WOMEN AND SCIENCE IN JAPAN

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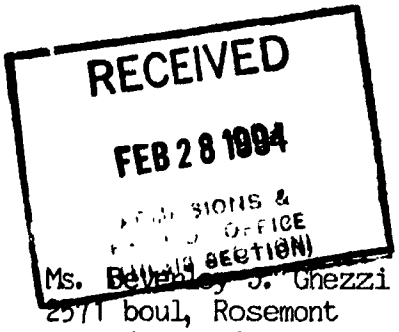

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Ms. Beverley J. Ghezzi
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February 10, 1994

Dear Ms. Ghezzi,

Thank you for your letter dated October 22, 1993. It has been long time since you studied here in Japan. Please forgive me for not writing you sooner. How are you doing these days? I heard a big cold wave hit Eastern Canada and I hope you and your family are not so damaged by it.

Answering to your question on copyright in the letter, I would like to inform you the copyright belongs to you and then you can cite from the material which is in our Bulletin. In that case please note our Bulletin of the Institute for Women's Studies No. 6 in the column of Work Cited or Bibliography.

I hope you keep doing your research successfully.

Sorry again for my late response.

Sincerely yours,

Hiroko Hara

Professor in Anthropology
and Women's Studies,
Institute for Women's Studies,
Ochanomizu University

Dedicatiсn

To Bill, who suggested the M. A., and Hanniel,

who waited patiently

for it to be completed.

Acknowledgments

Academically, I wish to acknowledge the help of a number of persons without whose help and expertise this thesis could not have been complete. Most immediately, the following come to mind:

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Professor Eri Yagi, of the Faculty of Engineering of Toyo University in Saitama, Japan, a woman scientist and benevolent activist in various spheres, who graciously facilitated the personal and institutional contacts so essential in Japanese settings, and virtually sponsored this project in her country;

The Society of Women Scientists of Japan, who cooperated in this project by filling out questionnaires, being interviewed, and distributing questionnaires to other women scientists at their workplaces;

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My late parents, John William, and Winnifred Margaret Webster, who, having been born at the turn of the century, and having immigrated from European cities to the hinterlands of Canada and America, supplied sufficient examples of pioneering, and of its associated virtues for me to recognize these characteristics in another setting. They provided, also, examples of courage, and of the idea that God gives us the wonderful pleasures of the mind and the opportunity to use them;; and, although I have not effectively emulated them in any of these matters, I would say that, without a doubt, these were "always on my mind."

On Being a Scientist

People become scientists for all sorts of reasons.... The things we learn about the world, through science, are simply very exciting. There is an order and a beauty in the world that lies hidden. Science is the formation of a partnership between human understanding and the rest of creation.... When you become a scientist you form this partnership, too. What you discover will often be new only to yourself; sometimes it may be new to everybody.

The next thing to be said is that it is <u>fun</u> to do science. This very important fact was pointed out long ago by King Solomon.... Science is a kind of play. To be a scientist is to couple the wonder and imagination of a child with the creative understanding of the adult. Doing science is fun.

Moreover, doing science is an adventure.... What's needed at times is the courage to sail over the rim of the world, and find out what's on the other side. Earlier travellers have found wonders. But what will happen to you?

People sometimes say that science is "about things" and not "about people." Be that as it may, science is very much <u>for</u> people.... Einstein's science is <u>for</u> people in the far more basic way that Shakespeare's plays and Beethoven's symphonies are <u>for</u> people.

Why do science, then? Because it is <u>worth</u> doing. The science created in the past few generations is one of the glories of the present age. What a privilege to take part. And what enormous fun.

E. A. Johnson. (1986). In J. Harding (Ed.), <u>Perspectives on gender and science: Part I. How it is with women</u> (p. 103). Philadelphia: The Falmer Press.

Abstract

In recent years, very few Japanese women have entered the fields of science and technology despite the fact that Japan has specialized in these areas. This study attempts to develop a preliminary profile of those women who have despite odds, made careers in science. Generally, these women were found to come from families of high socio-economic status. These families had socialization patterns typical of middle and upper classes which included the teaching of universal, rather than of local, values, little sex-stereotyping, non-arbitrary verbal communication between generations, and field-independent views.

