergraduate Physics which stated that "Only those with confidence and competence can teach their subject well, engaging and enthusing pupils and motivating them to pursue careers in science and engineering. Unfortunately, teaching is not seen as an attractive career option for physics graduates, and the number entering is at an all-time low." The same point was emphasized more recently by the Roberts report[6] into the supply of scientists and engineers in the UK.

Because the percentage of women studying physics has remained low, the percentage of physics teachers who are women is also low. This has compounded the problems of providing good role models for girls.

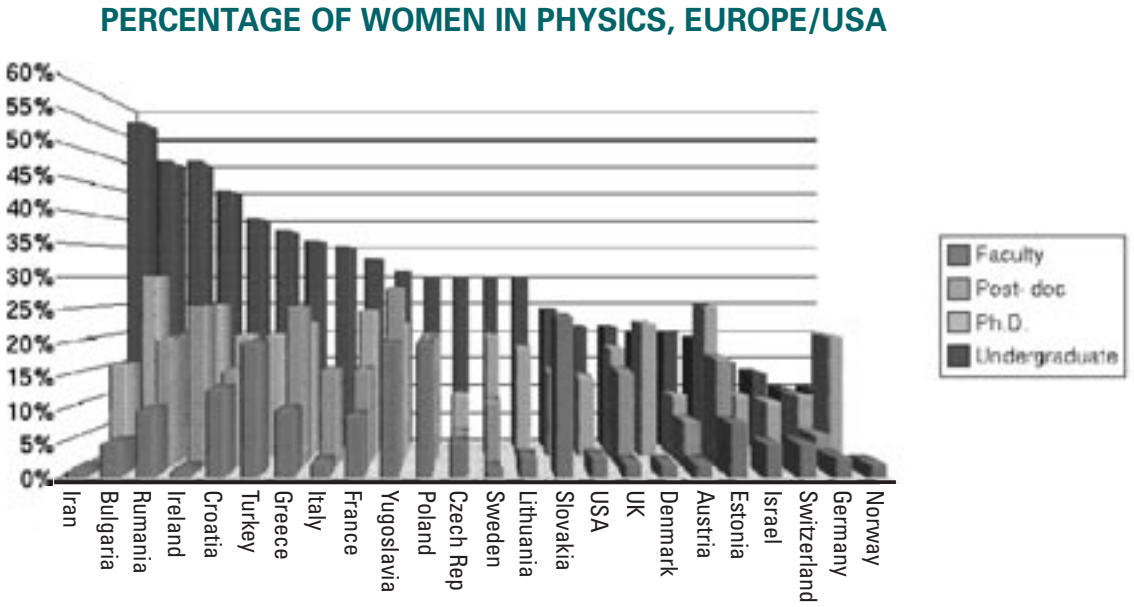

FIGURE 1. DATA FROM THE IUPAP CONFERENCE – compiled by Karoline Wiesner [1]

The data in figure 1 show that the UK is worse at recruiting female undergraduates than several of its European neighbours. The figures for graduate students and post-docs (research associates) are distorted in the UK and most of Western Europe by the large fraction of foreign students who opt to study or work in these countries and by the fact that many UK physicists choose to work abroad as a research assistant (RA) for some period of time. Concern was expressed at the conference that degrees mean different things in different countries – hence the only really sensible measure is how the statistics are evolving in any one country.

The academic figures are even more distorted because an academic lifetime may be as long as 40 years. The number of women physicists appointed to academic posts within UK universities in the great expansion period of the 1960s was very close to zero. A large cohort of male academics is still moving through the university system and will have retired by about 2005. The Roberts report[6] found that of 25% of all academics in physics and other mathematical sciences were aged over 55. The figures given in Appendix II show that there was one woman in the cohort of 138.

The dearth of women physics academics born in the 1930s and 1940s seems to be a special phenomenon associated with growing up in the period immediately following the second world war and is not repeated internationally. One of the consequences of this is that almost all the graduate physicists who are older than, say, 40 were taught physics in a university department that had no women on the staff. The perception of physics as a subject where the only real professionals are male was current for many years and still affects the subject at all levels.

3.3 UK LEARNED SOCIETIES FOR PHYSICISTS

The largest society for physicists is the Institute of Physics. This is both a professional and a learned society with currently 37,000 members. Many astronomers will be members of the Royal Astronomical Society and members enjoy reciprocal membership with the Institute of Physics. There are no single-subject astronomy departments in UK universities but all are joint with either physics or, in a few cases, mathematics. In this report, "physics" means "physics and astronomy" unless specifically stated otherwise.

Many physicists work in areas that may be described as electrical engineering. They frequently become chartered engineers as well as or instead of chartered physicists and are likely to join the Institution of Electrical Engineers (IEE) as well as or instead of the Institute of Physics .

3.4 Why physics is special

Many of the problems raised at the conference are common to other sciences and indeed to other academic disciplines outside the science, engineering and technology (SET) area. But there are two ways in which physics feels it is "special".

The first is the isolation of many women physicists. Most do not have other women physicists around them who are five to ten years older and to whom they might naturally turn for an occasional word of advice. (This can be alleviated to some extent by networks across institutions and even across national boundaries, but does not really compensate for the absence of someone down the corridor with whom they might share experiences.) The obvious solution is to make male physicists more alert to the problems women may face and more able to act as willing counsellors.

The other problem is that many of the women physicists who are married have physicists as partners. In the US, a study showed this to be 45%. This has been termed the "Two-body problem[10]". In many cases, the man is older and will be more likely to get a permanent position first. So although the problem of finding two jobs in one place impacts on both partners, it is more usually the woman whose career suffers.

Many of these problems are of course shared with other disciplines, particularly in the physical sciences. Physics is perhaps the "extreme science" in which the problems are magnified.

The Royal Society of Chemistry recently commissioned a report[11] that considered the working environment for university chemists and identified the reasons why the number of women falls so sharply with seniority. A similar study in physics departments might give an equally depressing picture.

IV. Assessment of the problems

4.1 Under-representation of women scientists in the UK

Most reports refer to Science Engineering and Technology (SET)[4,6] rather than just to physics. However, as a subject with a high academic profile and a particularly low percentage of women undergraduates, physics probably encounters most of the problems more severely. A DTI report[12] published in January 2002 found that 40% of male SET graduates and 25% of female SET graduates found their first employment in the SET sector. Of the women who had originally worked in SET and then took a career break, only one-third returned to a career in the SET sector. Moreover, a higher fraction of women SET graduates remained economically inactive compared with all women graduates.

Many (but not all) active physicists choose to become a member of the Institute of Physics. Appendix III shows Institute membership figures broken down with respect to gender and highest degree obtained. These show that the pattern of membership over a working lifetime differs sharply for women; however, there has been no investigation as to whether this results from different career patterns for women and men or from different perceptions of the usefulness of Institute membership.

4.2 Social climate for UK physicists

Modern UK society does not value intellectuals highly. Scientists in general, and physicists in particular, attract more distrust and disparagement than most – possibly because physicists are held responsible for nuclear weapons. The younger generation seems blissfully unaware of which group of people made the scientific breakthroughs that have led to such desirables as the internet, mobile phones and CDs.

It was clear at the Paris conference that intellectual climate is at least as important as the provision of crèches for the success of women physicists. There are many initiatives attempting to redress this imbalance: the British Association (BA) is very active, TV and radio have made some excellent contributions and the PPARC and EPSRC Research Councils (among others) now have awards specifically concerned with the public understanding of science. It appears that teenage girls may be more sensitive than boys to negative messages about science – although countering this view ought to have a positive effect on all university recruitment.

The "man in the street" believes that almost all real scientists are male and this perception is shared by even children in primary school[13]. In a recent US initiative as reported by the American Physical Society, women scientists went into schools as role models; the children did not believe they were "real" scientists and their parents assumed they must be wives of real scientists who were just helping out.

Girls who are interested in science will be told that they are outside the norm in all their social or casual encounters with their peers or adults[14]. This will probably occur at least once a week, every week. Every girl who comes to university to study physics will have been experiencing this social pressure from the time they chose their A levels, but it will probably intensify during their university studies. They are used to it – but it probably contributes in no small way to the fact that girls are frequently reported as lacking in self confidence and are exceptionally vulnerable to negative comments from university staff.

This is the background against which any move to increase the number of girls studying science has to seen. It is important to show that "normal people" – including, of course, "normal women" – can derive a great deal of satisfaction in pursuing a career that is not only intellectually demanding but also of great benefit to society.

4.3 Delaying childbirth

Many women working in SET, particularly in academia, have realised that their only hope of a fulfilling career is if they delay starting a family until they have an established position[15]. Indeed, this is the advice given to any academic hopeful, because it reflects reality. Academic women have acquiesced in a system whereby children are delayed until their thirties and often the late thirties. Women are being forced into a choice between career and family, according to author and economist Sylvia Ann Hewlett, who presents some startling statistics about career choices and fertility[16].

The statistical evidence that in the US women delay having children until they have academic tenure is very strong. Data from the Massachusetts Institute of Technology[17] show very clearly a dramatic increase in the fraction of women with tenure who had children compared with those who were not tenured. This supports the frequently quoted anecdotal evidence that women delay the birth of their first child until they have obtained tenure. However overall the percentage of women faculty members with children was 52% – far below the national figure for women of 83%. This may be compared with the male faculty members aged 40-44 where the percentage who had children was at the national average of 82%.

4.4 Evidence for discrimination

Over the last few years, numerical evidence of overt discrimination against women has come to light. The whole academic community has been very shocked by this. The main examples are:

- A study published in Nature[18] of the grading given on "track record" to medical scientists by reviewers in Sweden. Women with publication records equal to the best men were graded on a par with men graded as low candidates. This was a big shock because it was consistent and systematic throughout the sample, not an isolated case. Writing in Nature[19], Nancy Lane gave her views on the reasons for there being relatively few women in science. Much of what she wrote was echoed at the IUPAP conference.

  The UK funding agencies rushed to check their data[4]. They found that there was no difference in the success rate for women and men, but that women submitted fewer applications. There are several possible reasons for this: perhaps women spend less time putting in applications because of their commitments at home, or perhaps they tend to be more cautious and not want to tempt rejection by submitting something that is less than their best. If there is any credence in this second reason, then in an unbiased system, the applications from women should be on average more successful. A more detailed study is needed to investigate this.

- A study at the Massachusetts Institute of Technology (MIT) Science Faculty, which looked at the conditions of service for all professors. Women were paid on average 20% less than equivalent men and also had less laboratory space, less access to internal funding, disproportionate teaching loads and were less represented on hiring committees. Indeed, in the long list of topics considered, women came out worse in every single one. The matter that concerned the women most was that the more distinguished they became, the more they were marginalized by their departments. This report was published[20] and MIT took immediate steps to change. It also instituted a report into women in all faculties. It was expected that this would be a great deal better because the other faculties had the pure science report to guide them; however this has just been published[21] and shows a number of the same problems.

A number of other US universities ran similar audits to MIT and in all cases came up with similar results. There is also a celebrated case of Margaret Geller, an eminent astronomer, failing to be given tenure at Harvard[23].

In the UK, the Bett report[23] published in 1999 showed that in universities women academics were clustered in the lower grades. This is no great surprise in physics since nearly half of all women academics in physics were appointed in the last five years and are on average considerably younger than the men (see Appendix II). However, within each grade, their pay was lower. It was at least slightly reassuring that the difference at the professorial grade was only 5% compared with the 20% found at MIT. Bett recommended "Each university and HE college should have, and publish, a clear statement of its policies on equal opportunities and of the steps it is taking to ensure equality for women and ethnic minorities." No action has yet been taken. Academic salaries are frequently negotiated at the time of employment and then rise by a fixed amount each year. It is possible that women are less likely to be aggressive negotiators. The remedy would be to have salary reviews that relate to performance.

The American Physical Society published data on the salaries of members in different employment sectors within 10 years of and 11-20 years after obtaining a PhD. The results are shown in Appendix II. There was relatively little difference between women and men after 10 years and a small difference in the later age group.

Institute of Physics data are also shown for salary surveys performed in 1999 and 2001. In both cases the data only include those who work full time. (Note that not all working physicists are members of the Institute and not all members return the salary surveys.) The pattern is very different indeed for those with a Bachelors degree, where the difference in salary grows to be large. The survey excludes graduate students and hence the data for those with Bachelors degrees essentially excludes academia. It is very disappointing that while the 1999 data showed that salaries for women with PhDs kept pace with the men (as described in an article in Physics World[24]), this is no longer true. The salaries of women with PhDs are now falling behind the men. It is impossible to know if this is because women are not being promoted or if it is because they are being paid at a lower rate.

