June 2006

Women for science

An advisory report

InterAcademy Council

InterAcademy Council

Expert Advice

The InterAcademy Council (IAC) is a multi-national organization of science academies created to mobilize the world's best scientists, engineers, and medical experts for providing knowledge and advice to national governments and international bodies, notably the United Nations and the World Bank. Sound scientific, technological, and medical knowledge is fundamental to addressing critical issues facing the world today – economic transformation and globalization; sustainable use of natural resources; reduction of poverty, hunger, and disease.

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When requested to provide advice on a particular issue, the IAC assembles an international panel of experts. Serving on a voluntary basis, panel members meet and review current, cutting-edge knowledge on the topic; and prepare a draft report on its findings, conclusions, and recommendations. All IAC draft reports undergo an intensive process of peer review by other international experts. Only when the IAC Board is satisfied that feedback from the peer review has been thoughtfully considered and incorporated is a final report released to the requesting organization and the public. Every effort is made to ensure that IAC reports are free from any national or regional bias.

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At the United Nations in February 2004, the IAC released its first report, *Inventing a better future – A strategy for building worldwide capacities in science and technology*. A second IAC report, commissioned by the U.N. Secretary-General and published in June 2004, was titled *Realizing the promise and potential of African agriculture – Science and Technology strategies for improving agricultural productivity and food security in Africa*. Future published reports will also address critical global issues – fostering global transitions to sustainable energy systems, preserving the world's natural areas through better scientific management, identifying more effective measures of scientific and technological progress.

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For further information on the IAC, please see: www.interacademycouncil.net

Women for science


Introductory Solid State Physics

ISBN 90-6984-492-3

Design and Layout

Ellen Bouma, Edita-KNAW, www.knaw.nl/edita

Photograph credits

For information on photograph credits and content, please see Page 74

Foreword

Science and technology are fundamental to assuring humanity's welfare and enabling continued improvements in length and quality of life. Yet there are shortages—in developed and developing countries alike—of the requisite skills. In recent years, science and engineering organizations, business enterprises, governments, and civil society institutions have increasingly recognized the global need for a larger science and technology workforce in general and for women's full presence in it in particular.

The science, technology, and innovation capacities of all nations will be strengthened through the greater participation of women in all aspects of science, engineering, and medicine. National academies of sciences, engineering, and medicine can perform an important role in this effort.

In that spirit, in 2004 the Board of the InterAcademy Council formed an Advisory Panel on Women for Science. The co-chairs—Manju Sharma, President and Executive Director of the Indian Institute of Advanced Research, Gandhinagar, and former Secretary of Biotechnology in India; and Johanna Levelt Sengers, Scientist Emeritus at the U.S. National Institute of Standards and Technology—and their eight colleagues on the Advisory Panel represent a range of scientific and technological disciplines. The Advisory Panel members' professional experience spans academia, government, and the private sector, and it embraces research, teaching, and management. Almost all of these distinguished participants are academy members as well.

The result is this consensus report with a set clear recommendations and specific action items. It urges academies to assume a leading role in:

- Fully including women in science and technology and advancing them into senior and leadership positions
- Acting individually and jointly to engage the public, specifically women and girls, in the science and technology enterprise
- Empowering not only professional women but also women at the grassroot levels in the rural and urban areas of the developing world.

The InterAcademy Council and the Advisory Panel express their gratitude to L'Oréal (Paris), the Netherlands Ministry of Education, the Alfred P. Sloan Foundation, and an anonymous donor for providing the financial support to conduct the study and distribute the final report, which calls upon academies to immediately begin taking action, as follows:

First, the Advisory Panel asks academies to declare their intentions by formally committing to 'good management practice' —procedures designed to ensure the inclusion of women scientists and engineers—within all levels of their organizations and research institutes.

Second, the Advisory Panel asks all academies to designate a dedicated member—or, preferably, a gender-balanced committee—to be responsible for gender issues within the organization. This committee's duties should include proposing actions, collecting gender-disaggregated data, and monitoring and reporting progress—or the lack of it—to the president and council of the academy on a regular basis.

Third, the Advisory Panel calls upon all academies to address the underrepresentation of

women in their memberships by enlarging their membership nomination pools to include more women scientists and engineers, and to work to enhance the role of women as senior academy officials.

This *Women for Science* report, with supporting materials, is freely available on the IAC website at http://www.interacademycouncil.net. In addition, the InterAcademy Council, in close partnership with the InterAcademy Panel for International Issues, will work to make sure that the messages in this important report receive the attention that they deserve —not only from the world's academies, but also from the world's scientists.

If we are to spread science and its values around the globe, both in industrialized and developing nations, the full potential of all populations must be harnessed for scientific endavors, and the science must be belong to all citizens, whether male or female, rich or poor.

Bruce ALBERTS
Past President, U.S. National Academy of Sciences
Co-Chair, InterAcademy Council

LU Yongxiang
President, Chinese Academy of Sciences
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Preface

With phenomenal technological advances sweeping across the world, sufficient numbers of scientists and engineers, science and technology educators, health professionals, and technicians, together with a wide spectrum of skills, are needed to realize some very important objectives. Together they can help to avert starvation, unhealthy living conditions, and unemployment—particularly in the developing world—and to sustain a productive life, and *quality* of life, in developing and developed countries alike. Given these needs, women—along with men—should be given ample opportunities to enter and excel in science, technology, and related professions.

But while women constitute half of humanity, even in countries where they have ready access to higher education, the number of women studying mathematics, physical science, and engineering remains drastically below parity with that of men. Talented and capable women are essentially turned away from these and other fields, and the few who persist typically find themselves isolated and marginalized. As a result, the overall participation of women scientists and engineers in the workforce continues to be very limited, and these professional women seldom reach the pinnacle of the hierarchy—at universities, in companies, or anywhere else.

We are deeply concerned about this gender gap, not only because of its egregious moral implications but also for practical reasons. Science and engineering—essential to the survival, development, and prosperity of humankind in the 21st century—are being deprived of the vibrancy that would result from the inclusion of a wider range of abilities, experiences, viewpoints, and working styles.

Every man and woman should count. And young women aspiring to become professionals in science and technology especially need encouragement, nurturing, and a gender-sensitive and inclusive environment.

A laudable initiative aimed at academies

The InterAcademy Council (IAC), composed of the presidents of 15 prominent science academies, has produced two reports on building science and technology capacity throughout the world—and particularly on creating a strong foundation of science and technology in each of the developing countries.

But to achieve these objectives, the participation of women will be essential. Regarding, for example, the important goal of sustainable agriculture, the current practitioners in developing countries—most of them rural women—urgently need to become partners when modern scientific methods and technologies are introduced. Similarly, as women provide so much of the education and family care in the burgeoning megacities of the developing world, progress cannot be made without enhancing their skills and resources. Meanwhile, the full range of talents, perspectives, experiences, and skills of women scientists and engineers must be marshalled to advance the science and technology enterprise itself, as well as to act as conduits for inspiring and teaching their less formally educated sisters —literally, billions of them—at the grassroots.

Realizing that the low representation of women in science and engineering is a major hindrance to global capacity building in science and technology, the IAC at its annual meeting in January 2004 initiated a short-term project for helping to remedy that situation. The IAC formed an Advisory Panel on

Women for Science with the mandate to review previous studies, provide examples of effective projects already implemented, and issue a set of actionable recommendations addressed particularly to the world's science and engineering academies. The reason for choosing these specific targets is their likely multiplicative effects. Through their high prestige and alliances with governments, universities, and nongovernmental organizations, the academies can play a unique advocacy and leadership role in initiating enlightened actions and in accelerating processes that in some quarters, public as well as private, have already been set in motion.

Thus the principal purpose of this report is to advise academies. It unabashedly takes the practical approach of *women for science*, namely, that including women's talents, perspectives, and skills will enrich the scientific enterprise and will be an utter necessity in global science and technology capacity building. It is not a new study and does not present new research. Within the tight scope of an advisory report, it presents a limited overview of the extensive literature on the subject. And although it does not claim that academies are better suited than existing science and technology and women's organizations to remedy the underrepresentation of women in science, it does see them as playing a unique, prime-mover role. In that spirit, the report presents recommendations specific to academies that are designed not just for these institutions themselves but for much wider—indeed, global—impact.

The Advisory Panel's process

The Advisory Panel, consisting of two co-chairs and eight members —including both women and men— from four continents, first met in Paris in February 2005. They produced draft recommendations and an outline of the report, accepted individual writing assignments, and agreed on a timetable for production of the report. Throughout the year, the Advisory Panel co-chairs met with the study director and IAC staff and interacted with Advisory Panel members.

The study began by circulating a questionnaire to all 95 science academies that belong to the InterAcademy Panel for International Issues (IAP). The institutions were asked about programmes that they had developed to attract women to science and technology, programmes to retain them, the success of these initiatives, and the salient issues that they hoped the Advisory Panel would address. Relevant reports from many of these academies, as well as government agencies, nongovernmental organizations, and universities around the world, were then assembled. The Advisory Panel members themselves, some of whom had extensive knowledge of gender-equity issues in science and technology, provided additional information. All of these materials formed the inputs to this report.

The Advisory Panel members had access to a central group website containing the input materials, both in their original forms and as they evolved into contributions to chapters. The Advisory Panel co-chairs, members, and staff went through several rounds of writing, reviewing, and fine-tuning, presenting the report to the IAC Executive Director in November 2005. It was then submitted to the IAC peer-review and monitoring processes, which took place through December 2005 and January 2006. The report's final version represents the consensus views of all Advisory Panel members.

Principal themes

The recommendations and action items presented in this report are grouped around three themes:

- Academies advocating and promoting the education and careers of women;
- Academies acting, both individually and jointly, to engage women in global capacity building;

- Academies building inclusive institutional climates and advising governments and other principal players on specific actions toward similar ends.

The Advisory Panel advocates that all academies adopt ‘good management practice’ throughout their organizations and in all their actions, and encourages this practice as well in other scientific institutions and organizations around the world. Essential features of good management practice are commitment by the top tiers of the organization, creation of an open and transparent management structure, regular review of all policies and procedures for their gender implications, leadership training and mentoring, and routine monitoring of progress.

Structure of the report

After introducing the major issues related to full inclusion of women in the science and technology enterprise (Chapter 1), the report sketches some of the existing efforts by governments and international organizations. It outlines new initiatives, additional measures that need to be taken, and recommends further strengthening and accelerating of efforts. This will require a cultural transformation from women’s consignment to a separate and lesser sphere to an inclusive climate that allows, even encourages, them to bring their talents to bear (Chapter 2). Education and training of girls and women, and the promotion of women’s careers, are presented in light of this necessary cultural transformation (Chapter 3). The report then argues that the engagement and empowerment of grassroots women are essential to technological capacity building in developing countries (Chapter 4). Recognizing that academies can take the lead and act as advocates, the report offers an agenda for changing of institutional cultures—beginning within academies’ own walls—to facilitate progress both at home and abroad. Finally, the report reorganizes its main recommendations (from Chapters 3, 4, and 5) in accordance with academies’ diverse functions, while also allowing for the great variability between academies, so that these action items may more readily be implemented.

We firmly believe that women have a critical role to play in harnessing the power of science and technology for the welfare of humanity, and that academies can help ensure the full contribution of women scientists towards this goal.

Johanna LEVELT SENGERS
Advisory Panel Co-chair

Manju SHARMA
Advisory Panel Co-chair

Report review

This report was externally reviewed in draft form by 13 internationally renowned experts chosen for their diverse perspectives, technical knowledge, and geographical representation, in accordance with procedures approved by the IAC Board. The purpose of this independent review was to provide candid and critical comments that would help the IAC to produce a sound report that met the IAC standards for objectivity, evidence, and responsiveness to the study charge. The review procedure and draft manuscript remain confidential to protect the integrity of the deliberative process. The IAC wishes to thank the following individuals for their review of this report:

Shaidah ASMALL, Manager, Science, Gender and Disability Unit, Department of Science and Technology, Republic of South Africa
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Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions and recommendations, nor did they see the final draft of the report before its release.

The review of this report was overseen by a review monitor:

Shirley MALCOM, Head of the Directorate for Education and Human Resources Programs, American Association for the Advancement of Science, Washington, DC, USA

Appointed by the IAC Co-Chairs, the review monitor was responsible for ascertaining that the independent examination of this report was carried out in accordance with IAC procedures and that all review comments were carefully considered. However, responsibility for the final content of this report rests entirely with the authoring Advisory Panel and the InterAcademy Council.

Acknowledgements

The Advisory Panel thanks the InterAcademy Council Board, and especially Bruce Alberts, Goverdhan Mehta, and Lu Yongxiang, for recognizing the urgency of the topic and providing the Advisory Panel with the opportunity to undertake this project.

The Advisory Panel acknowledges the many individuals and organizations that have shared information and provided leads and suggestions that have helped shape the report.

The science academies that replied to the Advisory Panel questionnaire, circulated by the InterAcademy Panel, deserve our gratitude for sharing their experiences and concerns: Albanian Academy of Sciences; Australian Academy of Science; Bulgarian Academy of Sciences; Royal Society of Canada; Chinese Academy of Science; Academia de Ciencias Exactas, Fisicas y Naturales, Colombia; Indian National Science Academy, National Academy of Engineering and National Academy of Sciences, India; Royal Irish Academy; Royal Scientific Society, Jordan; Kenya National Academy of Sciences; Mongolian Academy of Sciences; Royal Netherlands Academy of Arts and Sciences; Royal Society of New Zealand; National Academy of Science and Technology, Philippines; Academy of Science of South Africa; National Academy of Sciences, Sri Lanka; Swiss Academy of Medical Sciences; Turkish Academy of Sciences; Royal Academy, Royal Academy of Engineering and Royal Society of London, United Kingdom; National Academy of Engineering and National Academy of Sciences, United States; and the Academy of Sciences for the Developing World (TWAS). Their input and suggestions are woven throughout the report.

We thank Jennifer Campbell, L'Oréal, Paris; and Samantha Mattingly, L'Oréal, U.S.A., for hosting the full panel meeting in February 2005, and for their many acts of hospitality and support during that week.

The Advisory Panel consulted with numerous individuals during the past year. Ana Maria Cetto and Keiko Sugimoto attended and contributed to the full Advisory Panel meeting. The co-chairs gratefully acknowledge consultations, following the Panel meeting, with Pierre-Gilles de Gennes, Eugene Stanley, Alberto Robledo, and Marcia Barbosa.

Johanna (Anneke) Levelt Sengers acknowledges input and advice from Windsong Bergman; Suzanne Brainard; Catharine Didion; Mildred Dresselhaus; Ruth Fassinger; Judy Franz; Sandra Greer; Beverly Karplus Hartline; Shirley Malcom; Elisabeth Martinez; Eugenie Mielczarek; Vera Rubin; Vicky Wilde; NIST colleagues Sally Bruce; Elizabeth Hessel; and Magdalena Navarro; as well as Édouard Brézin, Yves Quéré, and Volker Ter Meulen.

Manju Sharma acknowledges Hamida Abdi, Vineeta Bahl, Mahtab Bambji, Anuradha Lohia, and Vineeta Sharma from India for providing valuable inputs.

Jan Peters thanks Mary Osborn, Teresa Rees, Virginia Valian, and Susan Vinnicombe for their thoughts and input.

The InterAcademy Council secretariat, headquartered at the Royal Netherlands Academy of Arts and Sciences (KNAW) in Amsterdam, provided support, guidance, and hospitality. Willem Levelt, President of KNAW and member of the IAC when the project took shape, played a major enabling role in that process. Regarding guidance, special gratitude is due

to Albert Koers, IAC Executive Director, who put the project on track, and his successor, John Campbell, who coached it through the rigorous IAC reviewing procedures. Their advice on matters of international protocol was invaluable. Margreet Haverkamp expertly took care of the travel arrangements surrounding the full panel meeting, and of the numerous visits to Amsterdam of the co-chairs and study director. Special thanks are due to Laura van Veenendaal, who acted as liaison for interactions with academies and with panel members, and provided staff support for the full panel meeting, co-chairs' visits to Amsterdam, and in assembling the report.