Families of respondents valued education and were interested in science. In many cases they included persons who were causal and creative. Familial males shared their activities with respondents and familial females modelled an independent, nonpassive role. Respondents often had their first positive science experience within the family, but there were also teachers, primarily at secondary and university levels, who encouraged them. In addition, critical experiences and role models also influenced them. Role models were sometimes persons the respondents knew; in other cases, they were literary figures.

In spite of frustrations and some gender discrimination in the workplace, respondents for the most part are happy to have chosen science as their profession.

Résumé

De nos jours, bien que le Japon soit spécialisé dans les sciences et la technologie, il n'y a que quelques femmes qui sont dans ces domaines. Cette étude essaie de développer une esquisse préliminaire par rapport aux femmes qui ont fait une carrière dans les sciences malgré tout ce qu'elles ont trouvé contre elles. On a trouvé que, normalement, ces femmes proviennent de familles d'un niveau socio-économique élévé. Ces familles ont fait parti des modèles de la vie sociale caractéristiques de la classe moyenne et supérieure qui a inclu l'apprentissage des valeurs universelles plutot que locales, la rareté de stéréotype sexuel, le rapport de communication non-arbitraire entre les générations et des perspectives objectives.

Les familles des personnes interrogées ont apprecié les études, se sont intéressées aux sciences et beaucoup de fois ont été créatives et débrouillardes. Des hommes de familles ont inclu les personnes interrogées dans leurs activités et des femmes de familles ont pris modèle sur un role indépendant non-passif. Les personnes interrogées ont souvent eu leurs premières expériences scientifiques positives avec leurs familles mais ce sont aussi les professeurs des niveaux secondaires et universitaires, essentiellement, qui les ont encouragées. En plus, les personnes interrogées ont été influencées par leurs expériences critiques et par des modèles à émuler. Dans certains cas les personnes interrogées ont

pris modèle sur des personnes qu'elles connaissaient; dans d'autres cas, sur des personnes du domaine littéraire. En dépit des frustrations et de la discrimination sexuelle dans l'endroit du travail, la plupart d'entre elles sont heureuses d'avoir décide d'entrer dans le domaine des sciences.

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Chapter I: Introduction

Background to the Study

Japanese Women in Society and in Education

Before the 6th century, perhaps because marriage was matrilocal and homes were woman-centred, Japanese women enjoyed considerable influence (Andrew, 1983a). Although six women ruled as empresses during the seventh and eighth centuries, from those years on, Confucian and Buddhist views eroded women's position (Andrew, 1983b), and the transformation to feudalism in the 12th century took away their property rights and introduced a great deal of social control, since it became more practical for one person, such as the eldest son, to inherit property (Andrew, 1983d). Nevertheless, perhaps because of the strains of matriarchy antecedent to these developments, Japanese women always maintained a certain profile in the society, and exercised some of their talents in literature (Andrew, 1983b), religion (Andrew, 1983a), martial arts (Andrew, 1983d), and in other work areas, and were never entirely crushed into oblivion. Yet women did continue to be encouraged to give primacy to the home: they were not encouraged, for example, to take active part in the 1940's war effort until some considerable time had elapsed, since their role was considered to be that of staying home and giving birth to more citizens and soldiers (Lebra, 1983c).

In modern times, the Women's Liberation movement, as such, was rejected by Japanese women because bra-burning, and similar activities in the West, were seen as unaesthetic, unwomanly, and not in keeping with common behaviour codes in Japan. The structure of Japanese society is vertical, and the aristocratic ideal has been democratized (Singer, 1973), so that lord/retainer type relationships exist at every level, and in every area, of society (Singer, 1973). Furthermore, dependency is a major theme of interpersonal relationship in Japan (Doi, 1971), the relationships within a vertical structure of society being complementary, not contradictory (Nakane, 1973), and women continue to be at the bottom in power relations.

Given the above, large cross-sectional movements involving the demanding of rights would have seemed inappropriate to relationships already established in the society, except in cases of severe duress.