Appointments and promotions are very important within academia. An appointment committee has to judge promise rather than achievement (which is more readily quantified) and this can be difficult. There is unease over the way in which "Old Boy networks" and lobbying by powerful men can affect the outcome. The recent incident in Oxford University's zoology department[25] may be a very isolated case or it may be symptomatic of what is occurring occasionally but in a less dramatic manner.

Discrimination often cannot be seen "on the ground" because there are so few women physicists in any one department. The Paris conference identified several instances where women said they had not realised they were suffering discrimination until they compared notes with each other. An individual woman is likely to ascribe failure to progress to her own inadequacies or just bad luck, and it is only when larger scale studies are carried out that a pattern emerges.

4.5 Anecdotal evidence

This section is anecdotal, in contrast to the more scientifically rigorous investigations described elsewhere in this report. As might be expected, there were many occasions at the conference when women explained how they thought they differed from their male colleagues. Male readers may be interested in what was said: such sentiments are rarely expressed in mixed company. What follows comes with the standard warning – men and women are both extremely diverse. A bell-shaped curve could be drawn for any attribute and the differences between men and women are likely to be less than the width of either curve!

In a study of undergraduates studying physics in the US[26], each student was asked where they would place themselves on a class list. Almost all the men were convinced they were well above average. The women also thought they were above average – but nothing like as far

above as the men. It seems to be a central part of a physicist's training to talk yourself and your colleagues up at all times; the problem arises because many women feel uncomfortable with this stance, which leads to what is known as "combat physics", the adversarial way of doing research that is certainly more common in the US than the UK.

Many women felt that this male confidence and determination to talk themselves (and other men) up was a defining difference. There are many anecdotes of women physicists meeting male colleagues who tell them all about their (very interesting) current research project. Scientific etiquette requires the posing of the reciprocal question "And what are you currently working on?", but a surprising number of men do not ask this (or even ask "And who's looking after the kids, then?"). The woman's response is often self-defeating – "Well, if they're not interested, that's their loss". At a professional level, however, the reciprocal enquiry is very important because colleagues' belief in the work that you do – almost more than the actual results that you publish – is thought to influence strongly the choice of speaker for plenary and invited talks at conferences. The percentage of women proposed for such talks is lower than would be expected and many were sure that it was due in part to women's reluctance to 'talk themselves up'. This is also a serious matter when it comes to comparing the CV's of men and women.

The Royal Society of Chemistry report[11] found that machismo attitude and the adversarial way of doing science deterred women from making a career in academic research. One response to this is of course to over-compensate: there are also very many assertive women in science. A number of excellent programmes have been designed to counteract this. One, Springboard, has run for many years at Cambridge University and is available for all women.

At the Paris conference, it emerged over and over again that although women came from very different cultures, the problems they face are frequently very similar. The percentage of women in the really top research institutes was also relatively similar. Why is this? One argument is that few women are cut out to be physicists, so at the end of the day, it is a subject best pursued by men, with only a small input from women. This view would not have found support at the meeting! Many women are inspiring physicists.

A historical connection looks more likely. Modern physics originated in Europe and the US. The European universities were monastic institutions for some time, and only really accepted women fully in the latter half of the last century. US universities were modelled on those in Europe (but without the religious connection). Physics research was also very important during the second world war, when it involved, for example, radar in the UK and atomic energy in the US. Men who had worked for the military were subsequently ready to use their expertise in basic research as soon as this became possible.

After the war, many US and UK universities were staffed by refugees from Germany and Eastern Europe, who came from a strongly male-dominated culture, and younger male scientists who had been working on the war effort. These universities acted as a schoolroom for the world – those who came to study physics went home to recreate their image of how a physics department should be run. So the US and European 1950s view of women in science spread to academic leaders worldwide. The number of women physicists has been so low for so long that many men probably believe that women in physics is just a statement of political correctness and has no basis in reality: it does not correspond to their own experience.

There may be a different approach to learning physics too. Women generally want to understand physics from first principles, while men are often ready to go ahead even when they don't immediately understand. This leads to women losing confidence in their own ability. Sometimes men underestimate women and treat them with less respect than their male colleagues, making the women feel insecure. Perhaps we need to change our examination system and ask questions to encourage students to understand physics from first principles.

V. Current initiatives

5.1 Government commitment

There has been serious concern over the under-representation of women in science for many years. The UK government's Office of Science and Technology (OST) commissioned the report The Rising Tide in 1992 and has been monitoring progress ever since. The Select Committee on Science and Technology 6th Report, published in 2001[4], welcomed the improvements that had occurred and said: "We welcome the Government's commitment to improving opportunities for women in science, engineering and technology. It is essential that we should be encouraging girls to take up science at school – physical sciences as well as life sciences – and to continue with it post-16, and into higher education. We must ensure that women scientists and engineers have equal job opportunities (for example, by requiring that there be at least one woman on every interview panel) and we must offer proper career pathways to women, with better arrangements for women returners. **It is clear that there are still barriers to women realising their potential in science, engineering and technology**".

5.2 Department of Trade and Industry initiatives

The Promoting SET for Women Unit[27], located within the OST, focuses on increasing the participation of women in SET as well as including them in key decision- and policy-making roles. Its current three-phase strategic plan is as follows (many of these initiatives are described in more detail below):

Phase 1: Fact finding, development of pilot studies and good practice dissemination; includes initiatives such as: "Breaking the Mould" report for teachers, X squared, "Go For It!" posters and "Get With It!" report, Spark magazine, Maximising Returns report[12], careers and courses in ITEC, the Athena[28] project.

Phase 2: Development of the women in SET community and key initiatives to deliver change and implementation of a mainstreaming approach; includes initiatives such as: WES and AWISE mentoring scheme for women scientists and engineers, core-funding the WISE Campaign, the Portia Project and Equalitec website, networking the networks, setting up a database of women experts in SET, the Athena project.

Phase 3: Monitor, evaluate and report on progress and continue to support the external infrastructure as long as necessary; includes initiatives such as: systematic incorporation of gender into policy making and practice, data collection and reporting of research funding, knowledge transfer schemes and other activities, labour force evaluation and benchmark report, statistics website.

In addition, the UK has a Women and Equality Unit, as part of the Cabinet Office, to support the Minister for Women to bring about measurable improvements in the position of women which benefit society generally.

5.3 Higher education initiatives and the Athena Project

The Athena[28] Project's aim is the advancement of women in science engineering and technology (SET) in Higher Education. It aims to increase the number of women working in SET (as postgraduates, researchers, and lecturers through to professors) and to improve the career development of women in SET (their recruitment, retention, participation, progression and promotion). It has funded a number of projects to increase awareness of special needs of women in university structures and to mentor women so that they can understand the structures of the university system and what they need to do to progress. Recently, Athena has become part of

the new Equality Challenge Unit, set up in June 2001, which has longer term funding to tackle the wider issues of equality in HEI employment.

In addition, a landmark audit document from the University of Cambridge[29] did not address the problem of how women should be schooled into adapting to the current system but rather how the system should change so that it could take advantage of the talents of more women. Cambridge has also set up an initiative to increase the number of women in SET[30] which stands as a model of good practice.

5.4 National initiatives to increase girls' uptake of physics

Increasing the uptake of physics by girls at A level, Highers or university is a high-profile area where there is cooperation between the education and wider science communities with government support. However, despite this, the situation is not improving.

For girls to have a career in physics, A level or Higher physics is a basic requirement. The number of girls studying A level physics has not increased over the period of time over which the initiatives below have been introduced.

In the 1980s, there were initiatives to introduce "girl-friendly" curricula with materials and ways of teaching developed specifically for girls. These materials were not widely adopted. There was also a belief in some quarters that best practice was to teach physics to girls in single sex schools or classes. Liz Whitelegg[8] comments: "These strategies did not have the hoped-for success. Delivering a special "science for girls" could actually reinforce the view that girls' lack of engagement with science was in some way a problem with the girls (a deficit model of girls) and not as a problem with the way science was taught."

In 1984, The Women in Science and Engineering (WISE) campaign[31] was initiated by the Engineering Council to focus attention and to promote initiatives to encourage girls to study science. The WISE vehicle programme provides mobile, hands-on exhibitions.

The introduction of "Balanced science", whereby pupils must study physics, chemistry and biology, followed by the new GCSE examinations in 1988 meant that all pupils studied physics to the age of 16. Prior to the new GCSE and the core curriculum, most girls dropped all science except biology at the age of 14.

In 2000, a new system of two-tier courses for ages 16-18 was introduced. It potentially increases opportunities for girls to study physics. The results for the first year are encouraging, a higher percentage of girls took the As in 2001 (24%) than had been taking A level and more significantly they did well. The following are the percentages for girls (boys) for the three top grades: A grade 27.7% (21.3%), B grade 19.7% (17.6%), C grade 18.9% (17.5%)[32].

The Institute of Physics has encouraged research in this area and Barbara Smail, Liz Whitelegg, Barbara Hodgson, Jan Harding and Alison Kelly, to name but a few, have contributed significantly to changes in thinking. At present, further research is underway. In the careers area, in particular, the Institute is working to make images and text appealing to girls.

The Supported Learning in Physics Project, an Open University/Institute of Physics collaboration, developed some examples for girls[33]. Girls have been seen to be benefiting from some Institute initiatives[34] directed towards both sexes. The Advancing Physics syllabus, introduced in 2000, is a fresh approach developed by the Institute to the 16-18 physics syllabus. Schools are adopting it enthusiastically and 20% of A level pupils are now studying it. The Institute of Physics travelling Schools Lecture, which is delivered in over 30 venues throughout UK, shows 14-15 year-olds something of the spectacle and the fun of physics. This year the lecturer, who is a young woman, is acting as an excellent role model. An Institute web page for school pupils also has some material of specific interest to girls.

The Department of Trade and Industry has several initiatives[27] to encourage women to study science and engineering, including role model posters featuring women who work in technical jobs and Spark, a magazine targeted at 11-14 year old girls. The "Get With It!" report contains a list of good practice guidelines to help other producers target their materials at girls effectively.

Many universities run events to show aspects of physics beyond school experience, giving girls aged 14-15 and 16+ opportunities to meet professional physicists. These "University Taster" courses are becoming increasingly popular.

The British Association for the Advancement of Science[35] aims to make science exciting, accessible and relevant to young people. GETSET is a three-day university taster event for girls aged 13 to enthuse them to study science.

The number of graduates entering physics PGCE courses has been about 200 for a few years. This is not enough to replenish the number of teachers retiring. At present, two-thirds of those teaching physics in schools and further education colleges do not have a degree in physics and one-third do not have even A level physics[5,6].

It is difficult for those who do not have a background in physics to inspire youngsters with an interest in physics. Their lack of confidence makes the subject appear very difficult. This is serious because physics has already been described as the most difficult A level. To alleviate this problem, the Institute of Physics is setting up internet support for under-qualified teachers of physics. Whilst there is such a shortage of physics teachers, the numbers studying physics are unlikely to increase despite all the other initiatives described above: teachers play key roles both as role models and in encouraging youngsters to study physics.

This list is not exhaustive but serves to demonstrate that despite considerable effort the solution has not been found.

5.5 Dorothy Hodgkin Fellowships[36]

The Royal Society has launched a new type of fellowship, the Dorothy Hodgkin Fellowships. This scheme, which is for research in the natural sciences (including agriculture, mathematics, technology, medical and engineering sciences), is designed to offer the kind of support and flexibility which are particularly beneficial for female scientists. Ten such fellowships were offered in 2001 to candidates from natural sciences (including mathematics and engineering). The fellowships may be taken up within four years of completing a PhD and offer guaranteed funding for four years. This is an excellent opportunity for the young woman scientist to break the cycle of continual movement from one research assistant post to another.

5.6 University Research Fellowships and Advanced Fellowships

The Royal Society funds University Research Fellowships (URFs)[36] and Advanced Fellowships (AFs) are funded by the Engineering and Physical Sciences Research Council (EPSRC) and the Particle Physics and Astronomy Research Council (PPARC). The Wellcome Foundation also funds advanced fellowships in medicine/biology, of which a very few are awarded to those working in medical physics departments.

These fellowships were not designed specifically to help the problem of easing women through the long apprenticeship (ten years postdoc/research assistant period) necessary in most cases to obtain a lectureship. However, their effect on the recruitment of women academics has been dramatic (see section 6). Although there has been no detailed analysis, the authors of this report estimate that probably at least three quarters of the appointments of women physicists to permanent university posts over the last ten years or so has been via one of these fellowships. Currently there are 57 such EPSRC fellows working in physics departments of whom nine (16%) are women; of the recent 64 appointments of PPARC fellows, eight (13%) are women. There are also 73 URFs working in physics and astronomy of whom 12 (16%) are women.

