Women in Science:
Issues and Actions

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Le nombre des femmes dans les domaines de science, d'ingénierie et de technologie, est insuffisant au Canada comme ailleurs. On ne saisit que mal les raisons de cette situation, et les actions qui pourraient y remédier sont remises à plus tard, alors qu'on continue à planifier et à faire de plus en plus d'études sur ce sujet, sans tenir compte, apparemment, d'un ensemble assez vaste d'information déjà acquis au cours des dernières années. Pourquoi les femmes sont-elles continuellement exclues d'une participation égalitaire au domaine scientifique? Pourquoi les études déjà faites sur cette situation n'ont-elles apparemment aucune valeur? Certaines solutions déjà préconisées devraient et pourraient être immédiatement mises en oeuvre. Il reste cependant certaines questions importantes à analyser en profondeur si nous voulons atteindre le but fixé.

INTRODUCTION

In the September 30, 1983 issue of *Science* an editorial by C.T.Bruer, entitled "Women in Science: Lack of Full Participation," presented a number of key recommendations which issued from a symposium on the present status of women in the United States. The editorial noted the significant advances made by women in the last decade in the pursuit of science at the level of higher education, post-graduate studies, and post-doctoral training. It suggested that the major efforts put into providing real equality of opportunity and of access for women to the level of first entry into a working position in science had paid off. The strategies employed, at least in part, derived from civil-liberties legislation and included affirmative-action programs (2-9).*

The editorial expressed wonderment and dismay that the march of women into science seemed to be coming to a halt at the first-employment level. In asking why and how to address this problem, the author focussed on the following: the "tenure impasse" which confronts women because of an apparent "productivity gap" and a perceived discrepancy between their success rate and that of their male colleagues; the mechanisms by which women and men "choose career development pathways"; and the way women "react to setbacks" in their lives. He suggested that we need more information about these processes so that we may devise effective remedies to buttress a "commitment to act . . . to improve women's status in science." Such a commitment needs nurturing in our society to bring it to the full flowering, without which women's progress will continue to be impeded.

The editor correctly placed the relevant investigations in the domain of the social sciences and humanities. He suggested that "the methods of sociology, psychology and history . . . should be brought to bear on all these questions."

THE INTELLECTUAL DILEMMA: WHICH SCIENTIFIC DISCIPLINES SHOULD ADDRESS THE PROBLEMS OF WOMEN IN SCIENCE, ENGINEERING, AND TECHNOLOGY?

We cannot quarrel with the recommendations of the *Science* editorial. However, it is critically important to recognize that the problems raised therein have been under investigation, in one form or another, for some 100 years, i.e. since women first began to practise the professions of science, engineering, and technology (SET)** (10-19). Data has been collected and analyzed; conclusions, hypotheses, and proposals for further study and action have been formulated. And yet the great body of knowledge accumulated remains largely unknown and/or unrecognized by so many in the infra- and superstructure of SET. Why should this be so?

Perhaps one answer lies in the fact that the scholarly articles which address the topic of the status of women in SET are most often written by women who, in the face of counter evidence (12, 14, 15, 17-30), are still considered to be biassed and non-rational. A second answer may be that this body of knowledge is largely to be found in publications of the social sciences, the humanities, and education, which are rarely read by those who practice SET. The relevant studies use the tools of sociology, history, ethology, anthropology, behavioural sciences, and educational philosophy and practice, i.e., the methodology of the so-called "soft sciences," automatically held suspect by those of us who practice the "hard sciences" of SET.

There is a third possibility. It is that these investigations focus incisively on women and their entry into, or exclusion from, SET. They address the very

issues raised by the *Science* editorial – how girls choose to enter or avoid a career in SET; how the family, society, and the educational process intervene; how women select career-development pathways; and how they react to setbacks imposed from within and without. Such studies generally appear in the pages of books and journals which are classified under the heading of "Women's Studies," a discipline still fighting for acceptance as a legitimate scholarly pursuit (21, 23-28). Sometimes critical information appears in government documents and other special reports which may never receive widespread dissemination (31-47). Rarely is the material validated by and for the practitioners of SET by publication in their peer-reviewed, scholarly journals. Those articles which do appear are likely to be in the form of editorial comment (48-66) rather than scholarly analyses (67-81).