Women's situation in the home had also improved so immensely, in the majority of cases, that the Liberation movement might have seemed unnecessary to those enjoying their "six new hours of leisure" (Pharr, 1980), and all of the other benefits that urbanization (Pharr, 1983a) and modernization had brought. And Japanese women have yet another reason to be happy about their situation, since theirs is one of the longest life expectancies in the world (Pharr, 1983d).

Nevertheless, a general type of feminism attempting to better the lot of women has had many adherents in Japan, and has had a long history there (Lebra, 1983a). Japanese women, for example, functioned as leaders in nationalism, socialism, social comment, and Christian social reform, feminism, labour reform, suffrage, and family planning during the late nineteenth and early twentieth centuries (Lebra, 1983a), Many other women's groups could be named, but one example, the Bluestocking women, emerged as a radical group that "projected an atmosphere of feminine defiance that stimulated other women of ideas and courage to act" (Robins-Mowry, 1983, p. 59). In recent years, Japanese women have participated in such activities as International Women's Year (Fuji, 1983).

It should be noted, again, that, despite the rejection of the Women's Liberation Movement, Japanese women have not had a history of passivity. The fight for woman suffrage, for example, was as intense in Japan as it was in other places in the world (Molony, 1983; Lebra, 1983a). And in more recent years, the Housewives' Association (Shufuren), which focused mainly on consumer protection, also enjoyed huge support from Japanese women, bringing corporations to their knees through nation-wide boycotts of over-priced products (Pharr, 1983e). Absence, more than vocal presence, is an acceptable tactic used in Japan to indicate dissatisfaction or protest. This boycott appears to have been one example of such a strategy.

Three kinds of contemporary Japanese women have been identified by one author: first, the neo-traditional, who relates nearly all of her activities to the home; second, the new woman, who gives primacy to the home, but engages in some non-home-related activities; and third, the radical egalitarian, who calls for a re-ordering of society (Pharr, 1980). In 1980, the first of these types was found to be the most predominant (Pharr, 1980).

The traditional reference work with regard to women in Japan is The Greater Learning for Women (Onna daigaku) (Andrew, 1983c). Although written in feudal times, and given authoritative status from 1603 to 1868 (Fukuzawa, 1988), it was still commonly invoked during the rest of the nineteenth century. Certain injunctions pertinent to this study in that they inform residual attitudes in some segments of the present society are quoted in the Appendix, but will be summarized here: girls and women were to observe a line of demarcation between themselves and men; a woman was to ask her mother-in-law and father-in-law for directives, and follow them; the woman was to look to the husband as vassal to lord, not despising or underrating him; a woman was to attempt to be pleasing to her husband's kindred, in order not to offend her parents-in-law and make problems for her own reputation; the wife was to be responsible for the good order of the household, and for its economy, avoiding luxury beyond her station; a woman was not to correspond with a young man, and

was to avoid familiarity with her husband's male relatives and fellows; a woman was to go nowhere without her husband's permission; she was to attend to everything herself, even when she had servants; those of her gender were prone to indocility, discontent, slander, jealousy, and silliness, were inferior to men, passive, stupid, and in great need of distrusting themselves and obeying their husbands (Fukuzawa, 1988).

Even in modern times the role of the housewife is more defined in Japan than in North America. It has certain obligations which go along with it. One of these obligations is still towards the husband.

Within this defined role, however, the Japanese woman has clearly demarcated decision-making roles. A wife is, generally, the banker of the family (Pharr, 1983a), and in charge of most expenditure. The husband is often given only a small allowance. The absence of the father from the home in recent years has created a somewhat different lifestyle, as well. It is now customary, and it is the mother's responsibility, to enrol children in all sorts of lessons of a cultural, athletic and educational nature, and often, to supply transportation, and to attend the lessons herself. Parents spend a great deal of money for outside-of-school expenses, such as fees for piano and dance lessons, and for sports activities.

At the junior and senior high school levels, mothers are heavily involved in bringing the moral support of their presence to their teenagers as they prepare for entrance examinations to the best senior secondary schools, or to the best universities. This preparation involves hours of study each evening (K. Usami, personal communication, 1991 and personal observation, 1984-1993).