These fellowships provide extended support for five years for PPARC and EPSRC and up to ten years for the URFs. They enable high-quality researchers to work in university departments, with the expectation of achieving permanent posts (in a UK university or in industry). It is widely believed in the community that the holders of these fellowships will be the academic leaders of the future. The young academic is given the freedom to plan his or her own research rather than being someone else's research assistant.

These fellowships allow for geographical mobility, as the holder may take them to a different university. This can make a very important contribution to solving the "two-body problem"[10] – a woman who has such a fellowship can move with her partner if required. Another important advantage is that because a woman holding such a post has relatively long-term employment, she is entitled to maternity leave. Currently some half of all new appointments in physics appears to come from the ranks of these fellows. The scheme proposed by the Roberts report[6] appears to differ from this in that the research fellow is given a guarantee of a permanent job on appointment.

The existence of these fellowships has gone a very long way to produce a "level playing field" for the very best young physicists wanting a university post. It is, however, difficult to see how a woman would be a strong candidate for such a position at age 30 if she has already taken periods of maternity leave, so the system is still filtering out women who want to have their children in their mid-twenties. There is also no such route for the women and men who do not get fellowships of this type, and it is here that the women are more disadvantaged.

One of the Paris conference plenary lectures was from Catherine Cesarsky, Director General of the European Southern Observatory. She told how she suffered from depression because she wanted children so much and became pregnant before completing her PhD. Would even someone as clever as her have survived in the UK system, with its postdoc mechanism? Would the UK academic establishment have believed that she was as serious about astronomy as about having a normal family life?

5.7 The EU 6th Framework programme

The EU has taken the lead on "gender mainstreaming". The ETAN[2] report identified the problems and, in the 5th Framework programme, applicants for a Training Network (RTN) award had to justify how they would ensure that the money was used to encourage the participation of women. There was additionally a target of 40% of all panel members to be women. However, the Marie Curie Fellowship scheme does not offer maternity leave.

The 6th Framework programme (FP6) foresees that the gender dimension will be increasingly integrated at all levels of implementation, on the basis of the recommendations arising from the ETAN Report. The gender impact studies as well as an enriched Gender Watch System will be the very heart of the mainstreaming approach. The European Commission has just published two calls for tender in the following areas: the continued development of work on statistics and indicators; a feasibility study regarding the European Platform of Women Scientists; the development of a strategic database "Women in the FP" containing all relevant information about women's participation and the gender dimension; and a qualitative analysis of women's participation in FP5.

Two more noteworthy action have been launched by the EU:

1) A high-level STRATA-ETAN expert group has been set up to report on the availability and shortages of data and information on women in research in the private sector and to provide strategic guidance to the Commission, member states and industry.
2) A study has been launched by Brussels University, the University of Barcelona and the European Trade Union Institute on data, statistics and best practices; this will support the work of the expert group.

5.8 The Women Returners' Network

The Women Returners' Network (WRN)[37] is a charity which helps women to return to work after a career break by providing information on education and training initiatives, offering an information helpline, running workshops, seminars, conferences and developing models of good practice. Currently, there are two re-entry schemes in the UK, set up and run by the Daphne Jackson Trust[38] and The Wellcome Trust[39] Trust. These support and encourage women returning to graduate SET careers; only the Daphne Jackson Trust finds placements within industry.

VI. Initiatives following from the Paris Resolutions

Delegates at the IUPAP International Conference on Women in Physics passed a number of resolutions in Paris. The following recommended initiatives would increase the representation of women at all levels in physics. Many of these suggestions would require considerable changes in current organizational structure, but this is necessary because the number and percentage of women studying physics at university has been static over the last 10 years and the number of women at the higher levels has risen only slowly over the last 20 years. Although these recommendations are intended to increase the number of women in physics, many of them should also serve to make the subject more attractive to men.

6.1 Systematic assembly of data

Policymakers need comprehensive and reliable data collected systematically over a number of years to assess the effectiveness of any measures taken. Since the age profile of women in SET is strongly biased towards the younger age groups – reflecting the less encouraging attitudes in the past to women making a career in these fields – it is essential that data are broken down by age. Although there are good data on the education of physicists, data on their employment are very scarce. The Institute of Physics, Royal Astronomical Society (RAS) and the Central Laboratory of the Research Councils (CLRC) should combine to keep an audit of the women employed in universities and research laboratories. Where appropriate, this should be done in collaboration with the EU Women in Science Unit. Data on astronomers has been collected regularly over the last few years and (incomplete) current data provided by the Standing Conference of Physics Professors (SCPP) for all physics departments (including astronomy) is shown in Appendix II.

A scheme should be established for the systematic monitoring of the numbers of women and men physicists in academia and research laboratories by age and seniority.

There are problems obtaining reliable data for women who work outside academia. Some graduate physicists (~10%) join the Institute of Physics and data are collected regularly on members' employment and salary. Recent data are shown in Appendix II. This allows the patterns for women and men to be compared. It is clear that many women do not remain members of the Institute for the same length of time as men. For example, in the age cohort 40-44 the percentage of women members has fallen to just 9%. It is possible that they leave the Institute of Physics because they are also leaving employment in the SET sector. This should be investigated.

Information should be obtained on why the percentage of women members in learned societies (particularly the Institute of Physics) decreases with age and whether this reflects a large percentage of women leaving employment in the SET sector.

It would be useful to establish what the large percentage of women (and men) physicists who are not members of the Institute of Physics are doing. Perhaps this could be a DTI project or a specially funded project. It is especially interesting to follow the cohort who have a PhD or MSc separately from those who have a first degree, BSc or MPhys: Institute of Physics salary data show very different salary trends for these groups (Appendix II).

Consideration should be given to setting up a project to establish how graduate physicists' employment differs between men and women.

6.2 What further initiatives can be taken to encourage more girls to study physics?

In England, in spite of various efforts including the introduction of new physics A level syllabi, the percentage of girls studying physics to A level has remained at about 20% over the last 10 years. The situation is better in Scotland, where 30% of the candidates for Higher physics are women. The percentages studying physics at Scottish universities is also higher – 28% for Glasgow University averaged over the last five years compared with 20% for the UK as a whole.

There were conference resolutions and recommendations that are relevant here.

***Conference Resolution:* Methods and textbooks used in teaching physics should include those that have been shown to interest girls in physics and foster their success. Studies show that young girls have a strong desire to help improve people's lives, and it is therefore important that they have the opportunity to see ways in which physics has a positive impact on society.**

***Conference Recommendation:* Revise educational curricula and materials to connect physics with medicine, biology, technology, the environment, etc, and to show diverse physics career paths and job prospects.**

The image of physics has been poor, with associations with nuclear fallout and pollution. Positive impacts of physics that interest girls are perceived as engineering or medical developments. Also, girls are fascinated by the "big fundamental questions" in physics and find topics like electronics more boring than do the boys. It is very noticeable that a disproportionately larger fraction of women choose to study astronomy or astrophysics. Girls who have the opportunity to delve deeper into physics, for example through university visits, are inspired by recent research. It is particularly important that GCSE syllabi include this material: this would encourage more girls to study physics at A level and also encourage many boys.

School physics syllabi should be reviewed with the aim of finding ways of making them more interesting to girls, including examples and exercises on topics that show ways in which physics improves people's lives.

Many of the textbooks are written by men who were taught by men and currently quote examples predominantly drawn from male hobbies. A more imaginative approach that incorporates a gender neutral approach is needed. The Institute of Physics publication Advancing Physics is finding favour with girls because of the nature of the examples, the course work and the potential it offers to do further work on one's own or in groups.

Of course, women are very diverse. Although some women are attracted to physics because of its applications, others have been attracted by the mathematics and the "big ideas", as evidenced by detailed questionnaires returned by women physics undergraduates at Oxford and Liverpool Universities[40]. The fact that physics is taught in a mathematical context is thought to be one of the reasons the percentage of women physics undergraduates is high in Italy. It is important that teaching is sufficiently flexible to allow women and girls to be exposed to the part of physics that they would find attractive.

***Conference Recommendation:* Opportunities should be found to feature more women physicists as role models.**

There are many successful women in physics today, but they are not widely known to the general public. The Oxford study[40] found that school teachers and Marie Curie were given as role models. There should be a campaign to raise the profile of eminent women physicists.

***Conference Recommendation:* Publicise physics role models who counteract the stereotypes and whose stories are examples of career success and leadership positions.**

The image of physicists is poor, with the stereotype being a boring, greyhaired, nerd-like male in a lab coat. Eminent physicists, both male and female, who counteract these stereotypes should be given a high profile, invited onto TV shows, etc. The general public is interested in the "big questions of physics" but unaware of the individuals finding the answers.

Physicists who "appeal" to young women should be identified and their profile raised in the media.

***Conference Recommendation:* Educate parents about opportunities for their daughters and how to encourage them.**

It is important to motivate parents and show them that a science degree is an excellent platform from which to launch a career. The study at Oxford University mentioned earlier[40] found that girls were not given sufficient career advice about the exciting career opportunities in physics. Materials about diverse career paths should be prepared and used to inform girls about the excitement of physics from an early age, so they are drawn into the subject rather than feel pushed.

Booklets for teachers, girls and parents of each Key Stage group in schools should be prepared to provide information about women's careers in physics. The booklets might be similar to the Engineering Equals publications by WISE[41]. These booklets should be available on the web, free of charge, and be the focus of a campaign to ensure their wide use.

Special events should be held in schools to inform parents, particularly parents of girls, about careers in science.

***Conference Recommendation:* Strengthen the training of science/physics teachers and include opportunities for them to do research and to interact with working scientists.**

Involve universities, research institutes and industries to help schools and strengthen teacher training.

Physics teacher training should include opportunities for trainees to do research and to interact with working scientists so that the excitement of physics and knowledge of its diverse career paths can be passed on to girls in school. As physics is often taught by teachers without physics degrees, and in some cases by teachers without A level physics, there should be "in service training" to enable them to discover the excitement of physics so that they can inspire their pupils. Experienced physics teachers who have had the opportunity to visit CERN (the European Laboratory for Particle Physics near Geneva) have returned fired with enthusiasm.

Consideration should be given to establishing centres for teachers at major research establishments and universities.

***Conference Recommendation:* Attract qualified school teachers with (a) fair pay, (b) respect, and (c) working conditions.**

In the UK, the shortage of well qualified physics teachers is at crisis level[5,6]. There is evidence[40] that girls may be more influenced by teachers than are the boys, so a lack of good physics teachers will have a detrimental effect on the numbers of girls taking physics as a career subject. Those with physics degrees can earn more in other jobs than in teaching. Elsewhere, they are well respected and do not have to cope with badly behaved pupils. Poor pupil behaviour has been quoted by the Roberts report[6] as one major reason for the scarcity of physics teachers.

A large proportion of 14-16 year olds take Dual Award Science. This is commonly taught to unstreamed classes and girls can be put off by laddish behaviour, particularly during practical sessions. Those with an interest in physics can be discouraged by the time spent by the teacher making the lesson interesting for pupils who have no intention of taking the subject further. The more complex topics may be avoided because some pupils will regard them as boring, thereby increasing the possibility of poor behaviour. Practical work may also be reduced for badly behaved classes, so those who are interested do not get the opportunity to develop their interest and gain confidence in their abilities. They are therefore unwilling to risk taking the subject further.

The teaching of physics in schools would be much improved if:

(a) Well qualified physics teachers could be attracted by pay commensurate with that expected in other careers requiring similar physics qualifications;

(b) Physics were taught in "streamed" classes so that those with the greatest interest and ability can gain a thorough grounding for the next stage of their careers whilst others can develop an interest in physics;

(c) Grants were available for schools to improve the conditions of their physics laboratories and restock their apparatus.

***Conference Recommendation:* Help smart girls network (clubs, enrichment opportunities, and encouragement).**

Schools are now required to run special classes for high achievers and this is warmly welcomed (although it is too early to see any results from this initiative).

Opportunities for high achievers in physics, such as university-run "Master classes", should be extended.

6.3 Women as students

Women who enrol on undergraduate physics courses have had to overcome very significant peer and social pressures. Physics staff should be aware of the number of negative comments girl students face almost every day. (They can't stop it, of course, but it would help to be more understanding and more sympathetic to girls who show diffidence and lack of self-confidence.) Women should be asked in confidence if they have been a victim of behaviour that they found offensive or even just unfriendly. (Any bad experiences are quite likely to get back to potential applicants via siblings in schools.) Because of the constant negative remarks from those outside the university, even one unfortunate remark by a member of staff can have very serious consequences.

Physics academics need to be observant for signals that girls find some parts of the department less welcoming than others. For undergraduates, it is important that women feel at ease in lectures, laboratories and tutorials. Some of the worst aspects of chauvinistic behaviour comes from the peer group. Staff must be certain that they and all demonstrators and tutors set a good example and show that laddish behaviour must be outlawed. It is often the case that women need extra reassurance at the beginning of their course but grow in confidence later.