WHAT ARE THE KEY PRAGMATIC PROBLEMS FOR WOMEN IN SET?

a) "Is Science Male?" (82, 83)

My own observations (84-87) and those of many others (2, 5-8, 11, 17, 20-30, 32, 33, 36-39, 42-47, 49, 51, 52, 55, 56, 58, 60, 62, 64, 66, 68-70, 73, 75-79, 81-83, 88-127) suggest that there are two global phenomena which contribute to the present unsatisfactory status of women in SET. The first is that SET as practised today is still populated largely by men, in hierarchical structures which continue to exclude women. These structures were developed historically (5, 6, 8, 9, 11-15, 17, 20, 24, 28, 37, 38, 44, 46, 54, 60, 62, 66, 68-83, 87, 89, 91, 94, 96-123) for the practitioners of the day, who were indeed men. It is therefore not surprising that the infrastructure, the superstructure, and the institutions put in place have often not provided a hospitable or supportive environment for the women scientists and engineers who have come knocking at their doors in ever-increasing numbers in the last quarter-century (11, 15-17, 30, 42, 45, 47, 54, 67, 73, 74, 81, 88, 96, 109, 128-133).

The second major phenomenon of relevance is the upbringing and attendant socialization of women and men by society, which fosters prejudicial thinking and behaviour evolved in bygone eras. In general this means that women are not encouraged to consider a career in SET (cf. 17, 30, 34, 35-39, 44, 82-87, 91, 93, 96-101, 103, 110-121, 123-125). They are not taught, nor do they learn, the skills for entry into any profession which is largely populated by men (8, 17, 28-30, 38, 39, 44, 64, 66, 68, 69, 75, 79, 84-87, 91-94, 97-101, 103, 113, 114, 123-127, 134-140). Finally, the joint sexual indoctrination of women and men by society ensures that women will be excluded from the key science networks, which function in every way like the apocryphal "Old Boys' Networks" (8, 30). We women scientists may try to enter a Man's World, but we will not readily be accepted as one of the Boys.

It is against this background that we must examine the very real phenomena of tenure impasse and the apparent productivity gap, the conventional and non-conventional patterns of selection and movement along career-development pathways, and the reaction to setbacks, which currently await a majority of women who move into SET. They should be analyzed within the framework of the hierarchical exclusive ow women from almost all policy-making and implementing structures within our societal institutions, including those of SET.

In this context it would be instructive for us to understand why women are now moving so rapidly into medicine (54, 55, 57, 59, 61, 71, 79, 129, 141-151), pharmacy (152), law (153-156), and more recently dentistry (157). A comparison of these situations with those of women in the "natural sciences" (cited above), the "physical sciences" (cited above), mathematics (14, 17, 18, 29, 30, 37, 39, 56, 64), and the engineering professions (15, 30, 77, 93, 131-133, 158-166) would be most fruitful. The study begs for an analysis of the major impact of the political and social movements for civil liberties, for equality of opportunity, equality before the law, and for human rights throughout the world, but more particularly in our closest neighbour the United States, which has often provided precedents for Canadian thrusts.

Close scrutiny of the most recent wave of feminism in Canada, especially as it has affected SET, is indicated. This began with World War II (167), which itself became a cause in the struggle for human rights and freedoms. An important outcome was the group of women veterans who chose to obtain higher education and professional training. Significant numbers of these women, along with their male ex-military colleagues, from sectors of society previously denied access to career-development opportunities of this kind, were enabled to pursue such goals through special legislation and funding.

These events were followed by the most recent swell of feminism and other struggles for human rights, to yield the growing cadres of women physicians, lawyers, engineers, and other professionals of today and tomorrow. They can, if they so choose, practise their professions with intellectual and functional freedom, outside the more usual strictures of exclusion imposed by the still male-dominated, hierarchical structures found in the analogous academic domains. The "different voice" of women (168) is perhaps an important factor contributing to their success in the free-standing professions.

b) The Real Tenure Impasse and the Apparent Productivity Gap

If we are to solve the problems facing women in science, it is essential that they be defined accurately, so that the appropriate solutions can be put in place creatively. What is the subtext underlying the terms 'tenure impasse' and 'productivity gap,' which are said to impede the progress of women into science? These define outcomes of criteria of excellence and performance developed and applied by the guilds of science. It is appropriate to inquire into how these criteria are derived and applied.

Clearly they are established by the members of the science community. Perhaps more to the point is the fact that the superstructure (i.e., the academic, industrial, and government bodies which determine the policies which are the ethos of science) and the infrastructure of SET (i.e., those who implement or practise the policies) still remain populated almost exclusively by men. These groups decide what is excellent and what are the norms of productivity. Indeed, excellence and productivity often go hand in hand in any assessment exercise.

