3. Measures for access, participation, and progression

– Academies must encourage, support, and celebrate the contributions of women to scientific discovery and application. –

This chapter considers programmes to increase the numbers of women progressing through science and engineering education, training, and careers. These are needed while women are still a minority. Briefly, these activities cover enhancement of visibility, the importance of role models, access to mentoring and networks and initiatives that provide earmarked resources to women in launching their careers or reestablishing them after a family-related break. In parallel, good management practice must be implemented to make organizations inclusive. Academies, individually and jointly, are requested to support ongoing programmes, and to develop measures of their own that give recognition to women scientists.

Increased visibility

Say 'scientists' to the average person and images of women do not usually come to mind. The embedded image of the scientist is very much that of a man. Changing the perception that women can and do become achievers in science and engineering, and that their numbers in these fields could one day reach parity with those of men, is an important part of the entire strategy relating to women-for-S&T careers.

Women scientists and technologists need to be featured in books (Wasserman, 2000; Padilla and Santos Ocampo, 2004) and textbooks, newspaper articles, on television, and in other media outlets. Professional forums and public events should highlight their successes.

Nothing spells success like an award, but at present women receive few of science's prestigious prizes and distinctions (Osborn et al., 2000). For example, out of the 491 Nobel Prizes awarded in physics, chemistry, and physiology and medicine, only twelve (two to Marie Curie) have been awarded to women (see Box 3.1). This phenomenon derives in part from the fact that women scientists and engineers have been scarce at the top levels, reflecting the much greater gender imbalance of earlier genera-

Box 3.1 Women scientists Nobel Prize winners

Physics
1903 Marie Sklodowska Curie
1963 Maria Goeppert Mayer

Chemistry
1911 Marie Sklodowska Curie
1935 Irene Joliot-Curie
1964 Dorothy Crowfoot Hodgkin

Physiology or Medicine
1947 Gerty Radnitz Cori
1977 Rosalyn Sussman Yalow
1983 Barbara McClintock
1986 Rita Levi-Montalcini
1988 Gertrude Elion
1995 Christiane Nusslein-Volhard
2004 Linda B. Buck

Peace
2004 Wangari Maathai

Source: www.nobelprize.org.

tions. Another reason is that suitable women candidates, when they do exist, may be overlooked by committees dominated by men. Approaches as simple as guidelines and training sessions for writing letters of support, recommendation, or nomination could help to broaden the pool and begin addressing gender inequities in this area.

Academies can contribute to the enhanced-visibility effort by honouring the achievements of distinguished women and awarding prizes created specifically for women. Further, academies can work to ensure that women scientists and engineers, whether they are top prizewinners or not, receive media exposure for their accomplishments. When books or reports related to the history of science are being written by academy members or staff, every effort should be made to highlight the women who have made significant contributions. Similarly, such achievers could be given enduring exposure in the naming of lecture halls, classrooms, awards, and fellowships. And in their routine activities, the academies should aim to achieve gender balance in their committees.

Resources exist that can be useful in such efforts such as the database on women experts (www.setwomenexperts.org.uk) maintained by the European Association for Women in Science, Engineering, and Technology; and the website www.alphagalileo.org, which provides a database of scientists for use by journalists.

By pursuing these and related options, the academies would be complementing the recent actions of countries, such as India, the United Kingdom, the Philippines, and the Republic of South Africa, that have made special efforts to recognize and promote the careers of women scientists. The Republic of South Africa's innovations, for example, include the Distinguished Woman Scientist award, the sponsoring of fellowships for promising young women scientists, and half of the TW Khambule NRF Research Awards for Black scientists and technologists.

Recommendation

- Academies are asked to identify successful women scientists and increase their visibility by such means as maintaining lists of their countries' top women in science and technology; including these women in academy publications and websites; recognizing them at academy events and inviting them to make presentations; and encouraging scientific organizations and establishments to nominate women for awards, while ensuring that women are represented on juries and selection committees.

Role models

Greater visibility is beneficial not only for practicing women scientists and engineers but also for *future* women scientists and engineers. It provides role models that are important for attracting girls into science and technology.

A 2004 survey by the Royal Society of London showed that just over half of the 1,000 scientists and engineers surveyed had been influenced in their choice of career by a visit to a scientist's or engineer's workplace, and that nearly a quarter had been influenced by a scientist or engineer visiting their school. The survey was part of a study of the impact of role model programmes. The good practice guide *Taking a Leading Role* produced as part of this study is available on the website www.royalsoc.ac.uk.

Similarly, in the United Kingdom, as well as in North America and elsewhere, university outreach programmes targeted specifically at girls give them positive impressions of science and technology in higher education. Open days, women-in-science events, residential courses, science clubs, competitions, and other mechanisms convey the message that science and technology are open to women. Emphasis should not only be on career possibilities but also on the fact that those careers are professionally rewarding and comfortably remunerated.