Judy Hemingway and Jan Peters collected a large part of the information, data, and references presented in this report. For assistance with writing, editing, and publishing the Advisory Panel thanks Ellen Bouma, Sheldon Lippman, and Steven Marcus.

The Advisory Panel is especially grateful to L'Oréal, Paris; the Netherlands Ministry of Education; the Alfred P. Sloan Foundation; and an anonymous donor for generously providing the financial support for the project.

Executive summary

'When a man is educated, an individual is educated; when a woman is educated, a family and a country are educated.'

Mahatma Gandhi

Over a century ago, women began seeking access to formal science and technology (S&T) education and to the full expression of their training and talents in subsequent careers. These quests have been a long hard fight, met by opposition sometimes blatant though often subtle. But while women have made inroads, their representation in most S&T fields—particularly at leadership levels—remains well below that of men.

National legislation in some countries, together with many campaigns, has helped as have efforts by a few forward-looking universities and companies. But for the most part, institutions have been resistant to fully opening their doors to women in science and technology, as well as to eliminating the obstacles they are likely to encounter if they do manage to get inside. Thus women scientists and engineers drop out at the early career stage at a much higher rate than do men, and few women are found in the upper strata of the hierarchy.

Under the circumstances, it is amazing that any women at all have been able to attain S&T leadership positions. Extraordinary individuals of sheer dedication and determination, who also were fortunate in finding a male mentor or supporter, account for the occasional success story. But given that males and females each constitute half of the human race, and given that S&T aptitude is just as likely in either gender, it makes no sense to accept just the exceptional cases as the best we can do. Full inclusion is the only acceptable outcome.

An urgent need for academies' actions

A critical omission has been the wholehearted commitment to inclusiveness on the part of the existing S&T leadership. Without support from that establishment, women can only progress so far. This is where academies can play a major role, as they represent the scientific and engineering elite and are thus held in high esteem. Moreover, their members are leaders at universities and other research institutions; and in many countries they are trusted advisers to government.

In that spirit, the InterAcademy Council (IAC) established the Advisory Panel on Women for Science with a mandate to propose what academies around the world can do to remedy the persistent and widespread underrepresentation of women in science and technology. This report is a result of that IAC initiative.

Based not only on a moral standpoint but largely out of pragmatism, the Advisory Panel concludes that the world's science and engineering academies urgently need to take action on this problem. That is to say, a greater range of styles and points of view, made possible by a diversity of scientists and engineers, will enrich the S&T enterprise as well as the societies it serves. Moreover, global capacity

'Voices that are silenced or ignored, for whatever reason, represent not only an injustice but also a valuable resource that has been wasted, a tragic waste of human capital.'

James Padilla,
President, Ford Motor Company (2005)

building, so strongly advocated in earlier IAC reports (IAC, 2004a; 2004b), is impossible without full engagement of women at the grassroots—and without the academies' help in making this happen. The Advisory Panel maintains that academies will exert true leadership and have considerable impact on the lives of people around the world by adopting and advocating some fundamental reforms in institutions' routine operations.

Toward inclusion: good management practice

Chapter 1 provides an introduction to the problem of women's underrepresentation in science and technology and explains why its solution truly matters. It notes the growing concern of governments and other entities around the world, justifies in some detail the critical role of the science and engineering academies, and specifies the Advisory Panel's mandate for this report.

Chapter 2 reviews some of the past and present activities of organizations that have been effective in advocating for and supporting the education and career prospects of women scientists and engineers. It describes the educational and inspirational efforts of women's groups, some of the national assessments and initiatives undertaken by governments in pursuit of gender equality, and trends both in improving access to higher education in science and technology and in enhancing prospects for employment that is not only productive but offers opportunities for advancement.

Chapter 2 also describes the application of 'good management practice,' which the Advisory Panel strongly recommends to the academies for their own operations and for dissemination to the larger S&T community. This management principle—an effective, well-demonstrated means of making an organizational culture inclusive of minorities, be they ethnic minorities or women in institutions dominated by men—is shared by many of the successful inclusion efforts reviewed by the Advisory Panel. Good management practice aims for establishing a culture in an organization that values all of its members and expects them—and gives them the opportunities—to function at their full potential for the benefit of that organization.

Elements of good management practice include:

- Commitment from top levels of the organization;
- Established infrastructure, such as a diversity committee;
- Review of all policies and procedures for possible differential impact on men and women;
- Transparency in all communication, recruitment, promotion, and awards;
- Wide inner circle, where decisions are made, that is inclusive;
- Leadership training and mentoring;
- Supporting a healthy work-family balance;
- Regular collecting of sex-disaggregated data and monitoring of progress.

As specified in the successive core chapters (3, 4, and 5) of this report, good management practice forms the backbone of the Advisory Panel's recom-

mendations for academies in the following three areas:

- Attract women and girls to science and technology, support their education throughout the 'pipeline', and retain and advance them in their careers.
- Fully include women in global capacity-building efforts.
- Fully include women in the academies' own organizations.

Advancing women in S&T careers and at the grassroots

Chapter 3 considers programmes—aimed at increasing the numbers of women progressing through science and engineering education, training, and careers—that have been developed by governments, professional organizations, corporations, universities, and even some academies. Such programmes cover enhancement of women scientists' and engineers' 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. Academies, individually and jointly, are requested to support ongoing programmes of this sort and to develop measures of their own that give opportunities and recognition to women scientists. It is worth noting, however, that good management practice, once implemented, will eliminate much of the need for special programmes because their provisions will have been built into the organizational structure, thereby benefiting all employees.

Chapter 4 advocates for academies' help in engaging grassroots women (who live and work in developing countries, often without the benefit of much formal education) in global S&T capacity building. This perspective—unique to reports of this type—is nevertheless complementary to IAC's visions for creating a better world. Just as a country's capacity building requires the development of an S&T cadre, it also requires the mobilization—the engagement and empowerment—of the country's citizens. This report argues that the billions of individuals at the grassroots around the world must be enabled to apply the fruits of science and technology, such as useful tools, products, and services, for the benefit of their countries' economies while improving their own lives. Such engagement cannot occur while excluding half of the human race, let alone the half that does the majority of daily hands-on work. Therefore women in the developing world's villages—rural townships and urban enclaves alike—must become engaged in the application of modern technologies.

The chapter goes on to sketch the three-pronged process needed for this engagement. First, access to and quality of primary and secondary education for girls must be dramatically improved while teacher training, especially in mathematics and science, receives urgent attention. Second, large numbers of women scientists and engineers must be educated at specialized research centres. Third, these women must form cadres that are dispersed from centralized institutes to local knowledge centres. Preferably indigenous to the local culture, these skilled cadres then transfer modern technology to local women while building on their traditional skills and experience.

The chapter then takes up the vital issue of improvement of public understanding of science and technology, both in developing and developed countries. To truly embrace it, academies may sometimes have to take their events and programmes out into the field—into communities that may well be remote—rather than limit their venues to university campuses or research institutions. Such public-engagement programmes, in addition to transfer-

ring knowledge, also enable the full cross-section of society to be involved in the social and ethical discussions that lead to better-informed policy. And, not least, such programmes raise awareness of the opportunities of working in science and technology.

What the academies must do

Chapter 5 directly addresses the academies, where women scientists and engineers presently form a small minority (typically less than 5 percent) of the membership. As with other kinds of organizations, the Advisory Panel recommends that in the academies themselves and in the research institutes that some of them manage, the fundamental approach for change be the adoption of good management practice. This implies a firm commitment by the president and council to inclusive practices and to putting gender issues permanently on the agenda. The Advisory Panel also recommends that each academy establish a diversity committee consisting of both male and female academy members. This committee should report directly to the president and council, helping them to develop the necessary policies and programmes.

A high priority is enhancement of the pool of qualified women to be considered for nomination to membership. Further, each academy needs to work on achieving greater visibility of women scientists in the publications and educational materials it develops. Women must be invited to chair conferences and speak at seminars, and they must be appointed to panels and committees that the academy organizes.

Academies that sponsor research need to give attention to the potential gender implications of proposed projects and their resulting publications. For example, do men and women researchers have equal access to grant money? In cases where a study could be influenced by the gender of the researcher, has the principal investigator made an effort to establish a gender-mixed team? Have the results been tested for differential impact on men and women, and are they free of bias? In addition, academies that evaluate research institutions need to include the working conditions of women scientists and engineers among their evaluation criteria.

For monitoring the results of inclusive programmes initiated by an academy, it is essential that sex-disaggregated data be routinely collected and then reported at the academy's annual meeting. For too long, the scientific establishment has dealt with the gender-equality issue essentially through the motto 'No data, no problem.'

The Advisory Panel recommends that, when interacting with their countries' governments, academies advocate for full inclusion of women in science and technology through measures such as nondiscrimination legislation, a national office focused on women's issues in science and technology, reform of textbooks and teaching materials, and the monitoring of girls' and women's progress.

Of course, academies can act not only individually but jointly. In that regard, the Advisory Panel recommends that IAC and its parent organization the InterAcademy Panel for International Issues (IAP), adopt the following initiatives:

- Commit to good management practice in their respective operations.
- Collect sex-disaggregated data from their constituent academies and report on these data at their annual meetings.
- Pay attention to gender issues in the studies they undertake.
- Facilitate exchange of information between academies and other organizations about innovative and effective programmes for developing an inclusive culture.
- Develop international partnerships to secure

funding for women-in-S&T programmes.
- Make use of various means of communication, such as S&T-friendly radio and television programmes, for increasing the public understanding of science with particular focus on girls and women.

Chapter 6, a summary, complements the other chapters—particularly Chapter 5—by reorganizing the report's recommendations by academy function, in recognition of the wide variations between academies. Categories include academies as honorific societies, as advocates of global capacity building, as employers, as sponsors of research and evaluators of research institutes, and as national advocates for education. Coordinated actions for academies—for instance, through IAC and IAP—are also proposed.

For immediate action

The Advisory panel proposes the following items for immediate implementation:
- Academies formally commit to good management practice within all levels of their organizations and research institutes by signing a commitment statement (see sample statement below).
- Each academy designates a panel—preferably, gender-balanced—to be responsible for gender issues.
- Academies enlarge the nominations pool of women scientists and engineers.
- The IAC disseminates this report widely, together with supporting materials, through posting on its website and other means.

Sample statement of commitment for academies

The president and council of the academy commit to full inclusion of women in science and technology. The academy will:
- ▶ Adopt good management practice—tools for inclusiveness—in its institutions and advocate such practice across the S&T community.
- ▶ Establish a committee that addresses gender issues and ensures follow-up.
- ▶ Promote women members to decisionmaking levels and include them in panels and committees.
- ▶ Increase the number of women scientists in the nomination pool for membership, prizes, and awards.
- ▶ Give visibility to women scientists and represent women in the academy's portrayal of science.
- ▶ Pay attention to gender implications of research sponsored or evaluated by the academy.
- ▶ Ensure that the criteria for evaluation of research institutes include organizational culture.

1. Introduction

Women must have the same opportunities to contribute to science and technology (S&T) as those enjoyed by men. This will reflect *gender equality*, described so compellingly by the Beijing Declaration of the Fourth World Conference on Women as 'an inalienable, integral, and indivisible part of all human rights and fundamental freedoms' (United Nations, 1995).

But there also are highly practical reasons to include women as equal partners in all human endeavours. A more diverse workforce, which reflects a wider variety of experiences and views, can greatly benefit the S&T enterprise as well as society as a whole. Technological innovation will broaden, competence will grow, and countries will prosper when the workforce is diversified to fully include both women and men. Optimal solutions to problems are more likely to be found, notes William Wulf, president of the United States National Academy of Engineering, where a greater number of perspectives are brought to bear (Wulf, 2005).

Unfortunately, the *under*representation of women in science and technology—especially in senior and leadership positions—remains a worldwide phenomenon. The number of women in S&T research and teaching is relatively low, there are few tenured professors, and still fewer women are deans or heads of departments. Women's presence in industrial S&T is usually even lower than in academe, and female industrial leaders are rare.

This omission is serious enough in scientifically advanced countries, but it is a major impediment to economic growth in the developing world. As emphasized in the report *Inventing a Better Future: A Strategy for Building Worldwide Capacities in Science and Technology* of the InterAcademy Council (IAC, 2004a), each developing country needs a critical mass of scientists and engineers to help ensure its sustainability. The *Women for Science* report extends this vision by arguing that it is equally important to transfer practical technological knowledge all the way down to the grassroots level. Aiming for anything less than the world's full engagement of its women—half of its reservoir of talent, skill, and energy—is tantamount

to condemning much of the earth's population to poverty and disease.

James Padilla, president and chief operating officer of Ford Motor Company, has stated the issue this way: 'Voices that are silenced or ignored, for whatever reason, represent not only an injustice but also a valuable resource that has been wasted, a tragic waste of human capital' (Padilla, 2005).

A growing concern

Extensive sociological research has identified many of the factors that contribute to the low representation of women in science and technology. They include girls' limited access to education, the demands of women's roles as mothers and caregivers, the lack of mentors and role models, and the lack of leadership training (Etzkowitz et al., 2000; Glover, 2000). These culture-based norms and prejudices create pervasive, intangible barriers that hinder the inclusion of women. Moreover, even when women do manage to enter science or engineering, they often drop out early in their careers. Reasons vary from culture to culture, but the drop-outs are usually caused by lack of provision for combining professional work with the family duties traditionally assigned to women. Such barriers are then heightened by institutional climates for women that are less than hospitable and sometimes outright hostile.

These problems are increasingly being recognized out of concern about another, overarching problem. In the past 30 years, governments, scientific organizations, business enterprises, and others have become more and more aware of the looming shortages in S&T skills needed for building and maintaining an innovative S&T base. Prosperous countries are particularly concerned about the low appeal that science and technology appear to hold for young people. An obvious strategy for addressing this supply issue is simply to make better use of available resources—to open the doors wide to girls and women for careers in science and engineering.

This strategy has been articulated in numerous national reports, such as the United Kingdom's *SET for Success* (Roberts, 2002), the United States.'s *The Land Of Plenty* (CAWMSET, 2000), and the Republic of South Africa's *Women in Science, Engineering and Technology in South Africa* (Bailey and Mouton, 2004). Meanwhile, several countries and international entities, including India, China, Japan, and the European Union (Osborn et al., 2000), have launched initiatives to address these shortages by expanding women's membership in the S&T community. The United Nations has a

core objective in its ‘Education for All’ programme that encompasses girls’ education and regional chairs for women in science (UNESCO, forthcoming).

These efforts are increasingly stressing the need for change in organizational culture so that gender diversity is accommodated, and they highlight the necessity of developing management practices that encourage all employees, women and men alike, to work to their full potential for the benefit of the organization. Still, while some institutions are taking steps in the right direction, women’s exclusion from prominent S&T careers largely persists, as documented by a number of influential reports (MIT, 1999; Osborn et al., 2000). Moreover, women at the grassroots levels, particularly in developing countries—where S&T capacity building is most needed—continue to be denied access. It has been hypothesized, however, that the high-level aptitude that characterizes top scientists and engineers might not be commonly found in women (Summers, 2005). Yet although there is a substantial body of psychological and brain research that verifies some differences between men’s and women’s mental processes, these differences have not been linked conclusively to S&T aptitude (Hyde et al., 1990; Leahey and Guo, 2001). That being the case, the clearing of existing, well-documented hurdles appears to be a more practical approach than speculating on women’s innate aptitudes.

A more interesting and fruitful question might be: What, if any, are common characteristics of the outstanding women who have risen to the pinnacles of science throughout the past century, notwithstanding the enormous obstacles they faced? Biographies of women Nobel Prize winners (McGrayne, 2001), interviews with women members of the U.S. National Academy of Sciences (Wasserman, 2000) and the biographies of women health-sciences trailblazers from the Philippines (Padilla and Santos Ocampo, 2004) unearth some of these common factors: an early fascination with science; independent thinking; early rejection of the cultural limitations imposed on girls and women; support from parents, particularly fathers; a good education, not infrequently in an all-girls environment; having been fortunate in finding mentors; marrying a supportive husband; and having access to reliable childcare. Women’s colleges, such as those established in the United States in the 19th century, have been exceptionally successful in producing female scientists and leaders. However, the number of schools with all-female student populations has been dwindling.