It is important to bear in mind the above general pattern when one considers community and family expectations which must be confronted when a woman makes a nontraditional choice in Japan, such as the one concerned with working full-time in any capacity at all. A woman involved in long hours of science research would not have sufficient time to fulfil these traditional demands. Unless her husband is seen as supporting or initiating the idea of this career, the wife might be considered to have failed in her obligations as a woman, and might bear a stigma which would be difficult to remove.

In 1947, the status of women in education changed:

> ..the change on the basis of the Fundamental Law of Education issued in 1947 was a revolutionary one since this law has assured equal opportunity for education regardless of race, creed, sex, social status, economic strata, or family background, and has admitted coeducation of men and women at all the levels of education. Consequently, women's participation in higher education in ages 15 and over have shown a remarkable increase (Hara, 1985, p. 2)

What has been the position with regard to women in education since that time? For one thing, there have been

demographic changes in the schools, in general. Whereas, in 1950, only 36.7% of girls (as compared with 48% of boys) entered senior high school, by 1970, 82.7% of girls (81.6% of boys) did. After that year, the girls' registration percentage continued to surpass the boys'. The statistic for 1988 shows 95.3% of girls registered (92.9% of boys). The year 1970, therefore, was a kind of watershed. From that time onward, it was usual to have at least as many girls as boys in senior high schools (Ministry of Education statistics). Since senior high school students enter at age 15, we may assume that girls born from 1955 onwards would have been in senior high schools with this kind of demographic distribution. After girls had entered the secondary schools in such numbers, they began to attend tertiary institutions. They did not, however, favour the four-year universities, and from 86-90 per cent of them are found in junior colleges (Hara, 1985). However, those young women who did enter four-year universities have been showing a trend towards entering graduate and doctoral programmes in greater numbers, with women tripling their numbers in medicine, and doubling them in dentistry (Hara, 1985).

In higher learning, women's study patterns at the tertiary level are different from men's, in Japan: for women, "the most common major is literature; the number of women in literature combined with those in nursing and home economics

constitutes approximately two-thirds of all women students" (Pharr, 1983b, p. 263).

Japan is a male-dominated society, particularly when it comes to institutions of employment, and science has been a particularly male-dominated discipline. The perspective of the Hennig and Jardim (1977) study of managerial women, although not one relating directly to science, is a helpful one to bear in mind when looking at women's entry into science, since it focuses on factors antecedent to women's entry to male-dominated areas. No doubt some of the socialization of the respondents who are the focus of this thesis also had factors which prepared them for the contingencies, language and culture of a man's world. It is necessary to bear in mind the following caveat: almost everyone in Japan, male or female, must know how to be part of a group, and to subordinate his or her interest to that group. In that sense, both Japanese men and Japanese women are well-prepared to enter organizational life, since, as Nakane (1973) indicates, <u>frame</u> is more important, in Japan, than <u>attribute</u>; that is, the group to which one belongs, or the framework within which one operates, is more important than the specific role one takes. This lesson is learned from kindergarten on, and there would be few surprises left by the time of job entry. It is evident, however, that the average Japanese young woman would have had less social interaction with men than her Western counterpart, since chumming and congregating

in schools and other areas of life occurs by gender, and the behaviours and even the language forms of the two sexes are different. While this social pattern occurs, as well, in the West, it is accompanied there by a much greater incidence of dating. In Japan, while many high schools are coeducational, many, also, are not, and even the educational avenue for interaction is closed to some.

Upon entry to the workplace, in addition to the constraints of gender itself, Japanese women will find other patterns in place which may mitigate against their long continuance there:

> Businesses still generally employ women only in low-level jobs because of the belief that women are less able than men, the long-established view that women should work only until marriage or childbirth, and the fact that women's working conditions are regulated by protective legislation. Thus, it is difficult even for women college graduates to find jobs suited to their skills and to advance within the firm once employed. (Fuji, 1983)

With respect to this constraint, Japanese women have greater odds against them than Western women do when they are considering science entry.