As the number of women academics is so low, many women graduate students may be the lone female in their group. They may be particularly vulnerable to pressures from other students or postdoctoral researchers. Many of the bad experiences reported at the Paris conference came from this period of individuals' careers.

Heads of physics departments should be made aware of the problems facing women students and of the need to ensure that they are treated sensitively by staff and by their peers.

An example of good practice is the American Physical Society's scheme "Improving the Climate for Women in Physics" site visits. Through this programme, teams consisting of men and women and often with a HR professional visit physics departments to assess the climate for women in the department and to make recommendations to improve the position for women undergraduates, graduate students and faculty. According to the APS brief, the aims of these visits are threefold:

1. Identify a set of generic problems commonly experienced by women physicists,
2. Intervene to solve many of these generic problems and
3. Address problems arising in the particular physics departments visited and help improve the climate for women (both students and faculty) in these departments.

Site visits are conducted at the request of a department chair. Members of the site visit team meet with the physics department chair, groups of physics faculty members, minority or women faculty members in physics (or related areas), administrators responsible for faculty appointments, minority or women graduate students, and minority or women undergraduates. The goal of these meetings is to provide the site visit team with the quantitative and qualitative information it needs to assess the climate for women or minorities in the host department.

Following the visit, the site visit team writes a report to the department chair, detailing its findings and offering simple, practical suggestions for improvement. The department chair is asked to respond in writing to the team, describing actions taken to improve the climate. The report is confidential to the department. The Standing Conference of Physics Professors and the Institute of Physics would appear to be the appropriate bodies to consider if this action might be useful within the UK.

Consideration should be given to the feasibility of establishing a programme similar to the APS scheme for assessing and improving the climate for women in physics at specific sites. This could include research laboratories as well as university departments.

6.4 Women as Research Assistants

The Research Assistant (RA) career stage is a crucial time for women as it is the time when there is the largest drop in the female/male ratio in physics. The Roberts report[6] has already suggested a better career structure for RAs and these recommendations would have a particularly beneficial effect on the position of women. The current situation – where the money for research staff comes primarily from the research councils but they maintain that career development is the responsibility of the universities – leaves research staff in a very poor position. In particular, there is no clear entitlement to maternity leave or career breaks. As made clear in the RSC report[11], women leave academia at this stage for many reasons including low morale and lack of a career structure.

Research Councils, government departments, universities and Vice-Chancellors should ensure that contract research staff within universities and laboratories enjoy career management and development of at least the same standard as permanent staff. This should include new career guidance materials, career tracking, staff appraisal systems, continued professional development courses for both research staff and line-managers/principal investigators, and survey and evaluation methods to monitor how far best practice is being translated into reality. Achieving the right balance between contract and permanent research staff in universities and research institutions should also be a priority. These recommendations are contained in the Roberts report.

The recommendations of the Roberts report[6] should be adopted*. In addition, the establishment of a career path should include the possibility of contract staff being able to take maternity leave or career breaks.

*Many of the recommendations in the Roberts report are now to be implemented, following the UK government's spending review in July 2002.

Many fellowships have age restrictions. It really is not enough to say that these may not apply in special cases: a woman may well be deterred from applying. It is important that the information should be made freely available. Some other form of words, such as the length of time in full time work since a PhD or (as has been done by the US National Science Foundation) restricting the number of times that an individual may apply for a given fellowship, might be used.

A way should be found (such as abolishing age restrictions) so that women who have taken a career break are not unfairly penalised when applying for fellowships; this should be made clear in advertisements.

6.5 Women obtaining their first tenured post in academia

The career patterns of two of the last century's most notable female chemists illustrate the importance of being an academic rather than a research assistant. Too many women remain in research assistant posts too long, as shown in the Bett[23] report.

Dorothy Hodgkin (1910-94)[42] was appointed to Somerville College at the age of 24 and had a small laboratory all her own. Of course, she had to apply for funds to do her research and this was not easy. However, she was able to stamp her style on her own research and already had made a sufficient name for herself to be elected an FRS at the young age of 37. She went on to win the Nobel Prize for Chemistry in 1964.

Rosalind Franklin (1920-58)[43] was said by J D Bernal to be "distinguished by extreme clarity and perfection in everything she undertook. Her photographs are among the most beautiful X-ray photographs of any substance ever taken". She was still a research fellow working in someone else's laboratory at the time of her death aged 37. The very poor treatment that she received from Crick and Watson as described in their book[44] was due in part to the fact that they regarded her as an appendage to the professor in whose laboratory she worked.

In the 1960s almost no women were appointed to physics departments in spite of the huge university expansion. This has, however, changed dramatically over the last few years as evidenced by the current age spectrum of women academics. A recent university survey (replies received from 21 departments) showed that 16% of the staff appointed to physics departments in the last five years were women. This has produced a significant change in the academic population; 48% of all women academics in physics were appointed in the last five years (compared with 22% of the men). The age structure is very different too, with 53% of the male academics aged 46 or older compared with 21% of the women.

	26-30	31-35	36-40	41-45	46-50	51-55	56-60	60-65
Women	4	16	13	4	6	1	0	0
Men	21	70	103	67	45	56	79	54
% women	16	19	11	6	12	2	0	0

The age spectrum of male and female academics in universities
(see Appendix II for full data from the recent SCPP survey)

Almost all of those who are awarded an Advanced Fellowship (AF) or a University Research Fellowship (URF) subsequently obtain a permanent appointment at a university. Personal experience suggests that many of the women who have obtained university positions in recent years did so following an AF or URF, and it seems likely that this is what has caused the increase in the number of women appointed in the younger age ranges. This could be checked by asking

departments for the number of appointments made following such a fellowship to both men and women, compared with the number of appointments made to other candidates.

Returns from the universities suggest that only half of the new holders of university appointments have entered via an AF or URF. The average age of all new appointments was 36. The balance would most likely have been employed on short term research associate contracts, either in the UK or abroad. This is a particularly hard route for women. The earlier that appointments are made to university posts the easier it is for women, as they are less likely to be partnered or have children.

Earlier appointment to tenured posts would also be welcomed strongly by young male academics. This was also advocated by the Select Committee on Science and Technology, whose report [(4)] Excellence and Opportunity acknowledged that the career development prospects for young researchers were a cause for concern; and promised that the government would encourage the universities and the Funding and Research Councils to promote good practice in career development. A possible scheme to do this is included as Appendix III.

The problems for women would be much alleviated if permanent university appointments were made at an earlier age and if imaginative ways of overcoming the 'two-body problem' can be found.

The Higher Education Funding Councils should take account of the way in which the Research Assessment Exercise (RAE) distorts the pattern of appointments to university posts. The RAE should recognise that it is good for academics to be appointed young and make it clear that a department with young researchers who have not yet made an international reputation will not be penalised. It should also be possible for a woman to restart an academic career after a break for childcare; the RAE should specify in advance guidelines that it will not penalize a department that appoints a woman who has had a career break. A possible scheme is given in Appendix III.

It would be very beneficial if the RAE treated young academics, part-time lecturers, women "returners" and those on maternity leave as special cases and published guidelines to make this clear.

Universities should also offer part–time working or job shares.

RAE panels should publish clear guidelines on how research by part-time lecturers or those who have taken maternity leave will be assessed.

Research assistant posts are funded by the research councils, so it is clearly within the councils' power to effect change. EPSRC and EU research posts are for two or three years or sometimes just for a few months. Research assistants have to go where the investigators have grants.

The current research council view that the councils' only duty is to fund the best research is irresponsible; they should also accept a duty to foster the career pattern of young scientists. In particular, part-time working and maternity leave should be possible. Comparing a plot of the age distribution of research assistants with the age distribution at which graduate women have children clearly demonstrates this need. This is the period of greatest attrition among women physicists who had hoped for a career in physics and is a major deterrent to many young women considering an academic career.

Most of the applicants who come as "returners" to the Daphne Jackson Fellowship scheme have left academia during the postdoc period. (Section 5.5 highlights as an example the decision of Catherine Cesarsky, Director General of ESO, to become pregnant during her PhD.) The UK community needs to recognise that a young woman can be very serious about physics or astronomy as well as about having a normal family life. At present, women who are certain that they want to have their children while they are young are effectively excluded from the pool of talent that can be used in physics. Surely if a woman academic is going to have children at some

point, it is better that she be able to do so at a time when medical evidence suggests that she is best suited to become a mother?

Age restriction rules on grants should not disadvantage women who have returned after a career break.

The EU is normally at the forefront of good practice, but its scheme for sending young researchers aged 32-38 across European boundaries does not take into account the limited possibilities for extended travel that affect many women of that age who have family ties. Working in another European country is a very valuable experience and often boosts a scientist's career, but for some women would be better to go as graduate students or later when their children are independent. These options would increase women's participation in the scheme.

The EU should consider how to modify its definition of "young researcher" so as not to discriminate against women. It should also reconsider its intention not to fund students.

A number of countries represented at the conference did have positive discrimination measures to ensure that a fair fraction of women were appointed to university posts. Some had AF-like posts leading to tenure at a named university that were open only to women (see recommendation 1.5). In Sweden, there are professorships that are only open to women.

Some measures, though, were counterproductive – for example a rule that if a woman was put on a shortlist she *must* be appointed. This had the predictable consequence that no women at all made any shortlist unless the university was certain that they should be appointed! Overall, the feeling at the conference was very mixed. Women who held one of these special posts were said to be made to feel like second-class citizens. Most conference delegates and the UK team thought it was better to ensure fair treatment of women rather than preferential treatment. This is reflected in the recommendations above.

6.6 Career development and the glass ceiling

The conference was welcomed by Burton Richter, President of the International Union of Pure and Applied Physics (IUPAP), who said "There is a general agreement that the glass ceiling exists everywhere". A depressing feature at the conference was the repeated statement that even when she had obtained a permanent post, a woman's struggles were not over. Although she thought she would have the same possibilities for progression as her male colleagues – particularly if she remained unmarried and childless – she found she was left behind for reasons that were hard to pin down. Marcia Barbosa, the conference chair, commented "The challenges women face are absolutely the same. Suddenly, you don't feel that you have challenges because you are stupid. You realize it's a common thing against women in physics." It is at this stage that the "marginalisation" of women as they become more senior (as reported at MIT[20]) becomes a real issue.

Our present-day career structure has evolved for men who do not have career breaks. It is important that a career structure leading to high levels should still be available for able women who have worked part-time or taken a career break. This can be achieved if all institutions accept the need for a work/life balance at all levels. The UUK can have an important role here in persuading universities to adopt more family-friendly policies.

Gender-neutral family-friendly policies should be adopted.

An academic physicist progresses by becoming known nationally and internationally. The literature is exploding at such a rate that people find it almost impossible to keep up and rely on conference talks and colloquia. If a woman is not invited to conferences, her career will suffer. Invited and plenary talks at conferences are not given by women as often as would be expected by their participation at each level in physics – hence the following recommendations to IUPAP and to learned societies.

***Conference resolution aimed at learned societies:* Include women on programme committees and as invited speakers for society-sponsored meetings and conferences; also include women on editorial boards of society journals.**

As the organizations charged with promoting the well being of their subject, the Institute of Physics might consider giving guidelines to conference organizers and monitoring the extent to which they are satisfied. (The Royal Astronomical Society already does this.)

Conference organizers should ensure that women are included in programme committees and in the programme as plenary or invited speakers.

The APS has a very successful initiative[45] to ensure that more women are invited to give colloquia in universities – an important way for a young woman academic to get known. The APS pays $500 towards the travel cost of one women speaker, provided that the university invites at least two women from other institutions in any one year. Every year the programme costs more as more women are invited. The APS maintains a list of possible speakers.

Consideration should be given to establishing a similar scheme in the UK, at minimum by keeping an up-to-date list of women speakers and their topics, and preferably by also contributing to travel costs.

One outcome of the Paris meeting is the formation of a European Physical Society (EPS) action committee on Women in Physics. This will be applying for EU funds to run such a scheme across Europe.

Women should be included on the editorial boards of all learned journals and should be editors of a reasonable proportion of them.

There appear to be many unwritten rules for promotion. Transparency is essential in making appointments. Women needed guidance both from other women and from successful men. It seems that because men are used to working in a male environment, they tend to regard the women as invisible.

Directors of research laboratories and heads of university departments should ensure that women receive the same career guidance and support as male colleagues. They should also ensure that women are given good advice about matters that affect them especially (like maternity leave). If required, they should help find an appropriate female mentor.

Promotion rules should be made clear and helpful feedback given on unsuccessful applications.

Another essential for a successful career is winning research grants. All competitions for funding must be clear and open, with sufficient time between the call for submissions and the submission date to ensure that those who had not been briefed in advance could still apply. Data must be logged to ensure that women are treated fairly. If they submit fewer applications, it should not be automatically assumed that an equal success rate was actually fair.