Critical role for the academies

To make such success stories more common, science and engineering academies in countries and regions around the world need to play a critical set of roles. They can effect change within their own organizations and, given the high esteem in which they are held, serve as prominent examples of good practice. They can advocate change on a national scale by collaborating with governments, universities, and research institutions, whether as partners or advisers. And they can work with sister academies and international organizations to help improve the local climate for women and further their participation in science and technology.

Given their objectivity, integrity, and position at the pinnacle of the scientific establishment in their respective countries, the academies are uniquely placed to collectively lead in the shaping of the scientific and technological workforce for the utmost benefit of humanity.

Although they may have different charters, functions, and organizational structures—as influenced by their histories, national scientific cultures, funding sources, and size—all academies honour scientific achievements and draw into their ranks eminent and influential people. The academies' impacts in general are thus wide-ranging, both through their activities as institutions and through the individual contributions of their members. In particular, they can advance programmes that eliminate the gender inequities seen around the world.

Indeed, some academies have begun doing just that, making laudable efforts to increase the participation of girls in science education. But these efforts have had limited effect on women's involvement in science and technology. Once girls grow up, graduate, and embark on S&T careers, they tend to be unsupported in their professional aspirations and to not receive appropriate recognition. Women who enter, or try to enter, the S&T arena—much less advance themselves to higher positions—are confronting societal barriers that in some cases have been maintained for centuries.

A broader strategic approach—one of deliberate top-down change in institutional structures across the global S&T community—is thus required. Academies can demonstrate such enlightened leadership and help other organizations, of all types, to adopt it as well.

Advisory Panel's mandate

In that spirit, an Advisory Panel was established in 2004 by the 15 academies of the IAC. The Advisory Panel's mandate was to propose specific actions that academies could take to increase the representation of women

at all levels of science and technology.

In particular, the Advisory Panel was asked to inform the academies on actions they could take to:

- Make science education more attractive to girls and young women,
- Improve the working conditions of women scientists,
- Remedy gender imbalances in scientific careers.

Interpreting its mandate broadly, the Advisory Panel has developed recommendations and action items for the academies in the following areas:

- Supporting women's S&T careers by means such as grants and fellowships for education and research, as well as explicit recognition for outstanding achievements;
- Advocating and enabling global capacity building and sustainability through programmes that engage women in science and technology at the grassroots level;
- Defining areas where gender equality needs to be realized in academies' own organizations, both as honorary societies and as employers of scientists;
- Influencing governmental bodies and other scientific organizations.

A major objective of this report, in other words, is to present academies with a strategy leading to the inclusion of women as equal and valued partners—and not only within the academies but throughout the S&T enterprise. Another objective, original to this report and more down-to-earth, may ultimately allow a great many more human beings to further their countries' development. It is to propose concrete actions for academies so that they help to technologically empower the planet's billions of women at the grassroots level. If these women, too often barely surviving, are strengthened with S&T knowledge and capabilities in areas such as agriculture, health, nutrition, and sanitation, they can play a critical role in rapidly setting the Earth and its people on a path to a sustainable future.

2. An overview and agenda for change

– Needed: A global strategy for building a culture in science and technology that allows full participation by women. –

As academies seek to establish gender equality in their operations and to encourage it elsewhere, it may be instructive for them to review some of the past and present activities of organizations that have been active and effective in opening doors for women scientists and engineers. Such efforts have been taking place not only at universities but also in government and private research institutes and, increasingly, in industry.

In unity there is strength

For over a century, women's organizations—whether informal or well-established; whether local, regional, national, or international—have played a valuable role in raising women scientists' and engineers' profiles and in bringing to light the problems they face in environments dominated by men. At the more informal levels, small groups of women from professional societies and learned institutions have met to network, support each other, and influence the policies of their employers.

More formally organized national entities assist local and regional networking groups by offering resources such as mentoring schemes, management training, and technical presentations. In addition, volunteers regularly visit local schools to offer advice for aspiring science and engineering students and to help provide role models. These organizations are often funded by membership subscriptions or grants from institutions, companies, or professional bodies. Some of these groups have gone further by publishing newsletters, maintaining websites, and convening symposia.

The Association of South African Women in Science and Engineering extends women's professional ties by helping them develop networks of colleagues (www.sawise.org.za). The Third World Organization for Women in Science (TWOWS), the world's largest organization of women scientists, aims to improve the status of women within the scientific community and provides opportunities for women to assume leadership roles in society. The TWOWS also provides graduate training fellowships

for women scientists in Sub-Saharan Africa and other countries in early development. A publication on women leaders in developing countries highlights how women scientists in key positions have affected S&T issues internationally. Many TWOWS activities are readily replicable (www.twows.org).

Meanwhile, the work of the Helsinki Group—a team of policymakers, social scientists, and physical scientists coordinated by the European Commission's Women and Science Unit—has had international reach, aided by the cooperation and support of member states. A variety of Helsinki Group reports and activities have brought together a wealth of comparative data (Rees, 2002), identified issues, specified good management practices, and widened participation. For example, *A Wake-Up Call for European Industry* (Rees, 2003) drew private-sector research organizations into the arena.

International conferences have also had significant impact, sometimes evolving into permanent entities. For example, leaders of the International Conference of Women Engineers and Scientists—a meeting that brings numerous stakeholders together every four years—recently formed the International Network of Women Engineers and Scientists (INWES). The 2002 and 2005 Women in Physics conferences, organized by the International Union of Pure and Applied Physics (IUPAP), have also been influential by focusing on a particular field that in many countries is still characterized by the virtual absence of women (Hartline and Li, 2002; Hartline and Michelman-Ribeiro, 2005). Faculty and students from over 60 countries have expressed their views at these conferences and made detailed recommendations for virtually all aspects of attracting, retaining, and promoting women physicists.

But the 'mother' of all international meetings in this domain was the United Nations' 1995 Fourth World Conference on Women, held in Beijing and attended by over 20,000 participants. While the Conference focused on the rights of women to acquire education, economic power, inclusion in leadership, and involvement in decisionmaking across diverse professional fields, its resulting Beijing Declaration and Platform for Action made specific reference to women in science and engineering (United Nations, 1995). These latter provisions spawned a number of actions, including a special study by the European Technology Assessment Network (ETAN) that resulted in the report *Science Policies in the European Union: Promoting Excellence through Mainstreaming Gender Equality* (Osborn et al., 2000). However, at the 10-year review of the Beijing

meeting, held in 2005 in New York, the only reference to women in science and technology was in relation to information technology (United Nations, 2005).

The United Nations has deployed numerous initiatives related to the education of girls and to the careers of women in science and technology. These include the Gender Advisory Board of the United Nations Commission on Science and Technology for Development (UNCSTD) and the Board's global network; UNESCO's regional chairs of Women, Science, and Technology, such as the one for Latin America (www.catunescomujer.org); and the establishment of African and other international networks for women scientists and engineers. Arab women in science and technology are being empowered by the Arab Network for Women in Science, under the aegis of UNESCO. Another UNESCO initiative, a joint venture with the Paris-based company L'Oréal, annually honours both young and senior women scientists around the globe. In several countries, L'Oréal national branch offices give grants to women scientists early in their careers.

National assessments and initiatives

Gradually, governments around the world have been recognizing the need to make women and men equal partners in science and technology. The United States took an early lead in improving diversity in science and technology by passing the Equal Opportunities in Science and Engineering Act of 1980, followed by the founding of the Committee on Equal Opportunities in Science and Engineering (based at the National Science Foundation). In much the same spirit, the United States Congress appointed a committee in 2000 to draw up action-oriented recommendations for facilitating the education, entry, and advancement in science and technology of women, minorities, and persons with disabilities. *Land of Plenty*, the resulting report, makes a strong case for the marketplace benefits of diversity in science and technology, calling it 'America's competitive edge' (CAWMSET, 2000).

A 1993 policy paper published by the Government of the United Kingdom, acknowledging that in science 'women are the single most underused and undervalued human resource,' led to the establishment of a small team in the Office of Science and Technology devoted to the advancement of women in science (HMSO, 1993). The United Kingdom also took the opportunity, during its presidency of the European Union in 1998, to put women and science on the agenda of other European coun-

tries. Aided by the ETAN group report (Osborn et al., 2000), it helped establish the abovementioned Women and Science Unit of the European Commission.

Progress in the United Kingdom itself had remained slow for 20 years or so, confined mostly to small projects on career advice and to networking groups struggling to raise funds. But new impetus was seen in 1999 with the development of a web-based statistical portal and the commissioning of evidence-based reports. In 2002, the 'SET Fair' report, submitted by the Baroness Greenfield to the Secretary of State for Trade and Industry, presented numerous recommendations regarding the retention and progression of women in science and technology. Promoting an inclusive workplace culture that values and benefits all employees through good management practice, the report called for investment in relevant infrastructure and proposed viable actions at all organizational levels (Peters et al., 2002). In response, the U.K. Government published a new strategy for women in science and technology and allocated £8 million over five years (Department of Trade and Industry, 2003) to fund the U.K. Resource Centre for Women in Science and Technology.

Since its establishment in 1949, the People's Republic of China has made steady progress in securing women's participation in public life. With women enjoying equal access to education and employment, they have increasingly been involved in most spheres of Chinese social, political, and economic activity, including science. The Chinese Government has in fact set targets for the promotion of women into leadership positions across all fields; and other Chinese institutions, such as the All-China Women's Federation—the country's largest women's nongovernmental organization—are actively involved in promoting women's participation in science. Consequently, women now make up some 40 percent of the country's technical and professional workforce, though they are still underrepresented in the science and engineering academies, where they comprise only about 6 percent of the membership.

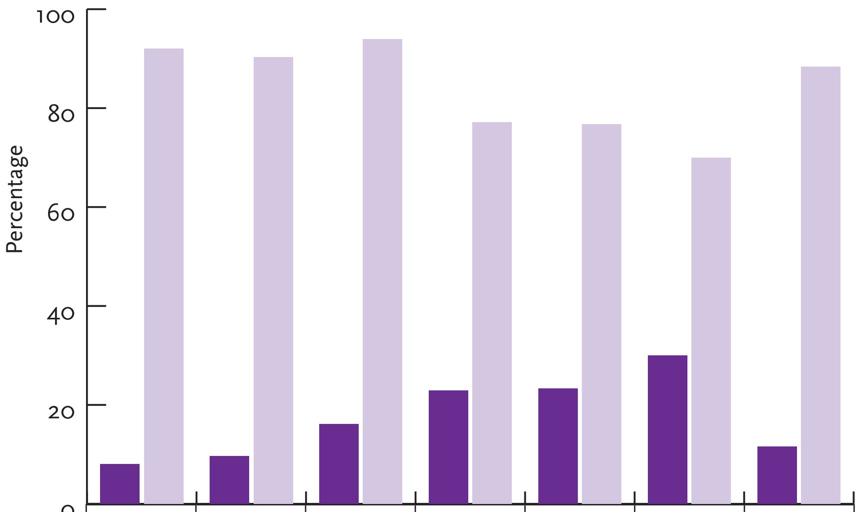
The Government of India responded to the need for women's rapid progress by establishing a Ministry of Women and Child Welfare, which funds a host of projects and social schemes. Since 1980, the Ministry of Science and Technology has had a task force for women in science, and it provides incentives and awards for women scientists and S&T entrepreneurs. For example, it established a biotechnology park in Chennai exclusively for women. The Government has also been building knowledge centres that teach basic skills in information technology, agricultural practice, public health, and nutrition to rural women (Ministry of Science and

Technology, India, 2004).

Although Japanese women and men have equal access to high-quality education at all , the representation of women in the total S&T workforce is the lowest of all OECD countries—only 11.6 percent (Normile, 2005). By contrast, women account for 26 percent of all scientists and technologists in the United States and 40 percent in Portugal. Moreover, women in Japan are generally confined to the lower levels of the occupational hierarchy (Figure 2.1).

In order to address this situation, the Japanese Government recently funded a large number of post-doctoral fellow positions for women. And because in Japan, as elsewhere, new areas of science, technology, and business—which are not burdened by a long history of dominance by men—often open the doors to alternative career paths for women, the Government is encouraging more start-up ventures for women and facilitating their increased access to venture capital.

The Science Council of Japan, in its report *Japan Vision 2050,* expressed concern about male domination of science and technology and recommended that the issue be addressed (Science Council of Japan, 2005). As



	President	Professor	Assistant Professor	Lecturer	Asssistant	Ph.D. student	R&D
%women	8	9.7	16.1	22.9	23.3	30	11.6
%men	92	90.3	83.9	77.1	76.7	70	88.4

Figure 2.1 Japanese women employed in S&T are confined to low levels of the occupational hierarchy. *Source*: Sodei, 2005

of October 2005, the Science Council of Japan had increased its membership of women scientists to 20 percent, and one of its three vice-presidents is a woman.

In Egypt, the Government has established the National Council for Women (NCW) directly under the President of the Republic, to guarantee the required political leverage for women's socio-economic empowerment and to ensure that they have equal access to the country's resources and can participate equally in its development. In order to enhance the status of Egyptian women in science, the National Council for Women is represented on the board of the National Commission on Scientific Research, and its Secretary-General is the Chair of the National Committee for Women in Science and Technology.

Influx of women into science and technology

Significant progress has been made toward attaining gender equity in higher education. In many countries, women now form the majority of college students. In Canada, some 55 percent of all undergraduates are women (Gilbride and Gudz, 2000). Similarly, in the countries of the European Union, more women than men are graduating from tertiary institutes, with 52 to 67 percent of degrees being awarded to women (Goetzfried, 2004).

Despite these impressive overall statistics, women students are still significantly underrepresented in S&T disciplines. While engineering undergraduates ('first degrees') in the United Kingdom, for example, have increased from 7 percent in 1984 to 14.5 percent in 2005, there is considerable variation by field. At one end of the spectrum, women make up 32 percent of chemical, process, and energy engineering students; at the other end, in mechanical engineering, they represent only 8 percent (www.hesa.ac.uk).

Different issues arise in a country like India, where nationally almost 40 percent of university places are filled by women—in 2000–01 their representation was nearly 22 percent in engineering and technology and 40 percent in science. Yet there is considerable variation between the country's states. In Kerala, women's college enrollment in science courses approaches 65 percent and for engineering and technology majors the figure is 31 percent. In Bihar, however, 21 percent of women enter college to study science and only 12 percent engineering and technology (INSA, 2004).

Efforts in the United States to attract women into science and engineering have been yielding results, with increasing numbers of women achieving Ph.D.s in recent decades. But underrepresentation still persists, especially in physics and engineering, as depicted in Figure 2.2.

The underrepresentation of women in science and technology is a phenomenon that transcends national boundaries, but interesting cultural exceptions do occur. Thus in the tertiary-education institutions of many Middle Eastern and Mediterranean countries—even in those where the general level of education is low and cultural traditions may often deny even superbly educated women a career—the gender balance across the S&T disciplines is relatively good (Figure 2.3). One reason may be that women from elite backgrounds have access to domestic help, thus levelling the playing field with the large majority of male scientists who assign the domestic sphere to their wives. To date, however, there has been little research in this area, but much could be learned from examining the reasons why in certain regions and cultures girls are on a par with boys in studying science, or why women and men choose S&T careers in comparable numbers.