Usually 'the tenure impasse' and 'the productivity gap' are considered to be problems afflicting women in academia. Although precise analogies are sometimes not tight, the same general princi-

ples apply to industry and government and frequently to the applied professions of science, which are collectively classed under the term 'engineering.'

In examining these, it is important to consider that, even today, most members of the SET professions have been able to devote a major proportion of their lives to the pursuit of their careers because they were carried by an extensive support system which functions in all of their other life activities (169). These individuals define and impose the guidelines which determine who shall leap over the abyss of 'tenure impasse.'

Leaving aside the factors which have established SET as a hierarchical network of Old Boys, it is crucial that we understand why and how the latter functions. This kind of network has been evolving over many centuries to support and entrench the group of interest. It self-selects on the basis of criteria which self-define. Thus the time frame and the other dimensions of productivity in SET are established by those who have practised the professions in the past. The "peers" by whom we are judged have themselves fulfilled the criteria of the group, or they have already re-defined them to accommodate themselves. If the criteria and/or those who establish them become rigid, self-seeking, and self-serving, the phenomena of 'tenure impasse' and 'productivity gap' are a natural outcome for women in science.

As already noted, our society raises its girls and boys so that they will inhabit separate spheres as adults. The sexual imperatives of our society militate against bonding amongst men and women beyond the limits set by "the family" in all its newly emerging guises (170-176). It is therefore not at all surprising that women are excluded from all "Old Boys' Networks," including those which operate in and sustain the status quo in SET. By their very sex, women can never totally fulfil criteria established by an "Old Boys' Network."

This becomes very clear when we examine the career-development pathway set out as the norm for those moving into SET. In Canada the direct route begins ostensibly at sixteen to twenty years of age, at entry into higher education. It rolls in through the B.Sc. or B.A.Sc., to the M.Sc. or the M.A.Sc., on to the Ph.D. and often through post-doctoral studies, bringing us to age of twenty-eight to thirty-two. These very crucial years of fundamental training, of mentor-bonding, and of stepping onto the lowest rungs of the ladders of success are the very same years of optimum productivity for those women who choose also to establish other bonds in life and to reproduce our humankind.

Our society, which gives lip-service to supporting the reproductive capacity of women, provides little reward for this activity of women in SET. Indeed, to a greater or lesser degree, it penalizes women in SET who also choose to devote time and energy to family life, child-bearing, and child-rearing. The infra- and superstructures of the SET community assume that the latter choice is somehow incompatible with excellence in the performance of a SET profession. This kind of conventional, prejudicial thinking contributes to the two related phenomena of the real tenure impasse experienced by women in science and their perceived productivity gap.

Recent data accumulated in scholarly publications (15-20, 28-31, 35, 40, 42, 45-48, 54, 57, 60, 67, 70, 72-78, 81, 88, 90, 96, 109, 126, 127-133, 141, 145, 147, 149, 151, 159, 160, 163, 164-166), by educational bodies (21, 25, 31-35, 37-40, 46), by the Medical Research Council of Canada (45), the Natural Sciences and Engineering Research Council of Canada (42), and the Social Sciences and Humanities Research Council of Canada (47) are of special significance. They reveal that women who elect to be scientists and engineers and who are permitted to function equally when compared with their male colleagues (e.g., by being provided equal-dollar funding), do so with great success. Indeed, they are often more productive, on the basis of such parameters as grades, successful completion of a training program, and their individual publication record (the latter sometimes requiring assessment outside the conventional time frame). Thus women in SET usually have little difficulty fulfilling those guild requirements which stem from the real pursuit of any discipline. The so-called productivity gap derives from parameters of success which have to do with the ethos of SET imposed not by the disciplines but by the practitioners within the guilds.

Society has, in recent years, assumed the stance that SET are populated by androgynous androids. When we accept the fact that scientists, engineers, and technologists are real people, women and men whose lives are multi- and not uni-dimensional, we shall be able to begin to address the problems which are defined by terms like 'tenure impasse' and 'productivity gap.' Some are easily addressed. Thus on-site daycare facilities, already shown to be so successful in the academic (177-179) and industrial workplace (180), should be mandatory in every institution of higher learning, to ensure that women and men can benefit equally without academic or financial penalty. The hidden agenda for implementation of such daycare is the acknowledgment that women in SET should, and will, be able to combine productivity in their training and professions with reproductive productivity.

Total success in achieving full participation of women in SET will require that the "Old Boys' Networks" give way to or develop into support systems for women and men. It will require revision of our educational system and our cultural socialization patterns.