Other programmes in this vein, such as the U.K.'s Partnership Grant Scheme, often cater to girls and boys alike. But special attention—stressing visibility of women scientists in particular—is focused on girls to show them that they can be successful in science. The Canadian Pathmakers programme sends women S&T students at local universities to visit elementary and secondary schools in Ottawa (www.carleton.ca). Since Pathmakers and other programmes, such as the Chairs for Women in Science and Engineering, started in 1986, the enrollment of women in engineering courses in Canadian universities has doubled to 24 percent while enrollments in chemical and environmental engineering are approaching parity.

A priority for academies and government policymakers should be to develop training procedures and standards for role-model programmes like these in order that they be conveniently replicable—sparing university and community counterparts elsewhere from having to raise scarce resources to reinvent the wheel. Such policy efforts must be supported by well-conducted and -documented longitudinal research, unfunded in the past, on the long-term effect of role-model programmes (Vlaeminke et al., 1997).

Meanwhile, it is important to appeal to girls directly and engage them by connecting with their pre-existing interests and culture. Working with girls themselves has already produced websites, designed and developed using bright and lively clubs, such as the U.S. *Engineergirl* initiative (www.Engineergirl.com), the National Academies' *I was wondering* site (www.iwaswondering.org), and the U.K. *Computer Clubs for Girls* site (www.cc4g.net).

Mentoring and networking

Isolation of women employees—their virtual exclusion from the culture in organizations where men predominate—can be the biggest and most significant impediment to women who are trying to establish, maintain, or progress in S&T careers. And comparable isolation in schools can be a major hurdle to girls who are considering such careers. A good way of supporting girls and young women in science and engineering education, and of assisting them once they are looking for work or being employed, is mentoring.

A mentor applies her or his experience, expertise, and contacts to help protégées exploit opportunities and face challenges that arise. The mentor can help launch a new employee on a successful career path by providing information and advice on subtle issues such as the organization's policies, procedures, and politics. The mentor can acknowledge achievements by the protégée and offer support when problems are encountered; and encourage the protégée to enhance her skills through, for example, training courses. And as a means to raise a new employee's profile in the organization and field, the mentor can simply introduce the protégée to colleagues. Women who have made it to senior positions in the organization have a special obligation to give guidance to and promote women in early career.

A mentoring relationship can grow informally between friends or people who work together, or it can be initiated within a formal scheme. An example of the latter is the mentoring programme of the Future Harvest Centres of the Consultative Group on International Agricultural Research (Wilde and Shields, 2002). Ford Motor Company also has a successful mentoring scheme.

While a mentor can help a young woman scientist jump-start her career and make new professional contacts, other types of support, especially within an organization, are required as well. She needs a sponsor—someone who has the authority to assign women to key positions or onto

committees. And she needs an advocate—a person who is familiar with her skills and capabilities and can recommend and endorse her candidacy for positions that provide advancement (Etzkowitz et al., 2000).

But as long as the institutional culture remains noninclusive, what a woman scientist or engineer needs most on an ongoing basis is a network of colleagues who can support each other and share the benefits of their experience in comparable situations.

Professional societies, women's organizations, and regional and local projects have developed such useful resources, often supported by websites. In addition, there are projects, such as UNESCO's Ipazia programme (www.womensciencenet.org) and the Global Alliance for Diversifying the Science and Engineering Workforce (www.globalalliance-esmet.org), that aim to link women scientists and engineers across the world. Networks perform a useful role not only by offering support to women but also by making employers aware of good-management-practice measures.

It should be noted that mentoring, sponsoring, advocating, and networking have long been universally accepted, even cherished, by men scientists and engineers. These processes are so routine—between men within male-dominated organizations—that they occur almost subconsciously. One day, women may participate equally and there will be no need to distinguish between genders. One day, for instance, a network of organic chemists will simply serve those professionals, women and men alike. In the meantime, networks, mentors, sponsors, and advocates aimed specifically at girls and women will help keep them in the game and perhaps hasten the arrival of that happy day.

Recommendation

- It is important that academy members make themselves available for mentoring women students, as well as early- and mid-career women scientists and engineers. Portfolios of projects to support girls and women throughout their education and employment need to be developed and disseminated. The Advisory Panel also urges academies, universities, colleges, and professional organizations to support women's networks in recognition of the important role they play on the road to gender equity.

Greater inclusiveness

Retention rates for women scientists and engineers can be improved by support from dedicated individuals. But to truly minimize attrition, the cultural environment of women's workplaces must become more inclu-

Box 3.2 Commitment to change yields results: Purdue University.