In addition to educating students, universities are of course major employers of highly qualified scientists and engineers. At 30 percent of the

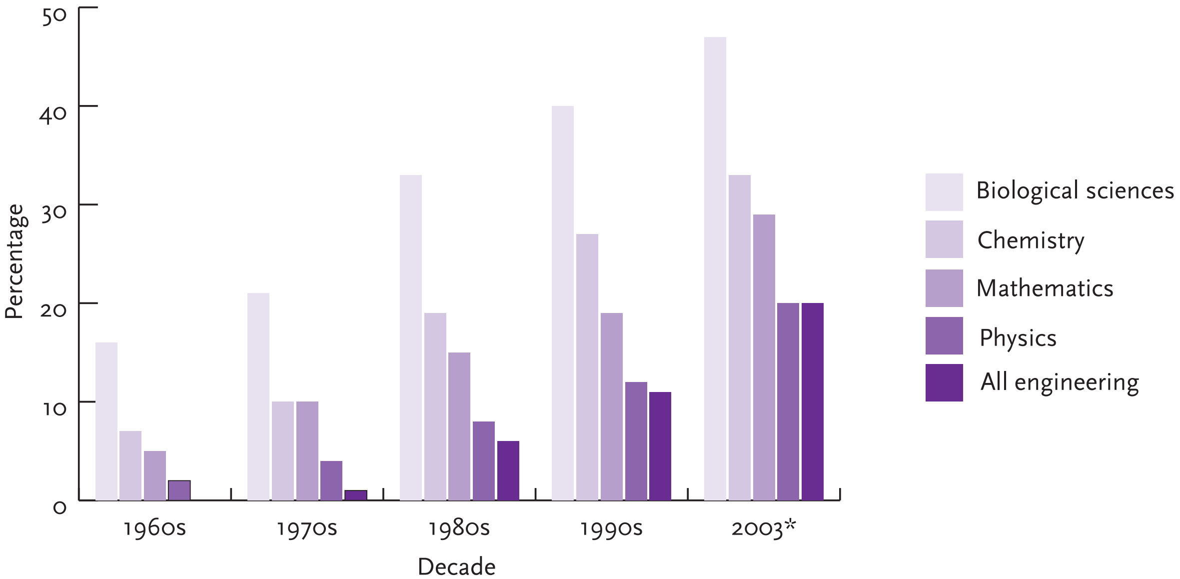


Figure 2.2 Increasing percentages of women have gained science and engineering Ph.D.s in the past four decades in the U.S.A. *Source:* Etzkowitz et al., 2000; and National Science Foundation, n.d.

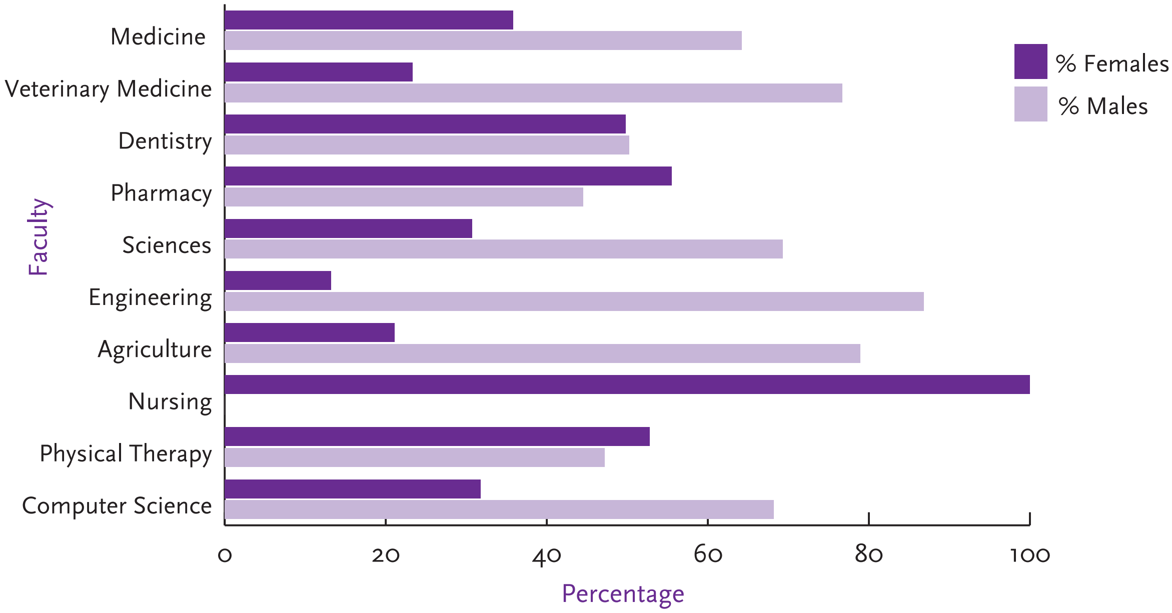


Figure 2.3 In Egypt, the percentages of women professors in scientific and medical fields are impressive. Nevertheless, 90 percent of engineering professors are men.
Source: Supreme Council of Universities, Egypt, n.d.

S&T workforce, women researchers are relatively well represented in the European Union's academic sector (European Commission, 2003). They account for approximately the same percentage in government.

But universities and agencies are not the only S&T employers. In most European countries, industry is the leading sector in terms of financing and working hours allocated to research and development, employing some 500,000 researchers. In terms of the employment of women researchers, however, the business sector—at 15 percent—lags far behind government and higher education (see Table 2.1). One reason is that few women have an engineering background, followed by specialized training to become corporate professionals. S&T entrepreneurship offers an attractive alternative that many women take advantage of. Governments and industry can facilitate women's entrepreneurship by providing training and access to venture capital, loans and guarantees.

The Australian Institution of Engineers publishes and updates annually an online handbook titled *The Engineering Profession: A Statistical Overview* (www.ieaust.org.au). It illustrates the difference in employment between the private and public sectors. A statistical example is shown in Table 2.2, which illustrates the extremely low presence of women in the country's engineering professions.

Table 2.1. Industrial researchers by sex, and proportion of female researchers by institutional sector in the European Union (1999)

	Number of industrial researchers		Proportion of female researchers (%)			
	Female	Male	Business enterprise	Government	Higher education	Total
Denmark	2,218	9,074	19.6	31.1	27.3	23.9
Germany	14,414	135,735	9.6	22.1	24.8	18.0
Greece	940	2,991	23.9	37.5	44.3	40.9
Spain	3,353	13,957	19.4	37.5	34.5	32.6
France	17,787	68,428	20.6	28.6	31.7	26.5
Ireland	536	1,364	28.2	25.2	46.2	29.8
Italy	5,490	24,216	18.5	38.1	28.4	27.2
Austria	1,258	12,708	9.0	31.9	25.7	18.7
Portugal	793	2,535	23.8	54.5	44.7	44.0
Finland	3,999	18,516	17.8	37.5	41.8	28.6
EU10	50,788	289,524	14.9	30.3	30.6	24.8

Source: European Commission, 2003.

Table 2.2. Employment in engineering by sector and sex, Australia, 2002 (%)

	Private	Public	Other	Total
Female	9.0	5.4	19.7	7.6
Male	91.0	94.6	80.3	92.4

Source: Engineers Australia, 2003.

Women's career paths

It used to be tacitly assumed that simply by bringing more girls into science and engineering, the number of women at senior levels would rise. That supposition, unfortunately, does not seem to be true, as women have a higher career dropout rate than do men. This 'leakage' of women from the professional pipeline is illustrated in Figure 2.4 for the European Union. Some of the reasons are the result of a poor work environment for minority groups of employees. Others are familial: interruptions resulting from pregnancy and motherhood; care-giving duties traditionally relegated to women; and disruptions caused by the move of a partner, whose career tends to prevail.

When women scientists and engineers do not drop out—and they are increasingly finding permanent employment at universities, private research institutes, technology companies, and other organizations—they progress less often than do their male counterparts into senior manage-

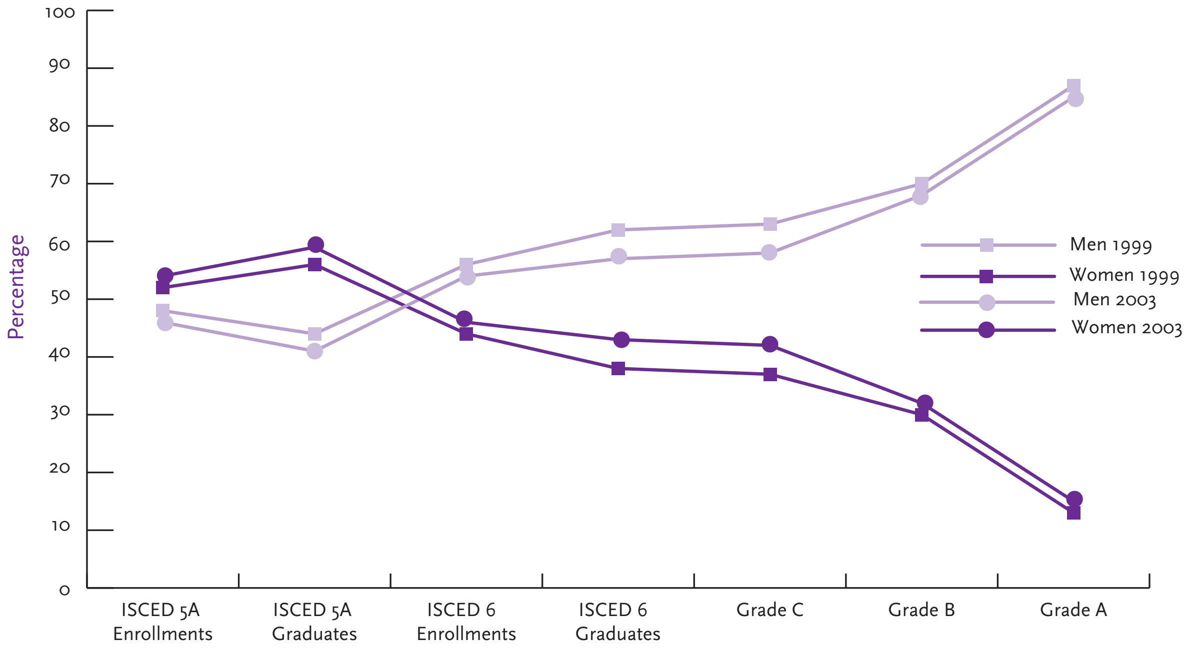


Figure 2.4 The relative share of women and men in a typical academic career for EU-25 (headcount, 1999 and 2003)

Note: International Standard Classification of Education Grades:

ISCED5A describes tertiary programmes that provide sufficient qualifications to enter into advanced research programmes and professions with high skills requirements.

ISCED6 are tertiary programmes that lead to an advanced research qualification (Ph.D.).

Grade A is the single highest grade/post at which research is normally conducted.

Grade B refers to researchers working in positions not as senior as top positions (A) but more senior than newly qualified Ph.D. holders.

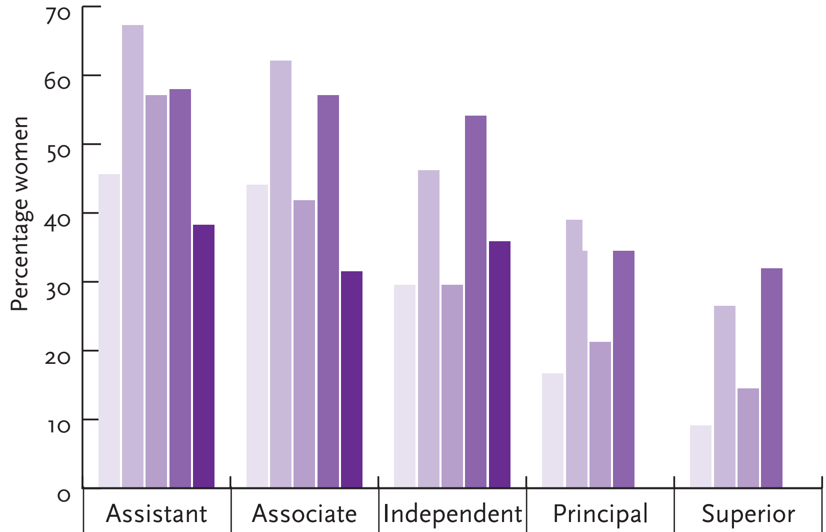
Grade C is the first grade/post into which a newly qualified Ph.D. (ISCED6) graduate would normally be recruited.

Source: European Commission, 2005.

ment (European Commission, 2003; Table 2.1). Figure 2.5 illustrates the percentages of fulltime women researchers for the five grade levels of Argentina's CONICET. Women are generally at or above parity with men at the lower grade levels, but women's numbers decrease at the higher levels. In technological sciences, women are absent from the top two levels.

Thus in addition to familial burdens disproportionately imposed on them, women in science and technology face workplace hurdles: they work as a minority in a male-dominant environment, and they rarely reach decisionmaking positions. One of the most influential reports in this regard

Percentage of women members of the career of investigators in Argentina



	Assistant	Associate	Independent	Principal	Superior
Physical sciences	45.65	44.13	29.58	16.67	9.09
Biosciences	67.32	62.12	46.24	39.02	26.47
Agronomic sciences	57.08	41.86	29.58	21.26	14.53
Social sciences	57.98	57.08	54.13	36.31	31.97
Technological science	38.27	31.51	35.90	0.00	0.00

Figure 2.5 Women employed in S&T research in Argentina (December 2004) are well represented at the lower CONICET grades, but they seldom rise to the top.

Note: Researchers in Argentina are associated with the National Research Council (CONICET), both in academe and at government research institute. CONICET has five grades of researchers, from the lowest (assistant) to the highest (superior).

Source: Argentine National Research Council for Science and Technology. n.d.

was produced in the United States at the Massachusetts Institute of Technology (MIT, 1999). Hearing complaints from senior women science professors about their marginalization, the Dean of the School of Science invited them to document their working conditions. The ensuing study provided quantitative evidence of the inequities that existed at this premier university—in particular the deficiencies in the working circumstances of these full professors and their exclusion from networks and leadership positions.

The MIT administration, widely praised for having the courage to face an embarrassing reality, also reacted quickly to begin changing it for the better. Consequences included additional appointments of women professors, much-improved job satisfaction, and a large influx of women science and engineering students. At this time, the world's foremost engineering institute has a woman as president, while women undergraduate students have reached parity in science and engineering. The MIT case is an example of a cultural transformation that yielded tangible results within in a matter of a few years once determined administrators took action.

Responding to MIT's example, other prestigious universities in the United States have assessed the working conditions of women professors and students, with the result that many of their administrations are now taking their own corrective actions.

Good management practice

If organizations are to make progress not only in the number of women in science and technology but in their levels of achievement and influence, the Advisory Panel believes that the problems of stereotyping, isolation, and exclusion must be tackled.

In recognition of the importance of using human resources wisely, the European Commission, the United Nations, and many employers have introduced 'good management practice': consideration of the differential impact on women and men of all policies, programmes, and practices that the organization puts into place. This strategic approach goes well beyond 'equal treatment,' or making discrimination based on sex illegal. Equal treatment (gender neutrality) often works to the disadvantage of women by not taking into account the differences in employment characteristics of women and men. Good management practice also transcends 'positive action,' or the introduction of special measures to redress disadvantages that women have experienced.

Good management practice addresses inequalities by modifying the policies and procedures of an organization so that they are fair and open for *all* employees. In this way, all individuals—not only from both sexes but also from diverse ethnic backgrounds, as well as the disabled—are included, with the entire staff valued as talented contributors to the well-being and performance of the organization. Diversity, from this perspective, is embraced as a competitive advantage, providing the entity with a wider range of experiences and viewpoints. Sociological research (Rees, 1998; Etzkowitz et al., 2000; Glover, 2000), meanwhile, has provided an

apt justification for changing a homogeneous institutional culture to one that is welcoming and inclusive of a diverse staff. Diversity is observed not only to be fair but also far better at achieving the organization's practical goals. The basic principles of good management practice are summarized in Box 2.1.

Good management practice implies the organization's commitment to equal pay for equal work; to including women and minorities in top management positions; and to offering provisions such as flexible working hours, telecommuting, and on-site childcare for employees, female and male alike, who are raising children. An example of good management practice in industry is given in Box 2.2.

Good management practice requires changing an organizational culture. This requires mundane efforts such as setting benchmarks and monitoring progress based on sex-disaggregated data. But many organizations do not routinely collect such data. Even when available, the comparison of data on national or international scales is difficult. For instance, the specific fields included among science disciplines, as opposed to engineering disciplines, vary from university to university and from country to country. Following a specified and uniform format, such as that put in place by the European Union (European Commission, 2003), would be a big step forward in measuring women's progress.