Problem Statement

In recent years, there has been considerable interest, particularly in the West, with regard to the underrepresentation of women in science. The concern has been within three sectors: first, on the part of educators who

found that science programmes they had designed were proving successful mainly for their male students, a fact which had implications not only for high schools, but also for the future employment options of their female graduates; second, on the part of feminists who wished to ensure equal opportunity for women in the school and workplace; and third, on the part of the science and technology sector, that a major group in society which could, potentially, be a source of needed skilled workers was not being utilized (Harding, Jan, 1986a, p. 1).

Although this underrepresentation of women is a general problem at the present time, Japan has an added aspect. Japan's reputation in the world is largely related to its accomplishments in, and use of, technology. Among the Asian nations, Japan is the most highly developed country. Yet, paradoxically, it is the only nation which has no women in its national academy, the prestigious Academy of Science. For this reason, Japan has been chosen as the focus for this study.

At the present time, Japanese women scientists are hoping that more women will be attracted to science. The women scientists, however, tend to rely on social scientists, rather than themselves, as being better equipped to investigate the problem.

Until recently, women's contribution to science has not been generally well-documented, even in the West. Most

accounts of it have been anecdotal (L. Pyenson, personal telephone communication, 1991). In both Japan and the West, some women report very few problems with regard to their situation in science while others report many struggles and ongoing discrimination. Within even the same discipline, experiences appear to be different for some than they are for others.

Why are there such disparities in the experience of women in science? Is it that some women simply do not encounter the same obstacles as others? Is there something in their position or stance which deflects trouble? Do they have special strategies for survival? Do they have characteristics in their backgrounds which could inform the socialization of other women? Or are they just the exceptions whose experience has been largely the result of a happy interplay of time and chance?

In the case of Japan, there is a small minority of women scientists who have successfully overcome obstacles in science entry. It is not clear to them, or to those interested in the problem of the underrepresentation of women in science in Japan, what has been distinctive about their experience. Were they motivated by the special circumstances of the times in which they lived? Were they all daughters of scientists? Were they especially able, by virtue of their financial or social position, to enter science? Did they become scientists to be different from the norm (science is not commonly chosen

as a career by women in Japan)? Or are they all persons of stellar ability who cannot really be considered part of the ordinary experience?

All of these are interesting questions. Without an answer, it would be difficult to know if, under other circumstances, or given other kinds of socialization, other women in Japan might be able to follow in their footsteps and pursue a path in science.

If the women are daughters of scientific people and are merely carrying out their biological destiny, then all that one could ask would be whether one could find factors in their socialization which would aid other women who come from scientific families to see science as a possibility. Just to involve more of these women would add considerably to the ranks of women in science.

But perhaps factors could be found which relate to the socialization of all girls and women in Japan enabling them to have a more positive attitude towards science entry, or enabling them to do better in science, generally. In such a case, this discovery could encourage the use of these factors by schools and other socialization agencies to facilitate girls' and women's progress in science, and a greater percentage of entry by them into it as a career.

This study will investigate the experience of women who survived whatever obstacles they encountered to their entrance

into science in Japan, with a view to discovering what might be helpful to all.

Objectives of this Study

The overall objective of this study is to develop a profile of the Japanese woman in science.

The specific objectives are:

1. to probe aspects of the informal, non-formal, and formal socialization patterns which may have been involved in the woman's decision to enter science.
2. to look into role models, special influences, and experiences which may have been catalytic factors in her decision to enter science.
3. to ask individual women scientists their views about their roles as women scientists in a male-dominated, traditional society, including their frustrations and satisfactions.

Significance

The study may produce information which would have implications for those involved in the formal socialization of girls in Japan, and in education, particularly as it relates to their attitudes to science.

By providing a profile of the woman scientist and her background, a picture of needed changes may emerge. This

picture should encourage plans to utilize half of society's brain-power (as represented by women).

Study Design and Analysis

The study was done by using three approaches: first, a questionnaire was given out to a group of twenty-eight women scientists; second, from this group ten women volunteered for an individual interview which would supplement and give greater detail than had been obtained in the short format of the questionnaire. Third, a pilot group interview was held before these individual interviews in order to inform the development of the interview protocol. The sample of women was obtained through the auspices of the Society of Women Scientists of Japan. Members of that group took and filled out questionnaires, then distributed extra copies to women scientists at their workplaces. These women were very cooperative and quite eager to further the study.