The Purdue WIEP (Women in Engineering Program) was the first initiative of its kind for women engineers in the United States and has been a model for programmes at other universities. The WIEP is a comprehensive effort that includes K-12 outreach, recruiting and creating a supportive campus environment both for women students and women engineering faculty. Since the programme was introduced in 1969 when enrollment of women in Purdue's College of Engineering was less than one percent, there has been substantial progress. Women now receive 20 percent of all undergraduate engineering degrees—with a total to date of more than 8,000 engineering degrees granted to women— thanks in large part to the efforts of WIEP.
Source: Purdue University, n.d.

Box 3.3 The Athena Project promotes gender equity in S&T graduate departments in the U.K.

Hosted by the Royal Society of London, the aim of this project is to promote the careers of women in science and technology at all U.K. universities and research institutions and to increase the number of women in high-level positions. In collaboration with U.K. universities, the project has developed the 'Athena Guide to Good Practice' that offers approaches for making S&T departments hospitable to women faculty members and for attaining gender equity. These strategies, which many institutions have adopted to varying degrees, include developing mentoring and networking programmes, overcoming career barriers in departmental management, and instituting good management practice. Athena now also has an awards scheme and an anonymous staff/faculty survey.
Source: Athena Project, 2003.

sive, making women feel valued and truly an integral part of the organization. Moreover, such policies and practices to maintain the supply chain must apply across time, beginning with girls' S&T education and running well into professional women's careers, including provisions for breaks from those careers and mechanisms for returning to them.

Many programmes have been in place since the early 1980s, particularly in the United States, for addressing the special needs of girls when trying to attract them to science and engineering or preserve their interest. For example, the Women in Engineering Programs and Advocates Network (WEPAN) and a consortium of New England colleges have produced a handbook, *Achieving Gender Equity in Science Classrooms* (NECUSE, 1996). A similar 'classroom climate' guide produced by Purdue University has now evolved into an extensive diversity 'climate change' programme (www.engineering.purdue.edu/Engr/AboutUs/Diversity/). Among these books' numerous observations relevant to S&T educators is that girls prefer learning through hands-on experimentation and that they like working collaboratively in groups rather than in competitive atmospheres that emphasize individual achievement. Some schools, in recognition of the significant differences in girls' and boys' social development and approaches to science learning, have shown girls can do well by having girls-only courses (WISE, 2004).

In many countries, women are entering science and engineering programmes at the college and graduate-school level in increasing numbers. The attrition rate of women students is substantial however especially in graduate school and in the transition to a career in science and technology. While many individuals, departments, and universities are trying to make the academic science and technology culture more inclusive, this turns out to be a formidable task that requires action from the top down.

In recognition of that need, the United States National Science Foundation launched its Advance programme five years ago with the goal of increasing the participation and advancement of women in academic science and engineering careers (www.nsf.gov/advance). To date, 19 of the country's universities have received Institutional Transformation Grants under the Advance programme. One, a model programme at the University of Washington at Seattle, has established inclusiveness training, mentoring, and leadership training for all faculty in all of its S&T departments. The University has also developed toolkits for other institutions' use in recruitment and hiring (www.engr.washington.edu/advance). Box

3.2 gives another example of the success of institutional climate change, and Box 3.3 shows examples of effective strategies.

At the next stage, when graduating students endeavour to find suitable positions, their interviewers need to be trained (and occasionally monitored) to ensure that knee-jerk assumptions about students are not made on the basis of gender. Similarly with regard to mature students, many of whom are women who have returned to their studies after family-related breaks. Prospective employers need to take into account the wider set of real-world and enriching experiences that such students may have gained.

Some industrial employers of science and technology graduates and technical staff— Ford, GlaxoSmithKline, IBM, Northrup Grumman, Pfizer, Schlumberger, and Unilever—have firmly committed themselves to these principles and in particular to encouraging more applications from women. The German Government presents a rating of companies relating to women-friendly practices, the Genderdax (www.genderdax.de). Highly rated companies are able to attract highly qualified women employees. Techniques that have helped these companies realize their goals include:

- Training all interviewers comprehensively,
- Sending women and men staff alike to recruitment fairs and open days,
- Improving the representation of women in company literature,
- Producing literature aimed at women,
- Holding events that are specifically women oriented.

Such approaches reflect good management practice, which embodies fairness and transparency. Its application at all stages of recruitment, retention, and promotion is critical to ensuring equal opportunities in career progression, not only at companies but—adapted to their own special needs—at universities and virtually all other types of organizations.