The UNCSTD Gender Advisory Board recently produced a toolkit for gender indicators in science and technology to facilitate the collection and comparison of gender-disaggregated data (UNCSTD/GAB, 2003). A similar toolkit, called WinSETS (Women in Science and Technology Scoreboards), was developed at Stellenbosch University in the Republic of South Africa (Bailey and Mouton, 2004). Both of them permit easy comparison of gender indicators across disciplines and between countries (Table 2.3).

Box 2.1 Good management practice

The objective of good management practice is to enable all employees to succeed in the workplace for the benefit of the organization. Diversity and equality are incorporated into the organization's decisionmaking processes.

Good management practice requires:

- Top-level commitment within the organization;
- Establishing necessary infrastructure;
- Reviewing policies and procedures for their gender impact;
- Transparency in communication, recruiting, promoting, salary reviews, and conferring of awards;
- Widening the 'inner circle', where decisions are made, so that it becomes inclusive;
- Leadership training and mentoring;
- Supporting a healthy work-family balance;
- Setting indicators and establishing benchmarks in comparison with other organizations;
- Regular monitoring and review of progress by collecting data disaggregated by sex;
- Sustained effort: changing institutional culture takes time.

Box 2.2 Good management practice: Joint venture of China and Canada

Good management practice was adopted in a major oil-and-gas technology-transfer venture between China and Canada that ran from 1993 to 2001. In this project, the policy was instrumental in ensuring that women accounted for 30 percent of the workforce. Affirmative actions included the establishment of a Women's Professional Development Committee, gender training workshops, and gender-equality awareness programmes. Networking opportunities improved consciousness of gender issues among women and promoted the growth of sustainable support groups. Later analysis of the enterprise revealed that career opportunities for women were improved, resulting in promotions and leadership appointments. The results of this project are important because its practices are readily transferable to other projects and organizations.

Source: Gibb, 2001.

Table 2.3 Proportion of female researchers in the scientific domain (%)

Countries	Natural sciences	Engineering	Medical sciences	Agricultural sciences	Social sciences & humanities
Belgium	30	22	39	35	36
Denmark	23	13	32	43	32
Germany	17	11	33	31	30
France	29	17	21	*	38
Ireland	45	26	68	12	55
Italy	31	14	23	24	36
Netherlands	20	14	37	26	30
Austria	15	6	27	26	30
Portugal	49	29	50	44	49
Finland	34	22	52	36	48
Sweden	31	19	51	41	44
United Kingdom	25	15	52	33	39
South Africa 2000	33	11	50	22	45
South Africa 2001	35	10	51	24	46

* Included in medical sciences
Source: Bailey and Mouton, 2004.

Many of the programs and policies for the improvement of women's status in science and technology, such as they are, were put into place only recently. Likewise the collection of disaggregated data in science and technology is also quite new. And with data-reporting usually lagging one or more years, the kind of long-range solid evidence that academies would love to see is simply unavailable. But if that is used as justification not to start making change, a vicious circle will be created, ensuring that the evidence will not be available in the future either.

Academies in action

Nevertheless, some national academies have begun to support efforts to increase the numbers of girls who study science or engineering and to help advance women's careers.

In India, which traditionally has had formidable cultural barriers that prevented women from succeeding in science and technology, three national academies—the Indian National Science Academy, the National Academy of Sciences, and the Indian Academy of Science—have helped initiate a profound change in attitude regarding women's participation. Working jointly, they convinced the Indian Government that it was urgent to take actions, and fund initiatives, to improve opportunities and working conditions for women scientists.

In addition, the Indian National Science Academy has helped establish websites that provide networking opportunities for women scientists. And in its recent report *Science Career for Indian Women* (INSA, 2004), which presents extensive data on women's movement through the education pipeline, it offers recommendations not only for increasing the numbers of girls entering science and technology but for alleviating the heavy familial burdens and professional constraints faced by women scientists and engineers. It is also noteworthy that the country's National Academy of Sciences has achieved gender parity on its Council.

In the United Kingdom, the Royal Society of London funds several types of grants that facilitate the careers of women with a Ph.D. in science who also have familial responsibilities. The U.K. Royal Academy of Engineering supports re-entry grants after a career break—as prompted for example by raising a family. It also supports a variety of youth education programmes, in which about 30 percent of the participants are girls. Both organizations support the Athena project, which aims to promote the careers of women in science and technology in U.K. universities and research institutions and increase the number of women in high-level positions. In 2003, the Royal Society helped produce the Athena good-practice guide for inclusion of women faculty at U.K. universities (Athena Project, 2003).

The Royal Society, as well as both the U.S. National Academy of Sciences (NAS) and the U. S. National Academy of Engineering (NAE) have made concerted efforts to increase the nomination pool of qualified women, with the result that the numbers of women in their memberships have grown.

Both American academies, in their educational materials, target girls—the NAE sponsors the *Engineergirl* website and the NAS introduced the *iwaswondering* website—and they publish biographies of prominent women scientists and engineers. The NAE has also distinguished itself by organizing a symposium on diversity in the workplace, with speakers from a dozen major U.S. corporations that presented a strong business case for diversity. The resulting report describes successful diversity programmes, in several companies, that deserve to be applied more widely (NAE, 2005).

A far-reaching agenda

The studies and initiatives discussed in this chapter show remarkable similarities in their ultimate objectives:

- Change institutional cultures through management policies inclusive of women at all levels and at all stages of their careers so as to accommodate a more diverse workforce.

- Provide focused support to girls and women in order to fully integrate them into the S&T enterprise.

The Advisory Panel's own recommendations, specified throughout this report, essentially incorporate the above two fundamental objectives into proposed action items for academies. In particular, the remaining four chapters focus on what academies can do to attract girls and women into science and technology, how they can support women in S&T education and careers, and how they can improve the gender balance in their own organizations and research laboratories. Central to these chapters, in effect, is good management practice.

Of course, the Advisory Panel's aim is not just that academies adopt such practices but that they also serve as models for the numerous entities they influence. Audiences that need to be engaged include governments, nongovernmental organizations, professional bodies and learned societies, companies and other private entities, S&T students, scientists and engineers themselves, career counsellors, and educators at all levels.

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.globalalliancesmet.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-

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

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.

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.

4. Technological empowerment of women at the grassroots

– Engagement of women at the grassroots is essential to worldwide science and technology capacity building. –

Previous IAC reports emphasized the need for global capacity building in science and technology, particularly the creation in each country of a critical mass of well-educated scientists and engineers (IAC, 2004a; 2004b). In that spirit, the preceding chapters of this report have argued for the inclusion of women among these professionals' ranks. This would make the greatest possible use of humanity's brainpower and—by giving women and men equal opportunities to excel—it would be the right thing to do.

In this chapter, the Advisory Panel offers a different and literally more down-to-earth perspective—unprecedented, to our knowledge, in reports of this type—that is nevertheless complementary to IAC's visions for building a better world. Just as global S&T capacity building requires the creation of a scientific and engineering elite, it also requires the mobilization—the engagement and empowerment—of a countries' ordinary folk, the public. We need to improve public understanding of science and technology so that citizens may be knowledgeably involved in modern S&T-related policy issues. And we especially need to enable the billions of grassroots individuals around the world to apply the fruits of science and technology, such as useful products and services, for growing their countries' economies while improving their own lives.

Such engagement cannot occur while excluding half of the human race. The vast numbers of grassroots women in the rural areas and the urban neighbourhoods around the planet are those who do a great deal—in some countries, the majority—of the daily hands-on work. Therefore these women in the developing world's villages—rural townships and urban enclaves alike—must become engaged in the application of modern technologies. Because they are the teachers of the young, providers of basic nutrition and health care to their families, and farmers and producers of commodities, as well as half of the voting population in democracies, grassroots women are an essential element in building their countries' S&T competencies.

In other words, energizing and empowering grassroots people, women and men alike, is the correct action to take for humanitarian and human-rights reasons. But it also makes eminent economic sense. Elites have a profound influence, of course, on the generation of S&T advances, but everyone else must be capable of putting them into practice.

For example, while the Green Revolution in India was a significant factor in enhancing food-grain production—enabling India to move from dependence on imported food to self-sufficiency—the Green Revolution reached a plateau during the 1990s when intensive farming began to threaten the environment. A more enlightened follow-on approach, according to M.S. Swaminathan, the highly influential Indian plant geneticist and advocate of sustainable agriculture, would be an Evergreen Revolution—a *sustainable* green revolution driven by science and technology—complemented by a Gender Revolution. The latter, a reference to empowerment of the women who do so much of the farming, would ensure their productive long-term access, along with that of men, to the resulting biological and information technologies (www.mssrf.org).

Similarly, people trying to cope in the fast-growing megacities of the developing world face their own set of challenges. And urban women in particular, just like their rural counterparts, must be recognized for the important economic roles they play. They need to become partners in capacity-building efforts appropriate to their situations.

In essence, this chapter proposes ways of enabling grassroots women in the countryside and the cities to gain scientific and technological competencies that lead to enhanced economic power for themselves and their families, communities, and societies.

Educating girls

A crucial factor in the establishment of a grassroots S&T base is to ensure girls' access to education. Girls in villages are faced with formidable barriers, including harsh living conditions, as well as cultural and religious traditions—such as leaving home at a very young age to get married—that may preclude or abruptly terminate their schooling.

There are also constraints for girls who remain with their families. While tuition and textbooks at the pre-college levels are often provided at negligible cost in the more prosperous economies, they are frequently a major financial impediment to people in developing countries. Parents generally spend what income they have on educating sons; and even when money is available for educating daughters, these children are often put to work for their families doing a variety of domestic tasks. This practice

leads to poor performance at school or even dropping out of formal education altogether. In Ethiopia, for instance, women have a greater chance of dying in childbirth than of finishing primary education (Wax, 2005).

There is also a vicious cycle at work. A UNICEF project examined barriers to primary education in developing countries and found that 75 percent of children who are out of primary school have mothers who themselves received no education, largely because of poverty. This proportion rises to 80 percent in Asia, the Middle East, and North Africa (UNICEF, 2005). These data emphasize the importance of getting girls into school, especially as they will be the mothers of the future and thus be essential to ending the vicious cycle. Girls' education is essential not only to building a science-literate and more affluent village population but also to launching the education of the next generation of teachers, scientists, and engineers, some of whom will then be available for outreach to the villages.

Education programmes based in developing countries typically face many challenges. These programmes must first aim to convince girls' families that their basic (primary) education is worthwhile. This is difficult to do however if schools are underfunded, teaching materials are insufficient, teachers are unprepared, and girls are ill informed about the benefits of learning about science and technology. In fact, in developing and developed countries alike, there is an urgent need for well-prepared primary- and secondary-level science teachers.

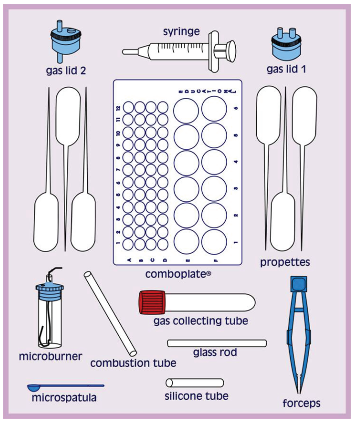
One increasingly popular way to stimulate people's interest in education in general—and in science and technology in particular—is the hosting of community-based activities. Undertaken at schools, community locations, and online, these programmes are typically run by enthusiasts who inspire students (and their parents), act as mentors, and provide career information. Online activities, of course, can reach diverse areas that include but are not limited to villages. One such programme aimed at attracting young people, girls and boys alike, is the pan-African online science magazine *Science in Africa*. Through mechanisms such as poems and lively storytelling, this innovative website builds science literacy and encourages exploration (www.scienceinafrica.co.za).

Other programmes begin addressing the cost barrier by providing inexpensive science-education equipment—such as the kit depicted in Box 4.1—that also supports girls' preference for learning through hands-on experimentation (Head, 1996).

UNICEF also sponsors multi-country projects to improve girls' primary education. In Gambia and Burkina Faso, mothers' clubs work with schools

UNESCO-IUPAC hands-on test kits. Box 4.1

Low-cost hands-on kits in lunchboxes, such as those funded by UNESCO and produced by the University of Witwatersrand in the Republic of South Africa, are effective in spreading an understanding of scientific methods. The microchemistry kit shown here, for example, enables students to carry out experiments easily, and its small size makes it especially beneficial to girls.



Source: RADMASTE Institute, University of Witwatersrand,n.d.

to help reduce the dropout rate of girls. In Ethiopia, teacher training is improving classroom learning. And a plan of action in 34 countries to promote gender-sensitive primary education is being developed and implemented (www.unicef.org).

If girls do manage to acquire a primary education, they face hurdles in obtaining parental permission and the necessary financial support to enter secondary school. Because one major obstacle is families' reluctance to allow an unmarried young woman to leave home, it is important that secondary education not be centralized; in order for high school or its equivalent to be accessible to girls, it must be decentralized.

Thus Turkey's Association in Support of Contemporary Living funds programmes for girls that include the setting up of distance-learning classes and the provision of resources to support their enrollment in primary and secondary schools. Girls in rural areas are also given access to computers and courses in tourism, business, and English. Acquisition of Internet skills and access to online education projects about small businesses and e-government are aimed at helping young women so that they may start their own commercial enterprises and generally be role models for girls in their region (www.cydd.org.tr).

Beyond providing girls with greater literacy and competence for their daily lives and future economic activities, educating them to a higher standard at the primary and secondary levels renders a new generation of women capable of pursuing S&T education at the tertiary level. They may then expand the ranks of women who train others—particularly grassroots women in rural and urban locales—in the skillful application of science and technology.

Recommendations

- Academies are called upon to ensure that their public-understanding-of-science efforts include community-based programmes. These initiatives, while addressing virtually all children and adults, must specifically appeal to girls and women.
- In those cultures where families are unwilling to let unmarried daughters move far from home, the InterAcademy Council, InterAcademy Panel, and academies are asked to advocate that secondary and subsequent schooling be made available locally for girls and young women, along with their access to the needed information technology.

Empowering women at the grassroots

Mahatma Gandhi had a deep appreciation of the value of educating women: 'When a man is educated, an individual is educated; when a woman is educated, a family and a country are educated.' Such imparting of critical skills—in a word, empowerment—has three essential elements: a teaching method that fits the needs and circumstances of the audience; a teacher well versed in the required knowledge, who is able to engage the target audience; and the incorporation of the traditional knowledge and expertise of the students into the capacity-building effort.

Moreover, certain common-sense principles of what technological skills to transfer, and to whom, apply to virtually all grassroots economic endeavours both urban and rural. If a developing country's agriculture, for instance, is to be sustainable, skilled workers in its farming communities are needed. And given that women perform a large fraction of the farm activities, S&T tools (both literal and figurative) will add great value to the local knowledge of rural women and enable them to face the challenges of sustaining high levels of crop productivity.

Thus rural women who own land may want to learn about seeds, fertilizer, water management, and pest control, while rural women who do not own land may want to acquire skills that enable them to establish businesses that make use of local agricultural processes and products.

Initiatives at the grassroots

One approach to women's empowerment is *self*-empowerment by means of local initiatives, especially those undertaken by voluntary or charitable grassroots organizations. Such entities are not only indispensable for providing initial support, advice, and coordination; they are sources of technological skills and new tools and may even facilitate access to city markets for goods that have been produced.

Collaboration among these groups can also direct workers' newfound skills and confidence by identifying and engaging sources of funding for pilot projects and for the creation of new businesses. Moreover, they can help secure the cooperation and support of government agencies—an important factor for women's inclusion in science and technology.

Grassroots organizations that arise from the need to meet local women's needs often function effectively when set up as small cooperatives, thus turning women's labour into paid employment. The enterprises are more efficient if the women themselves manage the finances and day-to-day operations. Such structures make sense in terms of economics, and they also have important implications for self-confidence and self-reliance.