Because there are very few women scientists in Japan, this ethnographic study aimed to gather data from the small sample available.

In order to capture the richness of the data, and because this is a small sample, the analysis will be qualitative. A descriptive analysis will be made with the intention of giving as much of the text as possible.

Limitations of the Research

Unhappily, due to language constraints, no reference was made to literature about women in science written in the Dutch language, believed to be the best source (L. Pyenson, personal communication, March, 1992). Thus, some very useful background to the study may have been missed. This might be an important literature source for another researcher to investigate when dealing with the kinds of questions found in this study.

The research in this study came, in the main, out of a specific organization, The Society of Women Scientists of Japan and its contacts. Its meetings are held mainly in Tokyo, and most members contacted through this survey live within 100 kilometres of this capital city. It is possible that some different views might be given by those who work in less proximity to this urban centre in which views and constraints are not as traditional as those in other areas.

Conceptual Framework

There are various psychological theories explaining women's relationship with science. Among the sociological explanations, several studies relate social class to women's career in science. For example, women choosing science as a career tend to come from high socio-economic backgrounds (Guilbert, 1987).

Sociological Theories

Theories of socialization.

There are various sociological theories explaining women's relationship with science. Theories of socialization suggest that girls are socialized into "female" roles and in the school streamed into "female" subjects. This leads to female ghettos in the economy, with large numbers of women taking up nursing, secretarial, and other occupations which have been traditionally considered female. Few women find their way into science and technology since most disciplines in these fields have been traditionally considered male. The exceptions to this stereotype are the particular scientific professions which are seen as an extension of the nurturing role, such as medicine and teaching, rather than research and development. Post-industrial society women are said to have "lost the technological race" (R. Ghosh, personal communication, August 16, 1993).

Social class and enclave.

A number of other studies relate social class to women's career in science. For example, women choosing **nontraditional science** as a career also tend to come from high socio-economic backgrounds (Guilbert, 1986). In continental Europe, women in science come specifically from aristocratic backgrounds. They also come, worldwide, from cities rather than from small towns and rural areas, a profile different from that of scientific men. And, on the whole, the well-rounded girls of broad

experience and interests enter science (Traweek, cited by E. Yagi, personal communication, 1992).

All of the above phenomena seem to support the idea that access to broad experience, either by virtue of being born in cities or in enclaves of society to which many doors are automatically open is a supportive antecedent of many women's entry to science. When one adds to this the further fact noted by Traweek (E. Yagi, personal communication, 1992), that American girls entering science are coming from first-generation immigrants' homes, a phenomenon which may, of course, yield many other more complex significances, the broad experience idea, nevertheless, gains further weight. Such women have had exposure to at least two cultures and have gained experience from each. They have also had the opportunity to look from a distance at factors normally taken for granted within the realm of their immediate experience, a perspective by no means inimical to attitudes held within science where such distancing is often required.

Androgynous outlooks.

Studies of women in nontraditional fields, scientific and otherwise, have noted that the women have been influenced by a man in their career choices (Guilbert, 1986 and Hennig & Jardim, 1977), and have had considerable exposure to both male and female roles (Hennig & Jardim, 1977), expanding the latter role in their own cases to include some aspects of the former.

Several psychological theories also explain women and science, and are included below:

Role Model Theory

Role Model Theory appears important, particularly when a significant person or persons have been the catalyst in a woman's choice of science (Matyas, 1985a). The literature indicates that students will choose science if there is a similarity between their self-image and that of their perceptions of scientists (Brush, cited by Matyas, 1985a); but will self-select, if they perceive themselves to have qualities different from those they perceive scientists of their gender to have. Same-sex teachers, when perceived as attractive, were found to have greater impact than opposite-sex teachers (Matyas, 1985). Fischer (1982) suggests that models of successful women scientists may illustrate visible career paths, and where the domestic and career interests threaten to conflict, "examples of happy husbands of high achievers might be in order" (p. 70).