The gender balance of research council grants awarded should monitored.

Most senior university staff, including Vice-Chancellors, Pro-Vice Chancellors, Deans and members of the most powerful committees are male. This sends as dispiriting a message to young women academics as the fact that lecturers are predominantly male does to women physics undergraduates. Many of the recommendations made here for the better treatment of women staff might proceed more easily if there were women at the top levels of decision making in the universities. The same argument applies here as elsewhere. If universities recruit their senior personnel from one gender, they are missing half the brains! They are also missing a very different perspective on the way in which academic and family life can be balanced.

On a positive note, women are clearly being promoted to chairs in physics and astronomy. The previous lack of promotion was because there were so few women of professorial age in the system. In 1992 there were two women professors; in 2002 there are at least 15.

Universities should appoint women to senior positions, ideally in the same proportion as the gender balance in the whole staff. If necessary, this should be monitored by the Higher Education Funding Councils.

The Bett report noted a systematic difference between the salary levels for male and female professors and this was also highlighted in the MIT reports covering both pure science and engineering. There is clear concern that the reported differences between male and female earnings are due to men being paid more for doing the same job. Another concern is that it is because women are not prepared for leadership in the same way as men. It is essential that there is equality and transparency.

The Bett recommendations on equality of pay should be studied in detail and implemented.

Within universities, promotion rewards activities which help the department score highly in the Research Assessment Exercise, or recruit more undergraduates or some other measure that has a high profile. At present, activities aimed at supporting junior women colleagues do not score at all. If the government is serious about increasing the number of women scientists, some measure must be found to reward universities that do this well. Women (and men) who actively promote science for women at all levels should be rewarded. (This should include all activities where women are being sought as role models)

Retention of women within physics should be regarded as an important activity that brings either extra money or prestige to a department; academics who do this well should be promoted.

6.7 Career paths in research institutes

Each research institute should be responsible for keeping statistics on the gender balance of employment. This should include the time taken for progression from one grade to the next. Action should be taken if anomalies appear.

Statistics on the employment of women and men in research institutes should be collected, maintained and monitored.

Many of the recommendations for universities apply here too, although a research institute does not have the problem of lack of tenure. It is, however, possible for staff to get trapped in a "support mode". It is important that women have the same opportunities for developing their own research programme as their male colleagues. Women should also be given appropriate training so that, if suitable, they can be promoted to the highest levels.

Women should receive the same career guidance and support as male colleagues and not trapped in a "support mode".

Part-time working or job shares should be possible and help should be given to overcome the "two-body problem" where it threatens to have a serious effect on the career of one of the partners. Shift work or overseas travel (to La Palma telescopes, for example) should be allocated with due regard to a woman's duties at home if she has young children. There will be other times in her life cycle when she will able to carry a full load.

Gender-neutral, family-friendly policies should be adopted.

6.8 Career paths in industry

There is a lack of data here. Some physicists are employed in very large scientifically based companies, but many more are probably employed in smaller enterprises. Some of them, at best probably less than 10%, are members of the Institute of Physics and complete membership survey and salary returns. Institute figures show that among those whose highest degree is a Bachelors, the men earn very much more than the women. As there are fixed salary scales in universities and research laboratories, it is likely that this reflects what is happening in industry. There are, though, some very high profile women physicists with doctorates who are clearly enjoying very successful careers.

The Institute does have a number of corporate affiliate companies and should ask these companies for a breakdown of the number of graduate men and women physicists employed and their relative seniority. Many physicists work in an interdisciplinary environment, so the DTI is probably a more appropriate body to seek out information.

Information should be obtained on career patterns for women in industry and how they compare with those for men.

There are a number of government schemes here. Opportunity Now promotes family-friendly policies and Maximising Returns[12] promoted the idea of industrial fellowships for women wishing to return.

Women in industry, particularly those in small- and medium-sized companies (SMEs), may feel isolated.

Employers should encourage women staff to network with other women physicists and allow them time off to attend women in physics meetings and courses specifically designed to help women (as well as general courses).

6.9 Maternity leave, childcare and returners in a physics context

The Paris conference demonstrated that academic women physicists who have children are not freaks; they are the norm. If they are the norm, then institutions should expect to have a well thought out strategy.

There are two views on the question of graduate scientists having children. The "traditional" view is: Career paths have been mapped out and work well for men. Of course, it is difficult for women to fit into these if they take maternity leave or – worse still – want to work part-time or (even worse!) want to spend time at home with their children when they are young. They then expect to be able to pick up where they left off, in spite of being out of touch with the latest developments and the wrong age for that particular level. If we do not want to exclude women altogether, we had better accommodate these difficult cases as best we can.

The "radical" view is: The population needs children to be born. Most, but certainly not all, women would like to have children. Most, but not all, men would like to be fathers. Graduate women physicists are likely to make as good mothers as average women because they will be likely to pass on their love of science to their young. It takes time to train a research physicist – at least three years for a PhD and another five years or so working in a good research group. If someone takes a break of a year or so, the training time is probably increased because of the need to revise what had been learned before. Good female students should be able to call on this training at any time in their lives to fit in with their commitments as carers.

Organizations that employ physicists should, when assessing experience, recognise that some may have taken time off for child rearing and not expect a straight correlation with age.

In the traditional view, how are women with children accommodated in the current structure? As we have seen, most physicists (at all levels) are men, so work environments have not habitually needed to accommodate women with young children. Women physicists have to work out their arrangements from scratch – career structures do not accommodate gaps.

Consider various patterns.

First, the dedicated academic who takes three or six months maternity leave then returns to full time work, possibly with a brief spell working part-time. Almost all women with academic appointments in physics departments followed this route. There is much evidence to show that the academic performance of this group is no different from that of women without children. For example, in the UK, nine out of 15 women physics professors and one of the two who are Fellows of the Royal Society have children.

It appears that although they cannot be part of the long hours culture, women with children compensate by being better focused. A number of things would make their lives easier. Academic salaries at the lower age range are low. Costs of childcare are high. The ideal solution would be to raise salaries so that academics could pay for childcare if they wished. Primary school finishes at about 3.15pm, so a family in which both partners work full time needs to have extensive childcare arrangements for many years.

The high-flying academic must have a conference presence and this requires very significant extra childcare. The children may be born during a period of a fellowship or after a lectureship has been obtained. The government-commissioned report *The Rising Tide*, published in 1992, suggested that childcare should be a taxable deduction but this has never been agreed. So, as a second-best this report suggests:

University academic staff should receive help with childcare costs in university crèches and that the cost of extra childcare should be automatically allowed on travel grants.

One good idea that actually takes advantage of the two-body problem is used in Belgium: both parents can work at the 70%-80% level with flexible hours. This seems to work much better than schemes where, in theory, either partner can take maternity leave but in practice it is only the woman who does.

The father should be able to opt to work at 70-80% level for an agreed period of time to assist with childcare, without loss of a defined career path.

The next case to consider is the woman who wants to return part-time after her maternity leave. This is an excellent strategy as the woman never loses touch and yet is working the hours that suit her. Usually women who follow this strategy will become full time later on.

Several of the women at the Paris conference had followed this route, including Bev Hartline (currently deputy director of the US's Argonne National Laboratory) who did a job share with her husband. There seem, however, to only be a few cases in the UK where an established academic or Advanced Fellowship holder has been able to go part-time and no instances for RAs. The report Maximising Returns[12] found relatively few women working part-time in any SET employment.

It is absolutely essential that a woman is not disconnected from consideration of promotion at this point but stays on her original career path; if she is working part-time, it will clearly take longer to progress from grade to grade. Anecdotal evidence suggests that many women who are able to work part-time are then excluded from normal promotion procedures. Real data here would be very valuable.

All employers of physicists should be encouraged to allow the possibility of part-time working or job sharing (for both women and men), and this should be available also both to university contract staff such as research associates and to permanent academic staff. (Career advancement may be slowed, but it should not be reduced to zero.)

The last possibility to consider is a woman who takes a career break and wishes to return to physics-based employment when her children are at school. Her problem is her real and perceived lack of knowledge of the current state of the art. (Often the problem is more perceived than real, but neither she nor an employer really appreciates this.) At present there are few opportunities available.

If the woman has previously carried out research at a high level or held a responsible post in industry, she would be eligible for a Daphne Jackson Returner's Fellowship. This provides part-time retraining for two years, after which she can usually join the job market. One of the crucial aspects of the retraining is that she gains in confidence. But many women are not at this level – something should be done for them.

Retraining should be much more widely available and targeted at women physicists without a PhD or extensive research experience. Funding for a PhD (possibly part-time) should be available for suitable candidates.

The UK workforce is very mobile and a large fraction of women who apply for Daphne Jackson Fellowships have relocated, following their partner during their career break. SET is not a portable qualification like law or medicine. If, for example, a woman had worked in the semiconductor industry and then relocates to an area where there is only petrochemicals, she is going to need some retraining if she is to use her physics.

Short-term fellowships should be available to retrain women who have relocated to a part of the country where their previous experience is not relevant.

VII. Men helping women and women helping themselves

The responsibility of increasing the participation of women in physics at all levels must rest with the whole community. Women have to be ever alert as to how they can help younger women or draw attention to the achievements of women; men have to be on their guard against sexist behaviour in themselves and in others.

Many women have at least as heavy a domestic responsibility as men (and many have a great deal more). It is just not possible for them to spend a disproportionate amount of time promoting physics to women as well as maintaining a competitive career themselves; obviously only they can act as female role models, but other activities can and should be the responsibility of the whole community.

One important area is mentoring. There are numerous times during everyone's career when advice or encouragement is needed. This is true for both men and women. Most men are likely to have colleagues around them who have had similar experiences – male physicists meet numerous other male physicists and build a wide network of contacts they can approach for advice. Female physicists also make contact with many male physicists, the vast majority of whom are very well disposed towards them. But no matter how well meaning, these men are not necessarily able to give a woman sound advice simply because they are not women. The woman physicist is unlikely to have a wide network of other women contacts. Women physicists tend to be isolated. They may know some other women physicists, but they will not necessarily have suitable experience to give advice in a particular field.

Advice comes best from someone who has known the individual for some considerable time and who has had similar experiences. The advantages of mentoring were mentioned during several discussions at the IUPAP conference. It was clear that, although there is some value in a woman having male mentors, it is most important that she has a woman as a mentor – preferably a women who has had similar experiences.

Women are less likely to make applications for grant funding than men. A mentor with experience of making a particular type of application would be able to encourage (or discourage) a mentee considering such an application. A women returner would be able to help a mentee considering returning to work because she knows the problems involved with childcare as well as the problems involved with returning to the field.

To establish contacts with mentors maintained over long periods of time, it is necessary to have a mentor scheme for women which can make links that continue even when those involved move from one establishment to another.

The mentoring scheme should be cascading so that women who have broken through the glass ceiling are mentors for those who are in mid-career. Those in mid-career should be mentors for those who are starting. This should extend to those who are just established being mentors for students. As the women's careers develop, the links should continue.

A mentoring scheme which establishes life-long links for women physicists is strongly recommended.

Women who have returned from a career break can give invaluable advice to those considering how to do this.

A Physics Returners network should be established to act alongside the others that cover SET [37].

Women physicists should be prepared to visit schools or be particularly visible at departmental open days. (Men can help here by doing support work for open days, allowing the women to concentrate on the high-visibility activities.) Women should also compile a list of possible speakers that would be available to conference organizers. The IoP and RAS should join with the EPS to produce such a list across Europe.

VIII. Conclusions

The number of women physicists has increased over the last 50 years, particularly over the last 20. However, in spite of strong encouragement from central government we are a long way from gender balance. This report has made a number of recommendations.

Some of them are very radical. It is clear that the small changes made in the past were not enough.

There are two important features that need to be addressed and recognized:

Many women are conditioned to be polite, diffident and cooperative from their earliest childhood. This makes them less assertive (and much less aggressive!) than many young men. These same features that are so valuable in a team are also the characteristics that cause some women to underplay themselves both when they write CVs and job applications and also perhaps in making grant applications. What is needed here is a real change in the way that women scientists are assessed. This is preferable to the other approach – train young women to become as assertive as men.

Women who have worked full time for all or most of their careers while also raising children know full well that they have taken on a difficult task. Currently only those who are prepared to delay a family and are most dedicated choose this route. This report has suggested ways in which the way might be smoothed so that more physics-educated women could follow a scientific career. One feature that was brought out over and over again at the IUPAP conference – in written submissions from different countries, in invited talks and in discussions – was that women who had not had children still felt excluded by the system and that their careers had definitely suffered because they were a woman.