Important factors for the success and sustainability of such local training programmes are the establishment of an infrastructure, a strong spirit of community participation, and accessibility to all—even to the poorest individuals.

Research institutes and knowledge centres

The manifold bottom-up initiatives by nonprofit and charitable organizations need to be complemented by sustained actions from the top down. Many governments in the developing world are taking such actions by adopting a two-tiered strategy: formation of a cadre of experts in specialized research institutes, and technology transfer dispersed among local 'knowledge centres.'

Research institutes are centralized facilities that employ and train scientists and technologists, both resident and visiting. There are many such institutes, particularly in India, China, and Africa, that address agricultural issues in the particular region they serve. Knowledge centres, by contrast, are not research venues but decentralized training facilities that enable local people, typically trained by professionals from the research institutes, to become an essential part of the S&T capacity building of their countries. The IAC report *Realizing the Promise and Potential of African Agriculture* in fact stresses that such networks of research institutes and knowledge centres are the most promising mechanism for cultivating cadres of scientists and engineers who in turn may engage farmers, both women and men, in the capacity-building process (IAC, 2004b).

These networks of relatively large regional research institutes and small and dispersed knowledge centres represent, in effect, wholesale and retail levels of S&T training. While the research institutes concentrate on the production of knowledge, the knowledge centres focus on its distribution and practical application. Thus knowledge centres typically embrace animal science, agriculture, the health sciences, water technology, alternative energy sources, post-harvest operations, and sustainability of the environment. Information technology, an attractive career option in itself, is also an important subject for knowledge centres because it greatly enhances the community's access to relevant information.

For example, women farmers in South Sumatra are benefiting from Indonesia's national programme of Warintek Multipurpose Community Telecenters that promote sustainable development through the use of appropriate science and technology (http://portal.unesco.org). These noncommercial information technology kiosks, sponsored by the Indone-

sian Ministry for Research and Technology, offer a range of media for distance education and face-to-face education alike. The S&T-focused CD-ROMs, for instance, are geared to meeting local needs; they provide training and advice on crucial aspects of growing and marketing area crops.

In India's Pondicherry territory, the M.S. Swaminathan Research Foundation has established a pilot knowledge centre that is undertaking large-scale field demonstrations and training programmes for resource-poor farmers, principally women. They learn, for instance, about the serious consequences of malnutrition and are provided with knowledge of nutrition-security practices. To reach the largest possible population, a variety of technological and social procedures are being developed for attracting trainees, giving them training, and maintaining contact with them and their communities. And efforts are being made to ensure that administrative procedures involving appointments, training, recognition, and promotion are not slowed down by bureaucracy (www.mssrf.org).

In Burkina Faso, the UNESCO Chair, Women, Science, and Development in Africa, creates informal, interactive science-education programmes on health, water management, and agriculture, with university professors and students meeting with village women. It has also established a network with universities in surrounding countries (http://portal.unesco.org).

Recommendation

- Academies are urged to commit to and participate in the establishment of knowledge centres where rural women can learn to employ scientific and technological methods in applications, such as agriculture, health care, sanitation, energy production, nutrition, and environmental conservation. Training in information technology is also desirable, and often essential, for accomplishing programmes' objectives. Thus the Advisory Panel recommends that academies counsel national governments to establish training and demonstration projects of these types in rural areas.

A cadre of women scientists and engineers

Regardless of which entities create or operate a training programme, a reality they must respect is that women in rural communities learn most effectively from women scientists and engineers, especially in cultures where women do not interact with unrelated men. And if these professionals are themselves products of the local culture, they can more easily

establish rapport and act as role models. Moreover, where local training programmes are based on knowledge centres, these women are effective intermediaries between the research institution(s) and the community. Thus a cadre of such women S&T professionals should be established.

Developing countries' universities, often major sources of the national S&T talent pool, have to be more cognizant of this need. The participation of women in agricultural science in Africa, while not negligible, remains low, hovering around 15 percent at the Ph.D. level in Sub-Saharan Africa (20 percent in the Republic of South Africa).

One way to attract more women graduate students is to give them access to leading education institutions, outside their countries, through exchange programmes such as those that mutually exist between African universities and those between African and Western universities. Exchange arrangements of this type are often quite successful. In a period of only five years, the Wageningen University and Research Centre in The Netherlands has granted over 200 master's degrees and 50 doctorates to African scientists, many of whom now occupy senior governmental and university positions in their native countries (www.wageningenuniversiteit.nl/nl/).

In one pan-African programme, called 'Sandwich Ph.D.,' African students undertake thesis research at a host institution elsewhere in Africa or abroad, then return to complete their degree at the home university. The student and two supervisors (one from each institution) collaborate on fitting the capacity-building training to the home country's needs so that she or he, when finished, is prepared to tackle national priorities. In particular, some of these well-trained experts—such as women graduates of the Sandwich Ph.D. programmes—can take on the urgent task of merging modern scientific methods and technologies from universities and research centres with the traditional knowledge of village women of their own culture.

Other programmes are useful for picking up where women's graduate training leaves off. L'Oréal, the international cosmetics company, awards fellowships each year to 15 women—recent Ph.D.s from five continents—for post-doctoral work with foreign experts on research that benefits their native countries and that gives them a head start in launching their careers.

Critical to those careers however is avoidance of the woman researcher's bane—isolation—that results in marginalization and lack of access to places where power resides. Women researchers need to be valued, encouraged, and included every step of the way, not least because of their

crucial role as role models and technology-transfer agents in their country's development.

Two priorities for achieving this goal are to recognize that gender issues are impeding progress and then to take appropriate action. The College of Rural Development at the China Agricultural University, for instance, has established a Women and Development project to ensure that gender issues are considered throughout the agricultural-education system (Gibb, 2001). Similarly, the Consultative Group on International Agricultural Research (CGIAR), whose nearly 8,000 scientists, technicians, and managers bring their talents and expertise to 15 research institutes around the world, has established the Gender and Diversity Program to help its Future Harvest Centres attain staff diversity and, as a result, achieve excellence both in research and management (www.genderdiversity.cgiar.org).

Recommendations

- ► The Advisory Panel asks academies to advocate for and support the tertiary education of women in science and engineering. These women may in turn train rural women, in their own cultures, through outreach mechanisms such as local knowledge-based centres that are linked to regional research institutes.
- ► The Advisory Panel urges academies and their individual members to support, participate in, and establish collaborations between developed and developing countries that give women scientists, engineers, and science and technology students the opportunities to acquire contacts, build networks, and generally gain greater access to new learning opportunities.

Roles for the academies

The world's science and engineering academies are well placed to facilitate the transfer of technology from developed to developing countries—in part through the academies' advocacy of research institutes and knowledge centres and in part through fostering science literacy and technological competence among grassroots people. In fulfilling this important role, the academies should keep outreach to women particularly in mind, focusing on the key role that women scientists and engineers must play in the effective transfer of knowledge from research institutes to women at the grassroots.

The Indian Academy of Sciences, for example, is already active in this area through its work in Mission 2007, which aims to enlist one million S&T workers as master trainers. Meanwhile, a complementary priority is to build the audience, thereby expanding the number of grassroots people

who acquire new knowledge and learn to put it to practical use. Thus Mission 2007, in collaboration with a national alliance called Every Village a Knowledge Centre, aims to set up an actual or virtual knowledge centre in practically every one of the country's 600,000 rural villages through the integrated use of Internet, cable television, radio, and print media (www.mssrf.org).

In such pursuits, it is clear that academies sometimes need to leave their comfort zones and exert leadership in making science accessible and engaging to the general public, women and men alike. In so doing, they take their events and programmes out into the field—into communities that may well be remote—rather than limit their venues to university campuses or research facilities.

Public engagement programmes, in addition to transferring knowledge of S&T developments in order to improve quality of life, also enable the full cross-section of society to be involved in the social and ethical discussions that lead to better-informed policy. And, last but not least, such programmes raise awareness of the opportunities of working in science and technology. Consistent with the thesis of this report, moreover, public engagement in S&T activities are needed so that the interest of women can be gained; so that they can appreciate the scope and benefits of science and technology; and so that they may share their interest, appreciation, and knowledge with their children and neighbours.

The IAC and IAP are uniquely positioned to stimulate the interest of the S&T community's governing bodies in the transfer of science and S&T knowledge and a bottom-up engagement of women in science. And in so doing they can build on earlier IAC reports, which address the issues of competence building, improving the quality of schools and universities, and strengthening existing research centres (IAC, 2004a; 2004b).

Several academies in scientifically advanced countries are already working in partnership with academies and research institutions in developing countries. These relationships, built on existing alliances and methods that have proven effective, can be expanded to explicitly include women at all levels.

In summary, the Advisory Panel urges the academies, individually and jointly, to pursue a multi-pronged, strategic approach to engaging grassroots women in science and technology. That approach includes:

- Providing access to education for girls and women, while improving science education at all levels.

- Empowering women from rural and urban areas by stimulating their interest in S&T-related practical skills that improve their effectiveness and expand their vistas.
- Developing a local infrastructure of knowledge centres and support groups to enable women's access to S&T knowledge that is appropriate to the needs of their communities.
- Supporting the education of women who wish to become S&T professionals. Some of these women may then essentially act as extension or field agents in providing or abetting technology transfer to women at the grassroots.

Recommendation

► The Advisory Panel recommends that the InterAcademy Council and InterAcademy Panel become part of, and facilitate the efforts of, diverse organizations to provide women with access to the knowledge and skills needed for contributing to the world's science and technology capacity.

5. Academies to lead the way

– Academies must set an example for all of the world to see of welcoming women scientists and engineers to their ranks and treating them as full partners with men. –

National academies can play a valuable role in transferring S&T skills to women at the grassroots level, as described in Chapter 4; and they can be influential in other efforts—academic, governmental, industrial—aimed at achieving gender equity in S&T-related professions (Chapter 3). But in order for academies to truly help in the changing of corporate cultures and diversification of other workplaces, they must first put their own houses in order. Because academies are at the pinnacle of the S&T establishment, their own enlightened examples can inspire other organizations. Alternatively, if academies essentially adopt a policy of 'Do as we say, not as we do,' other entities could similarly take the issue less than seriously—with a consequent persistence or worsening of today's inequitable status quo.

National academies therefore each need to adopt policies and practices that create fair and inclusive working environments within their own domains and that influence individual academy members to practice inclusiveness at their home institutions. And through the workings of academies' far-reaching networks and collaborations, they may be effective in improving the representation of women not only throughout their countries but also in the international S&T community.

The present challenge for the academies, however, is sizeable. At the U.S. National Academy of Sciences (NAS), for example—an institution with more than 2,000 members as well as 340 foreign associates from 40 countries—women scientists have traditionally been a small fraction of the membership. With concerted efforts to increase the nomination pool, annual inductions of women have reached over 20 percent in the past few years, though many of these women are in the social sciences. Overall, the proportion of NAS women members is still under 7 percent, with the percentage among mathematicians, physicists, chemists, and engineers hovering around 2 to 3 percent.

In the United Kingdom, the Royal Society of London has seen a 10-percent increase in the number of women elected to membership in the

past five years. But because just 44 Fellows are elected each year, the presence of women overall—and especially in mathematics, physics, chemistry, and engineering—continues to remain low (at only 4.5 percent). Elsewhere in the world, the percentage of women academy members in the science and technology disciplines is similarly depressed—at an average of around 5 percent.

Within most academies, moreover, women members may not get to participate fully in meetings and committee work. And women members rarely find themselves in positions of power and leadership. Thus the InterAcademy Council Board, made up of the presidents of 15 prominent science academies, has no women members.

A December 2004 survey undertaken for this report showed wide variation in the range and strength of efforts by academies to address the underrepresentation of women among their membership. Most responses did show some awareness and concern about the problem, though they each tended to look elsewhere for direction. Many simply stated, in effect, that the academy is not actively doing anything but is interested to learn from others.

Yet among academies there are nevertheless some striking examples of gender balance worth emulating. The National Academy of Science and Technology of the Philippines (NAST), for instance, has had a woman president for two terms. Women have parity on the NAST Council, and women form almost one-third of the membership. Similarly, the science academies in India have a large number of women officers and pay strong attention to gender issues, as noted earlier in this report.

Several academies offered suggestions for action during the preparation of this report. All were considered by the Advisory Panel, and some have been incorporated into its recommendations. On the other hand, many of the proposed initiatives were small-scale and individualized, tending to focus on supporting just a few women, and were often based on the erroneous premise that women need help because they are inherently lacking in some way.

Stronger, more realistic, and more replicable efforts are required, especially those that go to the heart of the problem. Thus it is the Advisory Panel's belief that the most appropriate way for academies to address the underrepresentation of women members is to foster an inclusive institutional culture based on good management practice, as described in Chapter 2 and reflected in the discussion and recommendations below.

Commitment from the top

The first element of good management practice, simply because it affects all others, is commitment by those in the top echelons. In an academy, it is the president and council that must commit to including qualified women scientists throughout their organization, to appointing women to decision-making committees, and to introducing gender-equality principles into the academy's offices, programmes, and research institutes. In that spirit, the Advisory Panel recommends that the president and council of each academy sign a public commitment statement, a sample of which is shown in Box 6.1.

Put gender issues on the agenda

The single most important action an academy can take is to immediately put gender issues on its agenda. The president and council are thus asked to commit to the practice of inclusiveness at all levels of their organization and in all academy actions. Responsibility for gender issues may be assigned to a dedicated academy member (in small academies) but preferably to a standing diversity committee composed of women and men academy members. This committee, which helps formulate plans to remedy imbalances in gender representation within the organization, must report directly to the academy president and council.

Data monitoring

A primary responsibility for the diversity committee is the regular collection, analysis, and reporting of sex-disaggregated data. Such data are key elements in bringing gender issues to the fore and in measuring the success of programmes intended to improve the organization's gender balance. The Advisory Panel recommends that the committee report yearly to the academy's president, council, and membership, and that reports from the individual academies be aggregated and discussed at the IAP annual meeting. Within a few years time, the annual gender-issues reporting will become mainstream.

Widening the pool of nominations

Specific academy strategies must be employed to enlarge the pool of women who can be nominated for membership as well as for prizes, awards, and grants that the academy bestows. Raising the awareness of the membership of the need to diversify its ranks, and instigating more formal procedures such as mixed-gender search committees have been used with

some success. Other measures adopted by some organizations include a special election for women candidates only and the exemption of qualified women from the numerical upper limit set for the year.

One direct and creative way of increasing the nomination pool of women is by giving preference to the election of younger members. The reasoning here is that the traditional average age of election reflects the gender composition of science and engineering departments some 30 years ago. But with the definite progress that has been made since then, a younger cohort will have a much better gender balance. This reality has been incorporated into the policies of the National Academy of Sciences, India; the German Academy of Natural Scientists, Leopoldina; and the Royal Netherlands Academy of Arts and Sciences, each of which has introduced a 'young members' category. About one-third of Leopoldina's 'young academy' are women. In its first round of elections this past year, the Netherlands Academy selected 40 members of its new 'young academy.' Twenty of these members are in S&T-related fields, and 7 of the 20 are women.

Widening the pool by itself is only a first step; the people in that pool then need to be evaluated fairly. Awareness that women's accomplishments are judged more severely than men's, by women and men alike (Steinpreis et al., 1999), begins to reveal the additional obstacles that women have to surmount between being nominated and actually being elected.

Increasing women's participation and visibility

Academies can heighten the visibility of women scientists in general by expanding their involvement in academies' activities. Positive actions cited in responses to the Advisory Panel's survey include supporting women's inclusion in academy boards, panels, and committees (www.interacademycouncil.net). Also, women should be included in study programmes and professional meetings. Other positive actions cited were increasing women's presence on speaker platforms; ensuring that both women and men scientists and engineers are represented in academy publications and educational materials; and expanding women's opportunities to chair academy bodies and conference sessions.