The image of a scientist has been found to have more importance than the role of a scientist, insofar as choosing science is concerned (Keller, 1985). This may have considerable significance in self-selection.

Temperament Theory:

Temperament theories suggest that only 12 1/2 per cent of persons have the temperament to be a research scientist (Kiersey & Bates, 1984). This finding seems to underline the importance of counsel that emphasizes the wide diversity of occupations available to those who specialize in science, since some persons, otherwise interested in science, may avoid specializing in it because they lack interest in research as such.

Cultural Anthropological Theories:

Cultural anthropological theories consider scientists as occupying roughly the same position in modern society as priest doctors did in tribal groups. Priests and psychiatrists have this position in modern society, also (S. Traweek, personal communication, 1991). These are power positions held by men.

Feminist Theories:

Feminist theories, in general, give four or five major reasons for women's oppression.

Conservative feminism.

Conservative feminism is rarely given any lip-service in the West, now, but is briefly included here, since such an attitude is very common in Japan. It is one of considering women, for biological or other reasons, inherently unsuited to

pursue the same activities as men. In relation to science in Japan, the thought is that this field is an area of logic, that women possess little of this quality, and in fact, are more suited to the area of feelings, hence, should enter areas of study such as literature or music where there is greater focus on emotions. Another thought follows, that women should, perhaps, avoid fields such as science, which may subtract from their emotional capacity, and thus rob them of the grace for which they are highly valued in the home (Yamanouchi, personal communication, 1991).

Liberal feminism.

Another viewpoint is that of the liberal feminists. They see women's oppression as coming from lack of liberty and equality due to inequalities in power and opportunities. Liberal spurn hierarchy when there is no manifest reason for it. Liberal feminists would, therefore, not be willing to accept women as inferior in science or in any other field, unless it had been proven that they had opportunities equal to those of men, such as equal education. Legislation ensuring women's equal rights are thus important to this particular group, which separates public and private spheres in its considerations. In Japan, however, many of the legislations hoped for elsewhere have already been attained. The problem is that societal pressures bear more upon the individual than legislation. In addition, it should be noted that the

workplace there does not always pay a great deal of attention to what is on the lawbooks, and efforts to enforce such matters are less common than in the West. As well, horizontal groups, such as unions, are rather weak, since the society is vertically structured.

Marxist-feminism.

Another viewpoint on women's oppression is the Marxist-feminist one. From this perspective, the kind of society one creates determines the relationships between the people in it. Therefore, women's oppression is seen to be the result of private property ownership, which puts property, and thus, power, in the hands of a few, most of whom are males. Only by making the property common to the whole society, including women, would women's economic dependence on men, and hence, their subordination to them, be effectively abolished. Women in Japan did, in fact, experience this during premodern wars, when it became important for one person to inherit property, and that person became the eldest son (Andrew, 1983d). At the present moment, however, women do not need to deal with such a problem, since they again have property rights, and numerous other rights which came to them through legal changes which occurred just after the conclusion of World War II (Pharr, 1983c), perhaps the most important of which was the new constitution.

Radical feminism.

A further viewpoint is that of the radical feminists. They believe that women's oppression does not come from social class systems resulting from private ownership of property, or from the lack of legislation for equal rights or even from women's inherent natural differences. Rather, they believe that women's oppression is the first cause from which all of these other oppressions arise. This group sometimes argues that the basic struggle, therefore, is one against male dominance. They would not limit this struggle to the public sphere, but would carry it over to the personal sphere. In some cases, their leaders have promoted lesbianism as a kind of political decision limiting male dominance. In other cases, the abolition of the category of male and female has been encouraged.

Social feminism.

Another group is the social feminists, who, while agreeing with much of the Marxist position, expand it to categories not limited to social classes and their oppressions. These feminists also consider women's oppression to be related to kinship systems which use women in interfamilial exchange, at the same time encouraging a passive role in women as being most suited to this. Again, these women see a relationship between the public and private spheres, in some cases, between patriarchy and capitalism. In

Japan, marriage, in the past, has often been a kind of interfamilial exchange and a means of social mobility. A son could accomplish well for the family, but a daughter could give the family a new connection, perhaps to an imperial family (Andrew, 1983b, d). Much of the focus of the training of Japanese young women, even today, relates to increasing their potential to "marry well." In many ways, however, this focus mitigates against an entry to science, since it tends to reinforce passivity, and also occurs during the same years that tertiary education is being accomplished (Jaggar & Rothenberg, 1978).