Family-friendly policies are important and should be implemented, but no-one should think that this alone will solve all the problems. If anything, the change in culture is more important. The RSC report[11] underlines the effect of culture on the way in which women feel marginalized and the MIT report[20] confirms "There still is very little awareness at MIT, or elsewhere, of the gendered nature of academic rules: how criteria of evaluation, timing expectations, conventions of authorship – to name a few – help men more than women. Nor is there awareness that reputations are constructed, and cumulate from slight advantages that favor men, and slight inequities that disadvantage women."

A number of recommendations in this report place an extra burden on women: they should be role models in schools; they should be prominent in the media; they should act as mentors to those who are following them; they should sit on grant awarding panels; they should sit on appointment and promotion panels. It must be recognized that this group of scientists is probably under most pressure anyway, particularly when their children are young. These things cannot happen unless the whole community considers them important and proper ways for an academic to fulfil her duties.

The impact of implemented proposals must be monitored.

Finally, let us review why the community should want to increase the fraction of physicists who are women. There is ample data that intelligence is distributed equally between the sexes. Girls are performing well in all school and university examinations[32]. If it is important to have the most able scientists in the best equipped laboratories to maintain the science and technology base, then it makes sense to choose them from the whole population rather than just the male half. In so far as women are different, they bring important team working skills to the science environment.

There are a number of very successful women physicists in the IoP and RAS. This report highlights measures that should result in an increased number.

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References

1. Full report of the IUPAP conference on Women in Physics at *http://www.if.ufrgs.br/%7Ebarbosa/conference.html*
2. ETAN Report on Women and Science: Science Policies in the European Union: *Promoting excellence through mainstreaming gender equality* *http://www.cordis.lu/improving/women/documents.htm* Document at *ftp://ftp.cordis.lu/pub/improving/docs/g_wo_etan_en_200101.pdf*
3. *http://www.dti.gov.uk/ministers/speeches/hewitt210102.html*
4. *Excellence and Opportunity* House of Commons Select Committee on Science and Technology 6th report *http://www.parliament.the-stationery-office.co.uk/pa/cm200001/cmselect/cmsctech/200/20007.htm*
5. *Physics: building a flourishing future* *http://policy.iop.org/UPI/index.html*
6. *Set for Success* The final report of the review by Sir Gareth Roberts into the supply of scientists and engineers in the UK *http://www.hm-treasury.gov.uk/Documents/Enterprise_and_Productivity/Research_and_Enterprise/ent_res_roberts.cfm*
7. A Marks (private communication)
8. E Whitelegg Education section of *Routledge International Encyclopaedia of Women* ed C Kramerae and D Spender December 2000
9. A Kelly and B Smail "Sex stereotypes and attitudes to science among 11-year-old children" *British Journal of Educational Psychology* **56** 158-68 part 2 June 1986
10. "Love and the two-body problem" *http://physicsweb.org/article/world/14/10/10*
11. *http://www.rsc.org/pdf/policy/factors.pdf*
12. *Maximising Returns:* *http://www.peoplesscienceandpolicy.com/maximising_returns.html*
13. L D Newton and D P Newton "Primary children's conceptions of science and the scientist: is the impact of a National Curriculum breaking down the stereotype?" *International Journal of Science Education* **20** (9) 1137-49 Nov 1998
14. J Solomon "Girls' science education: choice, solidarity and culture" *International Journal of Science Education* **19** (4) 407-17 Apr-May 1997
15. L. Blackwell paper presented to the British Sociological Association Conference, Manchester Metropolitan University, April 2001
16. Sylvia Ann Hewlett. *Baby Hunger: The New Battle for Motherhood* (2002)
17. M Dresselhaus (private communication)
18. C Wenneras and A Wold *Nature* **387** 341-43 (1997)
19. N Lane *Debates in Nature* 9 September 1999
20. A summary of the MIT report is given at *http://web.mit.edu/fnl/women/women.html*
21. A Lawler *Science* **259** 2192 (2002) and *http://web.mit.edu/faculty/reports/*
22. *http://nextwave.sciencemag.org/cgi/content/full/1999/11/11/16*
23. *Independent review of higher education pay and conditions* Report of a committee chaired By Sir Michael Bett

24. G A Gehring *Physics World* September 2001
25. *http://www.warmwell.com/andersonstories.htm*
26. J M. Curtin et al *Journal of Women and Minorities in Science and Engineering* **3** 95-117 (1997)
27. *http://www.set4women.gov.uk/*
28. *http://www.athena.ic.ac.uk/*
29. *http://www.admin.cam.ac.uk/offices/press/factsheets/women3.html*
30. *http://www.admin.cam.ac.uk/univ/wiseti/*
31. *http://www.engc.org.uk/wise/*
32. *http://www.jcgq.org.uk/Exam_Result_data/GCE_VCE_Results_Press_Release.pdf*
33. *http://www.open.ac.uk/science/cse/SLIPP/SLIPP.htm*
34. *http://www.iop.org/sc.html/*
35. *http//www.britassoc.org.uk/*
36. *http://www.royalsoc.ac.uk/funding/index.html*
37. *http://www.women-returners.co.uk/*
38. *http://www.sst.ph.ic.ac.uk/trust/*
39. *http://www.wellcome.ac.uk/en/old/AWTpubNWSwlkPOLbal.html*
40. A Marks: Study of Oxford undergraduates while a Schoolteacher Fellowship at St Peter's College: Trinity Term 2001 *to be published*
41. *http://www.etechb.co.uk/promoting_engineering_and_technology/wise/WISE_publications/*
42. G Ferry *Dorothy Hodgkin: A Life* Granta 1998
43. *http://www.physics.ucla.edu/~cwp/Phase2/Franklin,_Rosalind@841234567.html*
44. F Crick and J Watson: *The Double Helix* Penguin 1999 (reissued)
45. *http://www.aps.org/educ/cswp/*

The UK delegates

The UK delegates at the IUPAP Conference on Women in Physics who participated in the preparation of this document were:

Professor Gillian Gehring (team leader)	University of Sheffield
Dr Yasmin Andrew	JET project
Dr Joanne Baker	University of Oxford
Professor Sandra Chapman	University of Warwick
Dr Dimitra Darambara	University College London
Dr Helen Heath	University of Bristol
Mrs Ann Marks	Physics teacher

Also present, from the UK:

Miss Joanna Hamilton (Glasgow University) and Miss Roisin Keenan (Queens University, Belfast) who, along with Dr Joanne Baker (listed above), obtained EPS bursaries available to young researchers (aged under 35) from the EU and candidate countries.

Dr Peter Melville and Miss Alex Byrne, representing the Institute of Physics

Professor George Morrison (University of Birmingham), representing Europhysics News.

Dr Yvonne R Masakowski representing The Office of Naval Research

Professor Teresa Rees who gave a plenary talk at the conference.

About the authors

Professor Gillian Gehring (team leader) works on condensed matter theory at Sheffield University. She is currently the longest-serving woman professor of physics in the UK. She had 20 years experience as a tutor (teacher/advisor) to women physics undergraduates in an Oxford women's college before moving to Sheffield and is responsible for many studies of women in physics. She was a member of the working party formed to write the Rising Tide government-commissioned report, is on the selection panel for Daphne Jackson Fellowships and is the author of a study into women physicists' salaries and an article "Scientific Mothers". Professor Gehring is a committee member of the Institute of Physics Women in Physics Group. She has two daughters who are currently students.

Dr Yasmin Andrew is a physicist working in the core spectroscopy group at the Joint European Torus (JET). She is involved in advising three female graduate students at the Centre for Plasma-Aided Manufacturing at the University of Wisconsin-Madison (1999-2001) and has a strong interest in women in physics issues. Dr Andrew has two children under the age of two.

Dr Joanne Baker is a Royal Society University Research Fellow (since 2001) in astrophysics at Oxford University. She is an independent researcher in extragalactic astrophysics and observational cosmology. Dr Baker is involved with the national and Oxford Women in Science and Engineering (AWISE) for Women in Science and Engineering (AWISE).

Professor Sandra C Chapman is the first female to be promoted to professor in the physics department at Warwick University. She was previously the first female to be appointed to a faculty position in the physics department at Sussex University, where she ran "Women into Physics" courses. Professor Chapman is head of the space and astrophysics group (which she founded) at Warwick and specialises in nonlinear phenomena in solar system, astrophysical and laboratory plasmas. She is Vice-President of the Royal Astronomical Society and a member of the PPARC Education and Training Committee.

Dr Dimitra Darambara is a Senior Research Fellow University College London, working on radiation imaging detectors. For the last two years she has chaired the Institute of Physics Women in Physics Group. She is heavily involved in the Women and Science sector of the European Commission, which aims to promote women's participation in research and evaluation panels and to set up a European Platform of Women Scientists. She is also involved with the DTI "Networking the Network" scheme for women scientists and is a member of the committee of the Women in Engineering section of the IEEE (USA).

Dr Helen Heath is a physics senior lecturer at Bristol University, specialising in high energy particle physics. She is responsible for recruitment to undergraduate physics courses at Bristol University and is involved in policy on PPARC studentships and fellowships as a member of the PPARC Education and Training Committee and several fellowship appointment panels. Dr Heath is the organiser of annual "Think about Physics" days for 14-15 year old girls. She has a family and is an experienced and enthusiastic promoter of science though schools talks (infants to sixth form), in-service training for teachers and talks to the public. She is an Honorary Ambassador for the Girl Guide Association.

Mrs Ann Marks is a retired teacher of physics, in girls schools. She was a member of the Institute of Physics working party for the "Advancing Physics" (new A level) syllabus and is also a committee member of the Institute's Women in Physics Group and heads its Education Sub-Group. She is also Education Secretary of the Institute's Merseyside Branch. As a Schoolteacher Fellow she has been conducting research on women in physics at Oxford University; concentrating on the drop out from physics at each stage and conducting a comparative study at Liverpool University. Mrs Marks is a Methodist local preacher and has a family.

APPENDIX I

INTERNATIONAL CONFERENCE ON WOMEN IN PHYSICS

Maison de l'UNESCO, Paris, France • 7-9 March 2002

CONFERENCE RESOLUTIONS

(References indicate the relevant section of the report)

RESOLUTION	ACTION BY	REF.
1. Resolution directed at Schools and their Government Sponsors Girls should be given the same opportunities and encouragement as boys to learn physics in schools. When parents and teachers encourage girls, it strengthens their self-confidence and helps them advance. Methods and textbooks used in teaching physics should include those that have been shown to interest girls in physics and foster their success. Studies show that young girls have a strong desire to help improve people's lives, and it is therefore important that they have the opportunity to see ways in which physics has a positive impact on society.	**DfES, OST, DTI, Cabinet Office Women's Unit** **Examination Boards** **Teaching Unions** **Headmasters conference, Headmistresses conference**	6.2
2. Resolutions directed at Universities **2.1 Students** Universities should examine their policies and procedures to ensure that female students are given an opportunity for success that equals that of male students. All policies that perpetuate discrimination should be abolished, and policies that promote inclusion should be adopted. This may involve adopting such practices as: using a broad interdisciplinary approach to physics; providing flexible entry criteria to the physics major; allowing early participation in research; providing mentoring; and exposing students to the important contributions physics makes to other sciences, medicine, industry and the quality of daily life. Adopting these practices will have an especially positive effect on young women, who often feel isolated and unwelcome in physics.	**Heads of physics depts.** **Monitored by IoP accreditation process** **Universities** **HEFCs** **UUK**	6.3

2.2 Faculty and researchers

Recent studies have shown that, even at top research institutions, women scientists have not been treated fairly with respect to their male colleagues. This is not only very harmful to women in science but in the long run will be harmful to science as well. Universities must examine and communicate their policies and practices to make sure that they promote equity; it is of key importance that universities guarantee transparent and fair mechanisms of recruitment and promotion. Additional important elements for success are access to research funding and facilities and sufficient time for research.

University heads of physics depts and personnel departments 6.4 6.5

Having a family should not be allowed to impede women's participation in scientific careers. A family-friendly environment that provides such things as childcare facilities, flexible working schedules and employment opportunities for dual-career families will enable career success.

Research Councils

RAE process 6.9

University governance has been found to be dominated by men. Women need to be included in university and physics department governance, particularly on key policy committees. Women must have input into those policies that control their own destinies. It is important for the development of young women physicists to see successful women active in research, teaching and leadership.

6.6

3. Resolution directed at Research Institutes

Research institutes will benefit from policies that allow women scientists to be successful. Institute directors should ensure that policies that promote gender equity in recruitment and promotion are adopted and enforced. Too often a "glass ceiling" is allowed to stop the advance of women's careers.

EPSRC, PPARC and MOD funded laboratories 6.7

Institute directors should take an active part in ensuring that family-friendly practices such as childcare facilities and flexible working schedules are available to all. Surveys repeatedly show that a leading concern of women is balancing career and family life; having a family should not be allowed to impede successful participation in scientific research.