In these ways, women become directly involved in setting research priorities and directions and in allocating funding. Such activities also offer exposure and self-development opportunities to women, and they raise awareness among men in their peer groups—along with that of the S&T

community in general—of women scientists' skills and talents. In addition to raising women's profiles, the full and equal involvement of women on these bodies serves to enhance their career development and helps them to cultivate leadership skills.

Sponsoring and evaluating research

In their roles as sponsors of research, reviewers of research proposals, and evaluators of research laboratories, academies have opportunities to show leadership on gender issues and ensure that good management practice is being followed. For example, when academies form panels to evaluate the performance of research institutes, they must include in their criteria the working conditions of women and other minority staff of the institute being evaluated. It is preferable, moreover, for such panels to be mixed-gender, receive diversity training prior to their visits, and include a member with expertise in diversity issues.

Academies must also be sensitive to the nature of the research itself. In some fields—life sciences, sociology, anthropology—the gender of the researcher may affect the choice of the research topic, how the research is carried out, the interpretation of its results, and the ways in which these results are applied. Academies sponsoring research and evaluating research proposals must therefore pay serious attention to the influence of the researcher's gender on the proposed work, as well as to the differential impacts of that research on women and men. By encouraging mixed-gender research teams and by including both women and men on evaluation panels, academies are helping to assure that results are as free as possible of gender bias. In this way, too, they are setting examples for other funding bodies to emulate.

Gender research and education

The issue of the underrepresentation of women in science and technology is not a women's problem per se but a problem for the whole S&T community, and, as such, for the academies. It warrants an objective analysis by the academies, carried out with the same degree of rigor that member scientists or engineers would apply to questions in their own fields. Moreover, the support of the academies in presenting this problem as a challenging intellectual endeavour will be invaluable to gender-equity issues' legitimacy and visibility. A prerequisite is that academies become more familiar with sociological research on cultural factors that influence women's participation in science and technology (for examples, Steinpreis et al., 1999; Etzkowitz et al., 2000).

Academies are urged not only to put the issue of women in science and technolgoy on their own research agendas but also to do so within a broader social context. They can do this, for example, by sponsoring studies, offering scholarships, inviting sociologists and anthropologists to give public lectures, and creating awards for researchers who have gained special insights into diversity matters or who have stimulated the general public's interest in this area.

This chapter has so far addressed what individual academies can do internally. But external forces also apply, both on an academy and by an academy, as briefly discussed below.

Advising and influencing government

Individual academies usually have considerable leverage within their own countries, with many of them providing independent advice to their governments on matters of scientific and technological importance. Thus, for example, academies may press for nondiscrimination legislation in countries where women and minorities lack such protection by the law.

Recommendations

- The Advisory Panel asks academies as employers to sign a statement formally committing themselves to good management practice. This will help ensure fair and transparent recruitment, employment, and promotion procedures in general, and in particular it will help expand the participation of women in academies' activities and lead to their increased membership.
- Each national academy is urged to establish an equality and diversity committee that advocates for the inclusion of women at the highest levels of science and engineering and that directly reports to the institution's governing body. The in-house committee proposes actions on diversity issues, and it regularly monitors and reports on these actions' results as benchmarks for further improvement.
- Academy leaders are encouraged to raise awareness among members regarding women's underrepresentation in the academy; strive to enlarge the nomination pool of women scientists and engineers; appoint women members to councils, boards, committees, and panels; and recruit women as speakers in the academy's lectures and symposia.
- When undertaking reviews of research institutes, academies are asked to stipulate that the working conditions and experiences of women staff be among the evaluation criteria.
- Academies are urged to become acquainted with research that examines sociocultural influences on women's participation in science and technology.
- In their interactions with governments, academies are asked to advocate for full inclusion of women in science and technology. They can urge the adoption of measures such as nondiscrimination legislation, a national office focused on women's issues in science and engineering, reform of textbooks and teaching materials, and a system for monitoring girls' and women's progress through the education/career pipeline.

They may look into specific cases of gender-based job discrimination and the legal recourses; or they may support infrastructure (such as the creation of an office focused on diversity issues in science and engineering) to help those who are discriminated against. Academies may also work with government and industries to develop and interpret data on girls' and women's progress, or lack thereof, through the education/career pipeline.

Contributions by the InterAcademy Council and InterAcademy Panel

The IAC and IAP are uniquely placed to help academies exchange information on good management practice and on innovative and effective programmes for improving women's representation in science and technology. Through their reports, meetings, and constant flow of global communications, the IAC and IAP can:

- Motivate women and men from the international S&T community in general and from member academies in particular to develop inclusive cultures,
- Ask each member academy to report annually on the status of women in its organization and on measures that are being taken to ensure its full inclusion of women,
- Engage social scientists to provide academic evaluations of issues and progress,
- Develop international partnerships to address the underrepresentation of women in science and technology and to secure funding for women-in-S&T programmes,
- Assist academies in consolidating their contacts and intellectual capabilities to advise numerous governments and international bodies on gender-equity issues.

The IAC and IAP can credibly undertake the above actions, however, only after putting their own houses in order. They need to develop a strategy, similar to the one outlined earlier for individual academies that involves:

- Commitment by the IAC and IAP co-chairs to equality and diversity;
- Placement of gender issues on the agenda of IAC and IAP study panel meetings;
- Monitoring of progress, based on the yearly (preferably standardized) collection, analysis, and reporting of sex-disaggregated statistics;
- Inclusion of women experts on study panels;
- Giving close attention to gender aspects of research supported and reports produced.

Academies acting on a global scale

In this planet's ever-more-interconnected 'global village,' progress in one country can readily inspire progress elsewhere as academies share information and experiences. The IAC and IAP can often function as facilitators. An excellent mechanism for such information sharing may be a dedicated website maintained by the IAP. At a minimum, the website would contain the *Women for Science* report, including references, resources, and supporting material.

The scope would be broadened, and duplication avoided, if the IAP website were developed in partnership with organizations already supporting women in science and technology through their own websites (for example, Women in Global Science and Technology at www.wigsat.org). Principally, the IAP website would bring the unique perspective of the academies to addressing gender issues. Links could provide access to resources, such as examples of successful programmes and good management practice, as well as to data on the education and employment of women in S&T jobs. In fact, the partnership could go further by creating a web portal providing a centralized venue for networking, and a search engine for resources and connecting users to relevant programmes. Individual academies on their respective web home pages will include a link to the IAP website or portal.

This will make IAC and IAP known as partners and even leaders in the existing global effort on behalf of women's inclusion in science and technology. One way to do so is by partnering with international bodies—such as the Academy of Sciences for the Developing World (TWAS), the Third World Organization for Women in Science (TWOWS), UN organizations such as UNESCO and UNCSTD Gender Advisory Board, and other nongovernmental organizations—that are effectively addressing gender issues and have implemented programmes for women in science and technology. Such organizations and the academies could be natural allies in coordinating a worldwide mobilization and in developing a strategy to establish gender equity throughout the global S&T community.

In particular, academies might want to collaborate with each other, as well as with other learned societies, to develop a set of indicators and benchmarks for assessing action plans for inclusive S&T practices. These measures should be based on the regular annual collection, analysis, review, and reporting of sex-disaggregated data. A standardized format (such as the European Union instrument, the UNCSTD Gender Advisory Board toolkit, or the WinSETS scoreboard as shown in Table 2.3) should be chosen. Academies that are planning or have already initiated interna-

tional efforts devoted to education and training programmes of various types need to consciously include gender-related issues in such initiatives. The IAC is thus urged to circulate this *Women for Science* report more widely than to academies alone. Higher-education institutions, public- and private-sector research laboratories, relevant nonprofit organizations, and others around the world may want to receive it and join in the action.

In much the same spirit, the IAC together with the IAP should make use of various means of communication, such as S&T-friendly radio and television programs, for increasing the public understanding of science, with particular focus on girls and women.

Recommendations

- The InterAcademy Panel is requested to establish a website for women in science that contains this report, supporting references, and links to other websites with resources for women scientists and engineers. The InterAcademy Panel may want to consider a multimedia approach for increasing the public understanding of science, with focus on girls and women.
- The InterAcademy Panel is encouraged to coordinate with other organizations—the Academy of Sciences for the Developing World (TWAS), the Third World Organization for Women in Science (TWOWS), and UN organizations such as UNESCO and UNCSTD Gender Advisory Board—on the acquisition and dissemination of sex-disaggregated data as well as the development of a global strategy to establish gender equity throughout the S&T community.
- Academies that have successful programmes for facilitating the entry and advancement of women in science and technology need to share their good management practice methods and develop partnerships with less-experienced counterparts elsewhere.
- The InterAcademy Council and the InterAcademy Panel are urged to develop and formally adopt statements of good management practice (aimed at the inclusion of women) and to pay attention to the gender implications of the studies they undertake and the reports they publish.
- The InterAcademy Panel is asked to feature at its general assemblies a report from each academy on its progress toward remedying the underrepresentation of women in science and technology. Furthermore the InterAcademy Panel needs to encourage each academy to maintain an ongoing advocacy position on gender-equity issues, particularly when meeting with high-level government and education officials.

6. Summary: actions for academies

It is important that each of the world's science and engineering academies develop strategies for implementing the recommendations of this report. These strategies must necessarily be customized, as each academy performs a different set of functions as a result of its own and its country's history.

Thus the Advisory Panel presents below a summary of the report's recommendations grouped according to the most prominent of those functions. Each academy can then select action points that fit its particular profile.

Science and engineering academies as honorific societies

All academies in the world share the characteristic that they honour the achievements of eminent scientists and engineers. The Advisory Panel recommends that they take the following steps to become societies hospitable to and inclusive of women scientists and engineers:

- **Put gender issues on the agenda**
  Some academies have appointed a person or created an office responsible for gender-equity issues. Preferably, a committee with responsibility for diversity—and that reports directly to the academy leadership—is to be established. That committee should enlist academy members, women and men alike, committed to women's full inclusion. Working with the president and council, it charts a course of action, and regularly monitors progress.
- **Increase the number of women academy members**
  A fundamental way of increasing the membership of women is by widening the nomination pool of eligible women scientists and engineers. The academy president leads by reminding members of the need to correct women's low representation and by proposing initiatives to enlarge it. The diversity committee complements the president's efforts by, among other things, collecting and distributing names of eligible women candidates to nominating committees.

- **Increase the visibility of women scientists and engineers**
  Academies are asked to include women among the scientists and engineers they portray in their publications and websites, recognize them at academy events and invite them to make presentations, and pay attention to gender balance on speakers' platforms.
- **Offer awards, grants, and fellowships**
  The Advisory Panel asks that academies encourage the nomination of women scientists and engineers for prestigious awards and that they explicitly call, in their announcements of grants and fellowships, for nominations of women, encourage them to apply, and ensure that there is gender balance on the decisionmaking juries.

Academies as advocates of global capacity building

A public commitment and sustained effort by the academies is needed so that grassroots women throughout the world may, in full partnership with men, acquire the skills for building their countries' capacities in science and technology.

- **Knowledge centres**
  The Advisory Panel asks academies to advocate and participate in the establishment of science and technology 'knowledge centres' for women in rural areas and urban enclaves. These centres provide training in S&T-based skills for local applications. Training in information technology and access to the Internet are essential elements in this process.
- **Educating S&T professionals**
  Academies are urged to advocate for and support the higher education of women in science, engineering, and industrial management, including entrepreneurship. Some of these women, associated with regional research institutes, may in turn train rural women in their own cultures through links to local knowledge centres.
- **Networking**
  Academies are asked to support collaborations between developed and developing countries that give women scientists, engineers, and S&T students the opportunities to acquire contacts, build networks, and generally gain greater access to new learning opportunities.

Academies as employers

Most academies employ staff—and in some cases manage sizeable in-house operations—that function in a culture largely dominated by men.

The institutional climate needs to be transformed into one that expects both women and men employees to perform to their full potential for the benefit of the organization.

- **Commitment at the top**
  An academy's working environment can be transformed only if top management, convinced that including a variety of talents, perspectives, and experiences is a worthwhile organizational goal, commits to acting accordingly.
- **Creating an inclusive working environment: Good management practice**
  The organizational transformation to an inclusive culture uses the tools of good management practice described in Chapter 2. Conditions for hiring, promotions, and awards must be made clear. Women need to be included in networking to end their isolation. The decisionmaking inner circle is gradually widened through attracting and preparing women for leadership. Both women and men employees deserve a healthy work-family balance.

Academies as sponsors of research and as evaluators of research institutes

- **Establishing criteria**
  When performing reviews of research institutes, panels should preferably consist of both women and men. Working conditions of women researchers need to be among the evaluation criteria.
- **Gender in scientific research**
  Academies that fund research must require that the researcher considers the differentiated impact of the work on women and men and ensures that the results are not biased by the sex of the researcher. Evaluation panels are required to assess whether gender issues have been adequately addressed. Granting organizations must analyze whether their funding allocations are distributed to women and men researchers without bias.

Academies as national advocates for education, science, and engineering

Many academies have formal roles as advisers to government, while others may be able to influence government—as well as other sectors— by virtue of the prestige their institution carries.

- **National office**
  Academies are asked to advocate for a national office that facilitates the entry and participation of women professionals in fields, such as science and engineering, traditionally dominated by men.
- **Public awareness**
  Academies are urged to emphasize that raising public awareness of science and technology is important to all aspects of society.
- **Educational reform**
  The Advisory Panel asks that academies advise government education agencies on reforms—in textbooks, teaching materials, exams, and career counselling—to remove gender bias.
- **Eliminating barriers to full inclusion**
  Academies are asked to advocate that governments remove barriers to the education and employment of women scientists and engineers, and redress women's underrepresentation; and that work and family responsibilities be balanced by a variety of measures, from child-care facilities to flexible work schedules.

Academies acting in concert

- **Global coordination**
  The InterAcademy Panel is encouraged to coordinate with other organizations, such as the Academy of Sciences for the Developing World (TWAS), the Third World Organization for Women in Science (TWOWS), and UN organizations, such as UNESCO and UNCSTD Gender Advisory Board, for implementation of the recommendations in this report. In particular, the InterAcademy Panel might want to work with UNESCO in two ways: establishing global indicators and the standardized compilation of sex-disaggregated data; and developing a global strategy to establish gender equity throughout the S&T community.
- **Dissemination**
  The Advisory Panel recommends that the InterAcademy Panel make use of various means of communication, such as S&T-friendly radio and television programming, for increasing the public understanding of science, with particular focus on girls and women. The Advisory Panel also requests that the InterAcademy Panel establish a website for women in science and engineering. In addition to providing an important bridge to the many other related sites on the Internet, the InterAcademy Panel website will help share information about varied

gender-equity programmes around the world. For example, the large amount of material reviewed in the preparation of this report should be made accessible for academies and the wider women-for-S&T community.

Statement of commitment

Academies across the world are requested to approve, and formally adopt, a statement of their commitment to the full inclusion of women in their organizations and throughout the S&T community. A sample for their consideration is given in Box 6.1.

A better future is within our reach—if we all take part

Women must become active and valued participants—full and equal partners with men—in the science and technology enterprise, as well as in the transfer of knowledge and skills to areas where the need for such skills is greatest. This must happen not only because it is their right, but also because women's contributions to scientific and technological advances are essential. In addition, women are urgently needed to help enlist their sisters at the grassroots in the ongoing knowledge transformation of the world.

As this past century has seen the gradual erosion of rigid views about which gender does what jobs, women have proved their mettle in many fields. Women have taken their places at all levels of government, they are no longer rarities among university professors (as well as university presidents), they are surgeons and astronauts, and are increasingly found in company boardrooms and other traditionally male bastions.

Thus women have strikingly confirmed their intellectual abilities and wide range of skills. It is now time to eliminate the remaining obstacles that keep women from becoming fully involved in the vital work—including leadership—of science and technology innovation and global capacity building. Academies must lend their prestige and resources to accelerating the inclusion process. The world cannot afford to wait another century for this to happen.

