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.