6.9

4. Resolution directed at Industrial Laboratories

Industrial laboratories will benefit from policies that allow women scientists to be successful. Industrial managers and research directors should ensure that policies that promote gender equity in recruitment and promotion are adopted and enforced. Too often a "glass ceiling" is allowed to stop the advance of women's careers.

Directors of industrial laboratories 6.8

Industrial managers should take an active part in ensuring that family-friendly practices such as childcare facilities and flexible working schedules are available to all. Surveys repeatedly show that a leading concern for women is balancing career and family life; having a family should not be allowed to impede successful participation in scientific research.

6.9

5. Resolution directed at Scientific Societies

Scientific and professional societies can and should play a major role in increasing the number and success of women in physics. Each society should have a committee or working group that is responsible for such issues and that makes recommendations to the society as a whole. At minimum, societies should: work with other organizations to collect and make available statistical data on the participation of women in physics at all levels; identify women physicists and publicize them as role models; include women on programme committees and as invited speakers for society-sponsored meetings and conferences; and include women on editorial boards of society journals.

IoP, RAS 6.1

6.2

6.6

6. Resolution directed at National Governments

Physics plays a key role in understanding the world we live in, and physicists contribute strongly to the economic and cultural development and welfare of nations. It is therefore in every nation's self-interest to provide strong physics education for all its citizens and to support advanced education and research. Governments must ensure that women have the same access and chance for success in research and education as men. National planning and review committees should include women, and awards of government funds should only be made to organizations and institutions that make gender equity a part of their policies.

OST,DTI, 6.1
Cabinet Office 6.2
Women's Unit, 6.3
HEFCs 6.4
6.6
6.7
6.9

7. Resolution directed at Granting Agencies

EPSRC, PPARC, Royal Society 6.6, 6.9

Agencies that make funding available for scientific research play a key role in promoting the success of individual scientists as well as science as a whole. Past studies have shown evidence for gender bias in the review process. To ensure that women have the same access to research funding as men, all competitions for funding should be transparent and widely publicized; the criteria for obtaining funds should be clear; and women should be included on all review and decision making committees. Limits on age of eligibility or grant structure and duration that seriously disadvantage applicants taking family leave should be reconsidered. Granting agencies should maintain and make available statistical data by gender, including such information as the proportion and qualifications of women and men who apply for funding and who obtain funding.

8. Resolution directed at IUPAP

UK representatives on IUPAP 6.6

IUPAP is the international organization of physicists and as such exerts considerable influence on the physics community through its statements and activities.

IUPAP should both endorse the above resolutions aimed at other groups and also examine its own actions to make sure that they contribute to increasing the number and success of women in physics. It will also be valuable for IUPAP to communicate the results of this conference to international scientific organizations in other fields.

In the election of IUPAP's Executive Council and Commission members, procedures should be instituted to ensure the full inclusion of women.

IUPAP sponsors major international conferences; a criterion for such sponsorship should be the demonstration that women are included on the international advisory committees and programme committees. IUPAP should require conference organizers to report gender distribution of invited speakers.

IUPAP should encourage all its national liaison committees to include women among their members. Liaison committees should also advocate these resolutions in their countries. IUPAP should continue its Working Group on Women in Physics and empower it to establish an international advisory committee with a member in as many countries as possible. Finally, this group will form the basis of a network that can continue the work of increasing the number and success of women in physics.

Recommendations

Many recommendations emerged during the conference. They are here grouped into categories, but many of them impact on other categories too. Most of these recommendations would improve physics for both men and women.

	RECOMMENDATION	REF.
I.	**General recommendations**	
1.	Coordinate data collection on physics demographics, including gender, to access internationally and watch and influence trends. Collect data regularly (every one to three years) and in a consistent way, to watch and influence trends. Request data from national and regional physical societies. Find out why women leave physics.	6.1
2.	Create, support, and encourage networks for women physicists: local, national, international, including a worldwide e-network. Create women-in-physics web pages in each country, with links to each other and to information on successful strategies and programmes. Provide a well publicized international web presence for Women in Physics.	7
3.	Involve men, especially highly respected physics leaders, in improving the climate for women (and minorities) in physics.	7
4.	Have transparent, gender-blind processes for important decision making. Transparency can be aided by having a requirement for decisions to be reported and explained. Important decisions include those related to recruitment, selection, salary, promotion, peer review, conference programmes, allocation of space and equipment, and other issues affecting important working conditions.	6.4 6.5
5.	Establish mechanisms to assess and improve the climate for women (and minorities) in physics. Proven approaches include creating special committees for women in physics and focusing resources and attention on this issue. Examples include having a source of matching funds for initial years of a tenure-track position filled by a woman, and committees that visit universities, research institutes and other physics employers to advise on their climate for women.	6.6 6.3
6.	Encourage written rules and policies (for example, an equality policy) to achieve fairness and transparency in policies, practices, and decision making.	6.6
7.	Provide web "index" of links to international funding sources.	7
8.	Adjust the reward structure at all levels to encourage desired behaviours.	6.6

II. Attracting girls into physics (childhood to university)

1. Revise educational curricula and materials to connect physics with medicine, biology, technology, the environment, etc, and to show diverse physics career paths and job prospects. Ensure physics courses, maths courses, textbooks, equipment, and funding for girls' education are as good as for boys' education, and feature women physicists as role models. **6.2**
2. Strengthen the training of science/physics teachers and include opportunities for them to do research and to interact with working scientists. Train teachers and counsellors about gender issues (girl-friendly classroom atmosphere, examples of interest to girls). Attract qualified schoolteachers with fair pay, respect, and working conditions.
3. Publicize physics role models who counteract the stereotypes and whose stories are examples of career success and leadership positions.
4. Educate parents about opportunities for daughters and how to encourage them.
5. Help smart girls network (clubs, enrichment opportunities and encouragement).
6. Attract more girls to compete in prestigious physics competitions.
7. Raise boys to share family responsibilities and to expect women to have professions.
8. Get international help and funding for schools in developing countries
9. Involve universities, research institutes and industries to help schools and strengthen teacher training.

III. Launching a successful career (university to mid-career)

1. Have flexible entry and graduation requirements for physics majors, and provide early opportunities for students to participate in research. **6.3**
2. Train/sensitize faculty and supervisors to gender issues (female-friendly atmosphere, respectful and collegial treatment).
3. Provide enlightened and supportive mentors and supervisors for women physicists. These people should find funding, teach the women the "rules of the game" and how to write successful proposals, introduce them to important professional contacts, give them challenging assignments and opportunities, provide constructive feedback on unsuccessful proposals or interviews, give them credit and advocate them in the physics community. . **6.4**
4. Provide training for women physicists in presentation of results, paper writing, grant applications, etc.
5. Shorten the post-postdoc phase with its inherent insecurity and relocation requirements.

IV. Balancing family and career

1. Respect and value family obligations (quality childcare convenient to the work-place and at conferences, flexible working hours). **6.9**
2. Pause the "career clock" and have flexible age limits and rules for grants and fellowships, to not disadvantage people who take time for family responsibilities. (Accord career interruptions for "family service" the same respect as for "military service".)
3. Provide funding sources to help people return to physics after a career pause.
4. Solve the dual-career couple problem by facilitating geographically co-located job opportunities and creative solutions such as shared positions.

V. Getting women into physics leadership

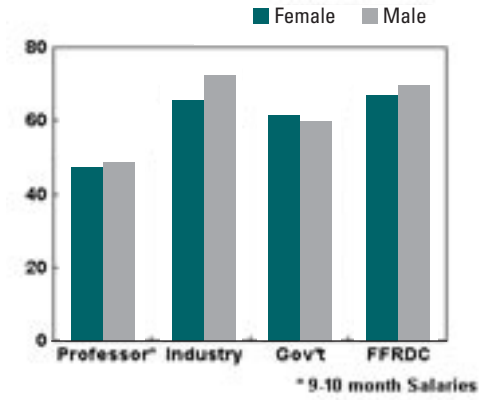
1. Appoint women physicists to leadership positions and include them on important committees in their institutions, countries, professional societies and IUPAP. **6.6**
2. Involve more people in leadership. Consider innovative approaches, such as shared positions, term appointments, and novel structures.

VI. International aspects

1. Create opportunities for R&D employment, funding and research equipment in developing countries (not just factories employing cheap labour). **7**
2. Provide opportunities for collaboration and exchanges between regions and countries. Provide resources for conference travel for physicists from developing countries, and for physicists from developed countries to be visiting lecturers in developing countries.
3. Establish and sponsor international speaker programme(s) for women physicists: web-accessible database of names and topics; source of travel support.
4. Sponsor prestigious, topical international physics summer schools with female and male speakers, organizers, and participants.

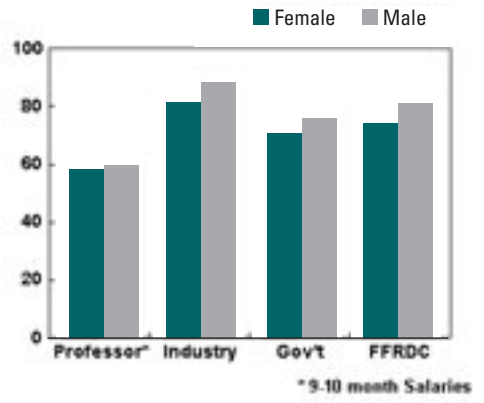
APPENDIX II: Data

US mean salary data for PhDs who are members of the APS, within 10 years of graduating



Controlling for years since degree, the difference between women's and men's salaries is significant only for those employed in industry (α=.05, one-tailed)

US mean salary data for PhDs who are members of the APS, within 11-20 years of graduating



Controlling for years since degree, the difference between women's and men's salaries is significant only for those employed in industry (α=.05, one-tailed)

UK salaries for members of the IoP who hold PhDs and are aged under 35.

	Women	Men
Mean salary	25,730	27,904
Number in sample	115	504

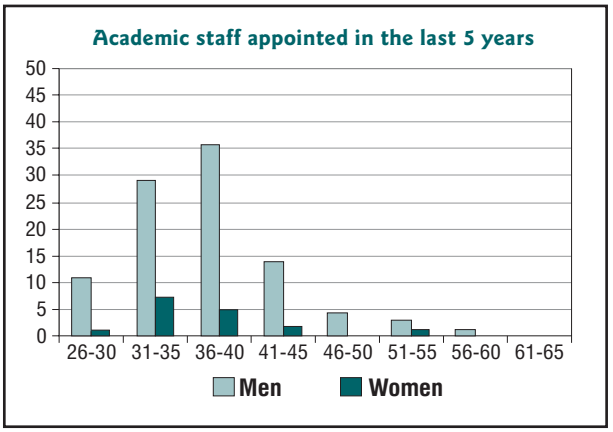
UK salaries for members of the IoP who hold PhDs and are aged 35-44.

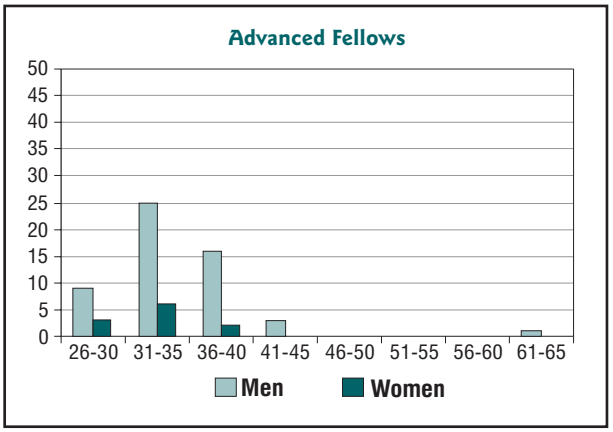
	Women	Men
Mean salary	32,452	39,712
Number in sample	76	541

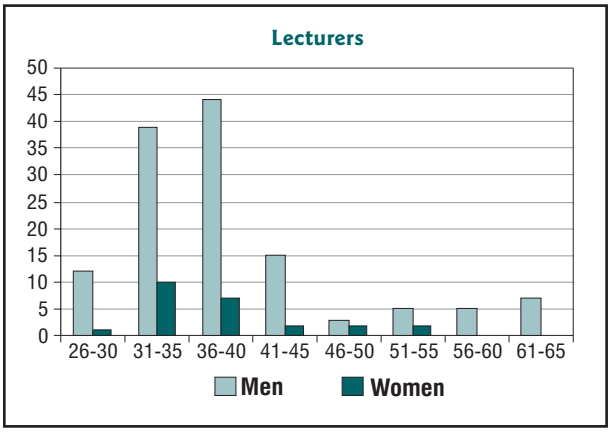
Salaries for UK women were 18.3% lower than the men when averaged over all fields of employment.