THE CANADIAN SCENE FOR WOMEN IN SET

In Canada the wheels have been rolling slowly toward these goals, as evidenced by the following developments.

The Royal Commission on the Status of Women in Canada

The Royal Commission on the Status of Women in Canada, convened in 1967 by the Government of Canada, provided the initial impetus for recent events in its major report (181). It resulted, if belatedly, in the establishment of offices, bureaus, and departments of federal and provincial governments with a mandate to improve the lot of Canadian women generally. It saw the designation of cabinet ministers of federal and provincial governments who are responsible for action to improve the status of women in every sector of Canada life, including SET. It launched provincial grass-roots committees on the status of women. Most important, it helped to extend to Canadian women the joy, the confidence, and the trust which empowered them to accept responsibility for their own growth and evolution.

From these initial thrusts came the mass action of the non-governmental bodies such as the National Action Committee (182) and groups of women from across Canada, which resulted in the enshrinement of equal rights for women in the repatriated Constitution of Canada, signed into law in 1984. Most recently, as the level of sensitivity of the whole Canadian people has been raised, governments have begun to move from gentle persuasion (183) to affirmative action in legislation, which has proved so effective in other countries. It is with some pride that we are able to view these developments, particularly in the face of the recent political defeat of the Equal Rights Amendment action in the United States.

These political and social events are the backdrop against which we can begin to appreciate the specific developments which have impacted on women in SET in Canada.

Thrusts of the Science Council of Canada

The Science Council of Canada, as part of a greater analysis of science education in Canada, launched a very important study of the education of girls and young women throughout elementary and secondary school. This gave rise to a number of reports (38, 43, 44, 101) which shed remarkable light on how girls and boys choose careers in SET; how we as a society impinge on the process of selection of career-development pathways by girls and boys; how sexism, sex-stereotyping, and sex biases impede the movement of girls into mathematics, chemistry, and physics (essential to subsequent entry into SET); and how the educational infra- and superstructures contribute to these processes. If the recommendations of the Science Council of Canada are implemented in full, we will have come a long way to addressing two problems identified by the *Science* editorial as still ripe for solution – i.e., how choices are made in terms of career-development pathways and what determines reactions to career-development setbacks.

The Organization of Women in SET

In the last few years Canadian women have recognized that alternative support systems must be created in their world of SET, to offset their exclusion from the "Old Boys' Networks." It has been suggested that such exclusion is not due to errors of commission but rather to benign neglect. Two mechanisms have emerged to correct this situation. One is evident in the creation of free-standing associations of women in certain areas of SET. The other has taken the form of the establishment of a Standing Committee on the Status of Women in already-established professional societies of SET.

1982 saw the formation of SCWIST, the Society for Canadian Women in Science and Technology (184). In May, 1982, they convened the First National Conference for Women in Science, Engineering, and Technology (185) in their home locale of Vancouver. 1982 witnessed the emergence, in Toronto and environs, of CAWIS, the Canadian Association for Women in Science (186) an indigenous offshoot from a vibrant plant of origin in the United States (187). WISE, Women in Science and Engineering (188), was also organized in 1982 and is beginning to spawn chapters right across the country. WISE will host the Third Canadian Conference for Women in Science, Engineering, and Technology in Ottawa in 1985.

The foregoing are support networks established to achieve for women in SET the goals already attained by their male colleagues in traditional structures of SET. Very significant for the advancement of women in SET in Canada was the formation, in 1983, of WISEST, The University of Alberta Task Force on Women in Scholarship, Engineering, Science, and Technology, in the Office of the Vice-President of Research (189). This is a structure (with university financial support) whose purpose is to seek out any and all mechanisms to ensure equal participation of women scholars in SET and other domains in the University of Alberta. In May, 1984, WISEST hosted the (second national) Alberta Conference for Women in Science, Engineering, and Technology with the theme "Steps to a Scientific Career" (190).

Some universities (e.g., Carleton, Toronto, York) have established offices which report to the president on the status of women. It remains to be seen whether these will serve equally well the same purpose as that pursued so vigorously by WISEST.

The several organizations described above were put in place to provide support and to develop strategies and tactics to bring women in SET to equal status with their male colleagues. A major network of liaison has now been forged among SCWIST, CAWIS, WISE, and WISEST. These are linked with the Equal Opportunities Committee (EOC) of the Canadian Biochemical Society (CBS) (191), the Standing Committee on the Status of Women of the Canadian Psychologists' Association (CPA) (cf. 192), and the Canadian Association of Physicists, who have been trying to recruit women to physics in Canada for many years.