Sample commitment statement for academies. **Box 6.1**

The president and council of the academy commit to full inclusion of women in science and technology. The academy will:

- Adopt good management practice—tools for inclusiveness—in its institutions, and advocate such practice across the S&T community.
- Establish a committee that addresses gender issues, monitors progress, and ensures follow-up
- Promote women members to decisionmaking levels and include them in panels and committees.
- Increase the number of women scientists in the nomination pool for membership, prizes, and awards.
- Give visibility to women scientists, and represent women in the academy's portrayal of science.
- Pay attention to gender implications of research sponsored or evaluated by the academy.
- Ensure that the criteria for evaluation of research institutes include organizational culture.

Annex A. Advisory Panel biographies

Co-chairs

Johanna (Anneke) LEVELT SENGERS is a native of the Netherlands, where she obtained her Ph.D. in physics at the University of Amsterdam. She joined the U. S.A.'s National Institute of Standards and Technology (NIST) in 1963, where she is presently a scientist emeritus. Dr Levelt Sengers' main professional interest is fluids and fluid mixtures. She was a Group Leader at NIST from 1978 to1987 and a NIST Fellow from 1983 to1995. She is past President of, and was the U.S.A.'s representative to, the International Association for the Properties of Water and Steam. A member both of the U.S.A.'s National Academy of Sciences and National Academy of Engineering, Dr Levelt Sengers is a corresponding member of the Royal Netherlands Academy of Arts and Sciences. She has received an honorary doctorate from the Technical University Delft, Netherlands, and was the 2003 North American Laureate of the L'Oréal-UNESCO 'For Women in Science' Awards.

Manju SHARMA is the President and Executive Director of the Indian Institute of Advanced Research, Gandhinagar, Gujarat, India. She is a former Secretary to the Government of India for the Department of Biotechnology. Responsible in this post for boosting the development of biotechnology in India, she set up many new research institutes and spread the educational network for biotechnology all over the country. She has initiated major programmes for the inclusion of women in science and technology. Dr Sharma has received honorary doctorates from many universities in India, as well as many national and international awards. She was the first female President of India's National Academy of Sciences. She is a member of the Board of Governors of the United Nations University's Institute for Advanced Studies, a member of the Advisory Panel on Agricultural Biotechnology of the U.S.A.'s Agency for International Development, and a Fellow of the Third World Academy of Sciences.

Advisory report panelists

Ken-ichi ARAI received his M.D. in 1967 from the University of Tokyo and his Ph. D. in biochemistry in 1974 from the same university. Dr Arai worked for the University of Tokyo before moving to the U.S.A. to join the DNAX Research Institute of Molecular and Cellular Biology and the faculty of Stanford University. He is presently Emeritus Professor of the University of Tokyo and a visiting professor at four different universities. Dr Arai was one of the founders of the Asia-Pacific International Molecular Biology Network and served as its President for the first five years. He is a member of the Executive Committee of the International Union of Biochemistry and Molecular Biology, serving as chair of Networking Industrial Relationship and Biotechnology. Always a strong advocate of promoting women in science, the fact that Japan's academic institutions now have women professors is due in large part to his efforts.

Jocelyn BELL BURNELL retired in 2004 from a three-year deanship at the University of Bath and is currently a visiting professor of astrophysics at the University of Oxford. As a graduate student at Cambridge University she discovered pulsars, and later worked at the University of Southampton, University College London, and the Royal Observatory in Edinburgh. Dr Bell Burnell has received numerous awards—including the Oppenheimer Prize, the Michelson Medal, the Tinsley Prize, and the Magellanic Premium (all from learned bodies in the U.S.A.) and the Herschel Medal from the U.K.'s Royal Astronomical Society—and she is much in demand as a public speaker. In 1999 she toured Australia, giving the Women in Physics Lecture. Dr Bell Burnell recently completed a term as President of the Royal Astronomical Society, is a Fellow of the Royal Society, and has been elected a Foreign Member of the U.S.A.'s National Academy of Sciences.

Ayse ERZAN is Professor of Physics at the Istanbul Technical University and a Researcher at the Feza Gursey Institute for Basic Science. Her research has long been in statistical physics, which she has more recently been applying to biological problems. She is involved in ethics, human rights, and science-education initiatives. Professor Erzan is a member of the Turkish Academy of Sciences. She received the Turkish Scientific and Technical Council Science award in 1997 and was the 2003 European Laureate of the L'Oréal-UNESCO 'For Women in Science' Awards.

Nancy IP has been on the faculty of the Hong Kong University of Science and Technology since 1993, and is currently the Head of Biochemistry and Director both of the Biotechnology Research Institute and the Molecular Neuroscience Centre. Known for her work on neuronal

signal transduction and neurodegenerative diseases, she holds 14 patents and her 150 publications have received more than 11,000 citations. Professor Ip obtained her Ph.D. from Harvard University and has seven years of industrial experience in the U.S.A. A founding member of the Asian-Pacific International Molecular Biology Network, she has garnered numerous honors; for example, Professor IP won the National Natural Science Award (2003) and was the 2004 China Laureate of the L'Oréal-UNESCO 'For Women in Science' Awards. She has also been elected as Academician both of the Chinese Academy of Sciences (2001) and the Academy of Sciences for the Developing World (2004).

Lydia MAKHUBU is Professor of Chemistry at the University of Swaziland. She has served on numerous consulting bodies and professional societies, was President of the Royal Swaziland Society of Science and Technology, and is a Fellow of the African Academy of Sciences and President of the Third World Organization for Women in Science.

Armando PARODI is a Laboratory Head and Professor at the Fundacion Instituto Leloir, Buenos Aires, Argentina. Well known for his research on protein structure, he has worked at the Institut Pasteur in Paris, the U.S.A.'s Duke University, and the University of Rio de Janeiro, Brazil. Dr Parodi, a Foreign Associate of the U.S.A.'s National Academy of Sciences, served on the Jury of the 2004 L'Oréal-UNESCO 'For Women in Science' Awards. He is highly regarded for his knowledge of the situation of women scientists in Argentina as well as throughout Latin America.

Anne STEVENS is the first female Executive Vice President in the Ford Motor Company's history and the highest ranking woman in the automotive industry. Elected in October 2005 to her post of Executive Vice President and to that of Chief Operating Officer for the Americas, she will lead the Company's core operations, including product development, manufacturing, and purchasing, in that region of the world. Prior to becoming Chief Operating Officer, Ms Stevens was Group Vice President for Canada, Mexico, and South America. Earlier in her career at Ford she worked in the U.K., at a time when women engineers were virtually unknown in Europe. Thus she has experienced first-hand, and on three continents, the barriers faced by women engineers. Ms Stevens has been named four times to *Fortune* magazine's list of '50 Most Powerful Women in Business.' She was elected to the Board of Directors of Lockheed Martin in 2002. Ms Stevens is a member of the U.S.A.'s National Academy of Engineering.

Jennifer THOMSON is Professor of Molecular and Cell Biology at the University of Cape Town, Republic of South Africa. She develops genetically modified plants and is an adviser to the Council for Biotechnology Information in the U.S.A. Professor Thomson is cofounder of the Association of South African Women in Science and Engineering and since 2003 has been Chair of the Board of the African Agricultural Technology Foundation. A member of the Council of the Academy of Sciences of South Africa, she was the 2004 African Laureate of the L'Oréal-UNESCO 'For Women in Science' Awards. In 2005, Professor Thomson received an honorary doctorate from the University of Paris.

Annex B. Glossary

Diversity: Characterizes a group marked by visible and non-visible differences between its members—such as sex, race, sexual orientation, age, and religious belief—that enrich their mutual interaction.

Equal treatment: Treating women and men in the same way, such as offering equal pay for equal work. Does not account for differences in employment characteristics of women and men.

First faculty positions: Posts in higher education filled by those who are academically young—i.e., have modest publication records.

Gender: The social differences between women and men that are learned, evolve over time, and vary between countries and cultures. For example, women give birth (biologically determined), but biology does not determine who raises children (gendered behaviour).

Gender blindness: Completely ignoring the gender dimension in setting policy, with the consequence that the policy usually benefits men over women (given that men are already in the majority).

Gender equal: Human beings are free to develop their abilities and make choices, with no limit set by gender roles.

Gender sensitive: Being aware of differential impact of customs, policies and practices on women and men.

Glass ceiling: Invisible barrier that prevents women from rising to the top levels of organizations.

Horizontal gender segregation: The differential concentration rates, by gender, in certain occupational sectors or disciplines.

Inclusiveness: An organizational culture in which all members of a diverse work-force contribute to the organization to the best of their ability. In the present context, this implies a gender-sensitive and gender-fair environment.

Leaky pipeline: The gradual loss of women from the science career path, even if women and men go into higher education in equal numbers.

Positive (or affirmative) action: An incentive to an underrepresented group in order to redress any disadvantages.

Positive discrimination: Choosing a person from an underrepresented group, regardless of whether they are the best person for the activity or post.

Sex: The biologically determined difference between women and men.

Sex-disaggregated statistics: Statistics separated out by sex.

Vertical gender segregation: Differentials in the positions of women and men within the hierarchies of a field.

Annex C. Abbreviations and acronyms

CAWMSET	Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology
CGIAR	Consultative Group on International Agricultural Research
CONICET	National Research Council Argentina
ETAN	European Technology Assessment Network
FREJA	Female Researchers in Joint Action
GAB	Gender Advisory Board of UNCSTD
IAC	InterAcademy Council
IAP	InterAcademy Panel
INSA	Indian National Science Academy
IUPAC	International Union of Pure and Applied Chemistry
IUPAP	International Union of Pure and Applied Physics
MIT	Massachusetts Institute of Technology
NAE	National Academy of Engineering, United States
NAS	National Academy of Sciences, United States
NAST	National Academy of Science and Technology, Philippines
NCW	National Council for Women, Egypt
OECD	Organization for Economic Co-Operation and Development
S&T	Science and technology
SET	Science, Engineering, and Technology
TWAS	Academy of Sciences for the Developing World
TWOWS	Third World Organization for Women in Science
UNCSTD	United Nations Commission on Science and Technology for Development
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNICEF	United Nations Children's Fund
WEPAN	Women in Engineering Programs and Advocates Network
WIEP	Women in Engineering Program
WinSETS	Women in Science and Technology Scoreboards
WISE	Women into Science and Engineering

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Annex F. Web sources of information

All links were correct at publication time. Because of the nature of the Internet, no responsibility can be taken for a broken or changed URL over time.

Education

Association in Support of Contemporary Living, Turkey — **www.ataturksociety.org**
Computer Clubs for Girls, U.K. — **www.cc4g.net**
CYDD, Turkey — **www.cydd.org.tr**
Ecsite, U.K. — **www.ecsite-uk.net/index.php**
Engineergirl, NAE, U.S.A. — **www.engineergirl.org**
Iwaswondering, NAS, U.S.A. — **www.iwaswondering.org**
National Childcare Strategy — **www.odpm.gov.uk**
National Children's Strategy, U.K. — **www.nco.ie**
Pathmakers for careers guidance in Canada — **www.carleton.ca**
Science in Africa — **www.scienceinafrica.co.za**
Science, Engineering, Technology, and Mathematics Network — **www.setnet.org.uk**
Supreme Council of Universities, Egypt — **www.scu.eun.eg**
Taking a leading role – careers advisers' survey — **www.royalsoc.ac.uk**
Turkey Educational Volunteers Foundation (TEGV), Turkey — **www.tegv.org.tr**
UNESCO-IUPAC microscience experiments — **portal.unesco.org/education**
UNICEF Girls' education — **www.unicef.org**
UNICEF Programs in Turkey — **www.haydikizlarokula.org**

Organizations and initiatives relevant to women and science

All-China Women's Federation — **www.women.org.cn/english/index.htm**
Association for Women in Science — **www.awis.org**
Association of South African Women in Science and Engineering — **www.sawise.org.za**
Athena Project — **www.athenaproject.org.uk**
CGIAR — **www.genderdiversity.cgiar.org**
European Association for Women in Science, Engineering and Technology — **www.setwomenexperts.org.uk**
FREJA — **www.cyborgs.sdu.dk**
Global Alliance — **www.globalalliancesmet.org**
International Network of Women Engineers and Scientists INWES — **www.inwes.org**
IPAZIA – UNESCO — **www.womensciencenet.org**
National Institute for Supporting Women in Science and Technology, Korea — **http://english.wist.re.kr**
Purdue University Women in Engineering Program — **www.engineering.purdue.edu**
Third World Organization for Women in Science — **www.twows.org**
U.K. Resource Centre for Women in Science, Engineering and Technology — **www.setwomenresource.org.uk**
Women in Global Science and Technology (WIGSAT) — **www.wigsat.org**

Women in Japan Physical Society — **www.aapps.org**
Women, Science and Technology in Latin America — **www.catunescomujer.org**

Science organizations

American Association of Engineering Societies — **www.aaes.org**
American Institute of Physics — **www.aip.org**
American Physical Society — **www.aps.org**
American Institute of Physics — **www.aip.org/statistics**
Argentine National Research Council for Science and Technology — **www.conicet.gov.ar**
InterAcademy Council — **www.interacademycouncil.net**
International Astronomical Union — **http://proceedings.aip.org**
International Union of Pure and Applied Physics — **www.iupap.org**
National Academy of Sciences — **www.nationalacademies.org**
Nobel Foundation — **http://nobelprize.org**
Royal Society of Chemistry — **www.rsc.org**
Royal Society of London, U. K. — **www.royalsoc.ac.uk**
Science Council of Japan www — **scj.go.jp**
TWAS The Academy of Sciences for the Developing World — **www.twas.org**
U.S.A. Food and Drug Administration — **www.fda.gov**

Science communication

AlphaGalileo — **www.alphagalileo.org**
EuroPAWS — **http://europaws.merzagora.net**
National Academies Press — **www.nap.edu**
PAWS — **www.pparc.ac.uk**
UNESCO-IUPAC — **http://portal.unesco.org**
Warintek Multipurpose Community Telecenters — **http://portal.unesco.org**

Sustainability

China's strategies for relieving poverty — **www.help-poverty.org.cn**
M.S. Swaminathan Research Foundation — **www.mssrf.org**
UNESCO — **http://portal.unesco.org**

Women and equality

ADVANCE — **www.nsf.gov/advance** and **www.engr.washington.edu/advance**
AT&T Labs internships — **http://public.research.att.com**
Beijing + 10 — **www.un.org**
Beijing + 5 — **www.un.org**
Beijing Conference on Women — **www.un.org**
Dartmouth College, New Hampshire internships — **www.dartmouth.edu**
Genderdax — **www.genderdax.de**
Max Planck Society — **www.mpg.de/english**
Maximising Returns — **www.setwomenresource.org.uk**
Natural Sciences and Engineering Research Council of Canada — **www.nserc.ca**
United Nations Commission on Science and Technology for Development/Gender Advisory Board — **http://gab.wigsat.org**
Women Scientists Programs, Department of Science and Technology, India — **http://dst.gov.in**

Reports and resources on women in science and industry

European Commission, Women in Science — **www.cordis.lu**
MIT Report — **http://web.mit.edu**
National Science Foundation — **http://www.nsf.gov**
U.K. Resource Centre for Women in SET — **www.setwomenresource.org.uk**
Women in Physics, IUPAP — **http://proceedings.aip.org**
Women Scientists in Industry, Catalyst — **www.catalyst.org**

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Page 54: Within the framework of 'Engineers without Borders', students of Engineering Professor Deborah Goodings, University of Maryland, USA, work with women of the Lisu tribe in Thailand to construct a sustainable wastewater treatment system for the Samli Health Clinic. Photo courtesy of Deborah Goodings.
Page 60: Nancy IP, Professor of neuroscience, consults with her collaborators. She is head of the Department of Biochemistry, and director of the Biotechnology Research Institute and the Molecular Neuroscience Centre of the Hong Kong University of Science and Technology, Hong Kong. Photo courtesy of Sam Mattingly/L'Oréal USA. Copyright Micheline Pelletier/Gamma.

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5.At the French Olympiads a team of five female high school students from Saint Vincent de Tyrosse, a small town in Southern France, won first prize in the category of sustainable development for their solar engine (Stirling motor). Image reproduced by permission of Prof. Brézin, president of the French Academy of Sciences

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