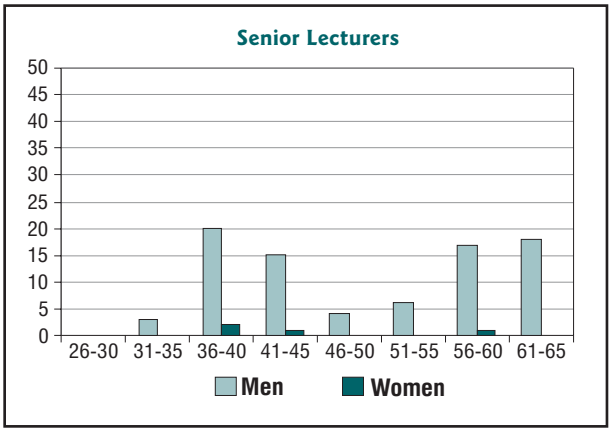
Academic staff by age, gender and position

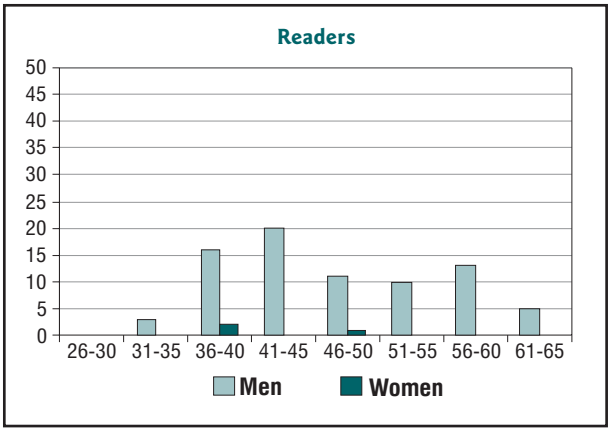
The following charts are compiled from data from the Standing Conference of Physics Professors (21 departments out of a possible 61 responded). The Research Fellows are included as it may be assumed that most of them will get university posts shortly. A much larger percentage of women has been appointed recently than is employed overall so the balance is shifting.

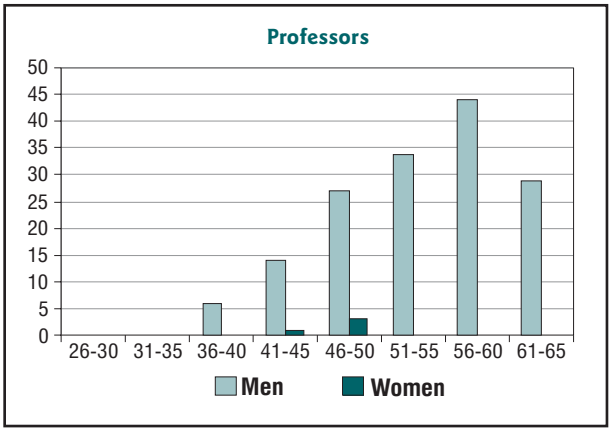












LEVEL	PERCENTAGE OF WOMEN (of the total number at that level)
Grade A* or A double science GCSE (women/men 2001)	13.4/10.8
A level physics	22 (2002)
Grade A at A level physics (women/men 2002)	32/25
Undergraduate physics (BSc or MPhys)	21
Research postgraduates (NB this number includes foreign students)	18
Postdoctorate (NB this number includes a number of foreign workers and excludes a number of UK nationals working abroad)	15
Advanced Fellowships (URF, EPSRC, PPARC)	16
Lectureship	8
Senior lectureship	5
Professor	3

Survey of Institute of Physics members

1998 SURVEY

As the numbers are of members over a ten year age span, we give the estimated number graduating over this time. This assumes that the number of physics graduates and percentage of women has remained constant over the period.

The current percentage of women studying for a physics degree is around 20%; in the late 1970s it was 16% and was, it seems, around 10% in the early 1960s. Hence the percentage of women in the 56-65 age group would be expected to have fallen by a factor of two compared with the men. In fact, the fall-off is very much higher than can be accounted for by taking a better estimate for the numbers who graduated. It is also assumed here that those who did an MSc or PhD also did a BSc and that a negligible number obtained both an MSc and a PhD.

WOMEN members of the IoP

Numbers graduating over 10 yrs	Age/degree	16-25	26-35	36-45	46-55	56-65
6000	BSc	553	346	106	49	26
1200	MSc	64	107	40	24	9
1000	PhD	–	192	156	70	26
8200	ALL	682	647	303	143	61

MEN members of the IoP

Numbers graduating over 10 yrs	Age/degree	16-25	26-35	36-45	46-55	56-65
15000	BSc	1981	1693	878	574	359
5000	MSc	173	445	301	289	215
4200	PhD	2	1135	1388	1459	1122
24200	ALL	2329	3283	2567	2323	1698

2001 Survey

	MALE						FEMALE					
AGE	BSc	MSc	MPhys	PhD	BSc/MPhys	Total	BSc	MSc	MPhys	PhD	BSc/MPhys	Total
Under 25	845	341	410	1	1255	1597	303	103	138	1	441	545
25-29	1381	359	601	198	1982	2539	395	117	125	37	520	674
30-34	1281	372	22	647	1303	2322	276	89	9	130	285	504
35-39	1406	367	8	823	1414	2604	214	64	2	109	216	389
40-44	1088	289	5	658	1093	2040	135	33	1	76	136	245
45-49	1050	336	4	697	1054	2087	103	29	0	60	103	192
50-54	986	320	4	740	990	2050	79	29	1	43	80	152
55-59	1009	352	3	873	1012	2237	46	17	1	21	47	85
60-64	721	255	0	607	721	1583	25	7	0	17	25	49
65+	1858	493	0	1181	1858	3532	42	12	0	17	42	71
TOTAL	**11625**	**3484**	**1057**	**6425**	**12682**	**22591**	**1618**	**500**	**277**	**511**	**1895**	**2906**

MEDIAN SALARY COMPARISON

IoP salary survey 1998

These show salaries for women and men separately and for those whose highest degree was a Bachelors (with honours) and those with an MSc or doctorate. All the salaries and ratios are given to two significant figures – the raw data was given to the nearest 10p. All data are for those in full time employment. (The rates of pay and career structures for women who work part-time are another issue altogether!). The women's figure is given first and the men's after in brackets.

Median gross annual income for women (men) in full-time employment (in £k)

	<30	30-39	40-49	50+
BSc	**17** (17)	**27** (28)	**26** (34)	**26** (36)
MSc/PhD	**18** (18)	**23** (26)	**35** (35)	**41** (40)
All	**17** (18)	**24** (27)	**29** (34)	**34** (38)

These data showed two remarkable features. First, the salary of the middle-aged men was very little different if they had taken a PhD whereas there was a large difference for the women. Secondly, the salaries of the women with PhDs were not lower than those of the men with PhDs. There is much more detailed analysis of the 1998 salary and members data on the WIPG website.

IoP salary survey 2001

These data differ from those obtained before in several respects. First, information is given in five year rather than ten year bands – one consequence of this is that the numbers of women become small, so gaps appear in the table where the number of returns falls below 10. Also, the MScs were counted specially so are not adding in to the PhD column this time. As the numbers were small, they were not included as a separate column.

The salaries for the women in this return are most disappointing. In some cases the median is below that for the 1998 survey. The women are falling behind the men in all categories and the women's salaries are on a plateau from age 35.

Median gross annual income for women (men) in full-time employment (in £k)

AGE	All	PhD	BSc (or MPhys)
<25	**17** (18)	– –	**17** (18)
25-9	**22** (22)	**22** (23)	**24** (23)
30-4	**26** (28)	**26** (27)	**25** (31)
35-9	**31** (33)	**30** (32)	**31** (36)
40-4	**31** (36)	**33** (37)	– (36)
45-9	**32** (40)	**33** (41)	– (38)
50-4	**31** (41)	**36** (45)	**29** (39)
55-9	**32** (42)	– (44)	– (40)
60-4	– (42.6)	– (42)	– (40)

The table would have looked very different if the mean salary instead of the median had been plotted. This is because for the higher age range the mean is weighted by a few very high salaries. For example, for men with BScs at age 45-49, the median salary is £38k and the median is £90k (there were 127 in the sample). Obviously some men have got clear through any glass ceiling but the evidence for such high salaries among the women is less clear.

APPENDIX III: A possible scheme to reform the RAE

Universities get much of their government funding through the Research Assessment Exercise (RAE). The RAE has an enormous influence on academic appointments, particularly in the physical sciences where the numbers of undergraduate students are low and research incomes are high. No department can gamble on an appointment that may cause its RAE rating to drop. This is a particularly severe problem for small departments where one new appointment represents a greater fraction of the whole.

Currently the RAE provides a very strong disincentive for universities to appoint a young person to a lectureship because of the need to show an international profile for all staff at the next RAE. Permanent appointments are made late: the returns from physics show an average age of appointment of 36. Such appointees are expected to have an international reputation in their field.

All the data suggest that the younger the academic appointments are made, the better the chance for women. (This was exemplified some years ago with the sudden appointment of women physicists when the "new blood scheme" was introduced: previously there had been essentially zero women appointed.) Currently in France, there is a postdoc period of a maximum of about two years; the percentage of women who get permanent jobs in universities and the CNRS is almost the same as that obtaining a PhD. It also makes an academic career more attractive to a woman who does not wish to be a "roving postdoc" until her mid-thirties but wants a more definite career path in one place where she may be domiciled with her partner.

The government could increase the rate of employment of women academics at a stroke if it removed the disincentive for universities to appoint young academics. The scheme given below would have this effect without eroding the country's science base in any way.

The scheme would aim to do the following:

1. Give a real incentive to universities to appoint lecturers under 30.
2. Allow young lecturers to develop their careers over the long term including the possibility of a change in field to adjust to their new department.
3. Give an incentive to universities to give permanent appointments to those who have just obtained AFs or URFs.
4. Give universities the reassurance that if a woman academic becomes pregnant the department will not suffer in the RAE. (While a woman is pregnant or has infants she is not able to travel as widely as her male colleagues. This will inevitably adversely affect her perceived international standing.)
5. Give a strong incentive to universities to employ women who have returned from a career break (returners).

A new category of return in the RAE would be instituted. The way it would work and the eligibility for this type of submission are described below.

A YP (Young Person's) return in the RAE

- A YP return for a staff member in the RAE would mean that no papers or statements about their international standing would need to be submitted for that staff member; the YP staff member would be assumed to have been assessed at a level equivalent to the returned member of the department who was 1/3 from the top. The YP staff member would be included in the volume statistic in the normal way.

The following categories of persons could be submitted for a YP return:

1. A member of the academic staff whose average age over the period of their appointment as a lecturer was less than 31.
2. Someone who holds an AF or URF who has been promised a lecturership (or other academic appointment) on its completion. In this case the age is calculated as in (1) above from the date at which the offer of a permanent appointment had been accepted.
3. Any women academic who is pregnant during the RAE period, adopts a baby in the period or has a child under one year old at the commencement of the period.
4. Any man or woman who becomes a single parent during that RAE period with children under 5.
5. The academic age of a "returner" who has been away for three years or more is to be calculated as 24 at the time at which she obtains a fellowship to return. This gives a long period when she could be entered as a YP and hence makes her a more attractive as a candidate for a permanent post.

No university would be *required* to enter anyone as a YP return. Clearly there will be a number of very distinguished academics who qualify for YP status but whose departments will choose to enter in the normal way.

No university would be prevented from continuing to make appointments to persons in their late thirties. This scheme is intended to allow a university to appoint someone in their twenties without the fear that they would not show up well in the next RAE.

This scheme is not intended in any way to diminish the quality of the research base. The same good people would be appointed to posts, but earlier. Clearly any YP staff cannot qualify on age grounds more than once, so departments would be keen to appoint someone who would be fully up-to-speed by the next but one RAE.

The generous provision for women on maternity leave would ensure that universities do not fear to appoint women to permanent posts. It would also recompense a university department in some part for the extra burdens that inevitable fall on other members of staff if one of their number works reduced hours during pregnancy and then takes maternity leave. The provision for men is even more generous – a man whose partner dies or suddenly leaves him is likely to be left with children in a disturbed state as well as suddenly having to cope as a single parent.

The academic age for a "returner" is fixed as one year short of the normal completion of a PhD, since a returned will need time to readjust and also possibly to change fields. It is not intended in any way as a salary guide, but exists only to determine eligibility for this scheme.

This scheme has been suggested for physics because of the high average age of appointments. It is not intended for all subjects.

All young academics currently suffer from the cyclical pattern of appointments in phase with the RAE and the very long period of apprenticeship. We believe that the scheme would be welcomed very strongly by young men as well as young women.