Status-of-Women Committees in Already-Established SET Professional Associations

In 1981 the CBS formed its Equal Opportunities Committee in response to a perceived need vis-à-vis women biochemists in Canada (193). The EOC is now in the process of establishing procedures which will ensure that the CBS fulfils its mandate to improve that status of women in biochemistry in Canada.

Of seminal importance for the present, and for the future, was the establishment of the Standing Committee on the Status of Women of the CPA. Within the framework of the discipline and the Association, the Committee developed a number of important policy statements. These and the deliberations of the Committee have been published (192, 194-210). They will undoubtedly serve as models and guidelines for all of us in Canada who strive for equality between women and men; for the uprooting and discarding of sexism, sex-stereotyping, and sexual harassment in the workplace.

Equally significant are those CPA policy statements which focus on the removal of implicit and explicit sex biases in the philosophy and practice of science. These guidelines are as important for such natural sciences as physiology, neurobiology, sexology, endocrinology, nutrition, behavioural sciences, and medical sciences as they are for psychology, history, sociology, comparative literature, economics, and industrial management, to name just a few of the social sciences and humanities. Clearly the policy statements of the CPA will serve Canadian women in SET well.

SUMMARY AND PERSPECTIVES

As pointed out by the *Science* editorial, it would indeed be a continuing "tragedy for women" in SET and a monumental "loss of intellectual power" for the immediate and more distant future, if we simply go on gathering data about what is obvious intuitively, which has already been documented voluminously (as indicated by the selected bibliography cited herein), and which continues to be unknown and/or ignored by the infra- and superstructures of SET. It is time for us, in Canada and elsewhere, to move into action. There is no doubt that some research remains to be done. The future directions of such research will emerge as we act on what we have before us. We must find mechanisms for moving the SET infra- and superstructures toward constructive, productive activity as soon as possible. One pathway along which change is indicated and desirable is that of education through elementary and secondary school. This has been drawn to our attention by the Science Council of Canada, which has issued reports recommending immediate action to government and those who develop and implement educational policy (cf. 38, 43, 44, 101).

We must evolve effective mechanisms for bringing together the various groups whose purpose it should be to provide real equal access of girls and boys to SET, i.e., practising scientists and engineers, science educators (from the nursery school to our advanced institutions of higher learning), sociologists, psychologists, government, industry, human-resource directorates, science-museum directors, the media, parents, and the non-scientific community. Together we should develop strategies and tactics for changing the structures and institutions of SET to accommodate women.

Of necessity these would address the fact that women bear children and, at the present time, carry primary responsibility for de facto child care (62, 85-87, 113, 172, 173-180). They would therefore emphasize implementation of measures to deal with the perceived productivity gap. These would include introduction of on-site, round-the-clock crèches, nurseries, and daycare facilities for young children, thereby recognizing the real time demands of a science career. They would provide for changes in the temporal framework of performance achievements, and they would encourage non-traditional career-development pathways. They would confront the problems of why and how women are excluded from the upper strata of societal structures, including those of SET, thereby addressing 'tenure impasse' and mechanisms for selection of career-development pathways. They would suggest how to effect real and constructive affirmative action and sex-stereotype avoidance (2-9, 30, 32-34, 49, 51-54, 57, 73, 81, 87, 94, 96, 101, 121, 126, 127, 130, 143, 144, 147, 148, 183, 192, 194-210) to bring women to equal status with men in all branches of SET.

By such actions we would respond to the request of the *Science* editorial to demonstrate "our commitment to act . . . to improve the status of women in science." More to the point, women

Photo: Ontario Women's Directorate Resource Centre

would begin to live the imagined in SET. They would contribute to, and share equally in, the major human intellectual activity which is science in its many guises. Canadian society, like all others, would then see the full flowering of its total human resource in a domain so crucial to its cultural, its economic, and its industrial survival (211).

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*The numbers in brackets throughout refer to items in a bibliography of 211 entries prepared by Dr. Sheinin to accompany this paper. Because of space restrictions, CWS/cf has been unable to reproduce this bibliography in its entirety. However, selections from the bibliography follow this article. Readers may request the full bibliography from *CWS/cf*; please send a stamped, self-addressed envelope.

**It is recognized that some professional activities of engineering and technology have received women more easily than others. The term 'SET' will be used here to describe science, engineering, and technology in academia and in the policy-determining structures of SET in government and industry.

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