For women to progress within universities and similar research institutions, career-development programmes for junior staff members, including mentoring and training, must be put into place. Other activities that may assist the advancement of junior staff generally, and women in particular, include seminars on pertinent topics such as applying for grants, receiving promotions, and gaining tenure. Even such prosaic needs as childcare, if provided or subsidized by the university, can make a big difference in helping women balance career and family responsibilities. In the United Kingdom there is in fact a national child-care strategy, initiated by an industry group *Employers for Childcare*, to ensure the provision of

Box 3.4

Physics departments invite visiting panels to assess their culture and receive advice on improvement.

Several U.S. women academy members have initiated a visitation programme with the American Physical Society. At the request of the women members, the American Physical Society arranges site visits to university physics departments in order to evaluate and advise on the university's gender-diversity programmes. A mixed-gender panel reviews policies and spends a day meeting with department heads, admissions officers, and those responsible for teaching. Men and women professors are interviewed. Lunch with undergraduate women is followed by a tour of the laboratories and workshops. The panel prepares a visit report. Department heads welcome the visit reports and suggestions for change because an improved culture benefits all department members and cuts down on attrition of students and faculty. On the basis of its experience, the American Physical Society has published a best practice manual for recruiting and retaining women in physics (www.aps.org). The U.K. Institute of Physics has established a similar programme.

affordable, accessible, and quality childcare. This is seen as benefiting not only women but men and employers as well. Box 3.4 shows an example of a voluntary evaluation of gender-sensitivity in physics departments in the United States.

Resources for launching or reestablishing careers

Women often take family-related career breaks. And as a consequence, they typically experience a loss of confidence and endure discrimination later on when applying for positions or being considered for promotions. In academia, the principal cause of this phenomenon is the women's publication record (the main productivity measure in research), which will have been disrupted; they will thus appear to have underachieved. The resulting unfair practices are being tackled by funding schemes and programmes—some of which are just for women. In certain countries, where such earmarking is illegal, programmes address the needs of women but are equally open to men.

Although many careers can be easily resumed after an interruption, this is not necessarily true for careers in fast-moving fields such as science and engineering. The linear academic career pattern that is typical of men—gaining in succession a first degree, an entry-level job in science, a Ph.D. by one's late twenties, and a post-doctoral position before securing a permanent research or teaching position—is not always an option for a young woman, who may be following a spouse or establishing a family. Women scientists may be retained in the pipeline however if support measures, such as a temporary replacement during maternity leave or subsidized childcare (which benefits both women and men employees who raise children), are available.

For those women who, for family reasons, have left scientific employment for a significant length of time and later wish to return, the creation of nontraditional career routes is essential. An element of such pathways should be mechanisms for maintaining professional contacts, at least minimally. The *Maximising Returns* report published in the United Kingdom in 2000 (www.setwomenresource.org.uk) outlined a series of measures for facilitating women's eventual return to careers in science and technology. Such measures include:

- Keep-in-touch schemes that involve scientific staff in various activities when they are on career breaks. These include continuing to send newsletters, arranging for regular interviews with colleagues, providing short periods of office or laboratory work, and assuring access to work-related emails and websites.

- Reduced fees offered by professional societies for the period of a career break. Members receive journals (or at least online access) and other benefits.
- Invitations to events such as conferences, often at reduced rates.

Because women are more likely than men to have interruptions in their career path, it is especially important that funding schemes aimed specifically at women be in place. Some countries provide dedicated funding for women researchers—such programmes include the Female Researchers in Joint Action (FREJA) initiative in Denmark, the Tham Professorships in Sweden, the C3 professorship programme of Germany's Max Planck Society, and the University Faculty Awards in Canada. Through the University Faculty Awards, universities can appoint talented women scientists to assistant professor positions that include salary allowances and minimum research grants for five-year periods. The Indian Department of Science and Technology has received sizeable government funding for three granting programmes—in research, capacity building, and entrepreneurship—aimed at re-entering women scientists (dst.gov.in).

The Dorothy Hodgkin Fellowship programme in the United Kingdom offers flexibility, even while women are on a fulltime career break or partial break, in applying for faculty positions. Funded by the Royal Society of London, this scheme enables recipients to move between parttime and fulltime work while receiving a salary, research expenses, and support. The fellowship programme is open to women and men, but it has been designed particularly with women in mind.

Recommendation

▶ The Advisory Panel recommends that academies establish or support leadership programmes and management training courses to empower women and provide them with the confidence, knowledge, and ability to launch, maintain, or reestablish their science or engineering careers.

Chapter 3 has focused on support programmes for girls and women who have access to education and want to pursue careers in science and technology. Chapter 4 focuses on girls and women who desperately need access to technology but who presently have limited or no access to education. While this grassroots approach relies on S&T professionals to create the tools and provide instruction in their use, it transcends the S&T community per se by empowering the millions, even billions, of people—that is, formally uneducated women—who are essential to their countries' economies.