"Genderization" theories

Feminists looking at science in relation to women point to its "genderization" as a field. Keller (1985) seeks to demonstrate that the objective attitude so prized in modern science has been imbued with a hegemony of extremely stereotypical "masculine" attitudes. The observer and the observed are very distanced from each other. Although practised in various ways by both men and women, science must finally be explained within a stereotypically masculine framework to receive the correct support. Keller believes that women's scientific research, unless framed in this manner, might be discriminated against (Keller, 1985).

Birke (1986) maintains, in a similar vein, that a reductionist type of science, emphasizing isolated facts, is

being taught in schools, and that relationship and connectedness in this subject is necessary if more girls are to be attracted to it. She suggests a more holistic approach.

The studies of Knut Sorensen appear to corroborate the idea that science culture is gendered. His research brings out the fact that, in Norway, both men and women lose some of their caring values after entry to science as a career, but women more markedly so. Women do not lose their caring values entirely, however, since their choice of discipline (usually chemistry, in Norway) appears to be one that is strongly connected to medicine, cures, and help to the household, and can thus be linked to caring values.

Sorensen says that there is a lack of an appropriate language for expressing and negotiating such values, and the gendering of the organizational culture undermines caring values, putting women at a disadvantage in forwarding them.

He sees the possibility that women could improve their position in science by greater numbers, which would allow for more networking, less tokenism, and more discussion of caring in technology. Political appreciation of caring values might thus come, caring becoming part of technology's "sales pitch," and thus a "rhetorical resource" which could help reform and redirect research and development (Sorensen, 1992, pp. 5-31).

This study takes as its framework sociological theories of socialization and class. In addition, Role Model Theory will also explain Japanese women's entry to science.

Sociological theories of socialization and class are important when considering the Japanese woman scientist for various reasons One of these reasons is the fact that Japanese women are socialized even more overtly and deliberately than those in the West into the female occupational enclaves mentioned above. Despite this, however, numerous respondents of this study have chosen scientific occupational areas which are not traditional for women. Why did they resist the socialization of their culture? Androgyny, also, said to be a helpful antecedent to confidence in nontraditional fields, is a practice avoided in Japan. There, it is very obvious that "boys may whistle, but girls must sing." Why did the women of this study happen, then, to enter "male" fields? Again, conservative feminism, as mentioned above, is the norm in Japan. Women are considered suited to emotional concerns, men to logical ones. Why did the respondents of this study persuade themselves and others that they, even though they were women, were suited to logical studies? And, given that women are, even in these days, encouraged to work mainly on developing skills that may aid them in marrying well, rather than those useful for a lifetime career, how did these respondents manage to pursue advanced degrees in fields other than home economics, nursing, or

literature at precisely the time when they would have been expected to be making a good "match"? How did they avoid the passivity so useful in kinship exchanges, but so inimical to the scientific perspective? Questions of this nature come immediately to mind.

Role Model Theory is also important in this study because of the necessity, according to this theory, of gaining a perception of the scientist as being like oneself, if one is to choose science. There is a very strong perception in Japan that the scientist is male. In addition, very few women are found teaching science in high schools or universities. How did the Japanese women of this study, then, find a similarity between their self-image and their perception of the scientist when they themselves were a) not male; and, b) not, probably, taught by a woman science teacher who might have acted as a role model? How did the women come to feel entitlement in a "man's world?" And where did they find role models?

Research Questions

The overall question is: "What is the general profile of a Japanese woman scientist?" Specific questions are:

1. What are the characteristics (size, socio-economic status, educational level) of the respondents' birth families?
2. What sorts of attitudes had the women scientists developed regarding male/female roles?
3. What values were significant to them?
4. What had been expected of them in relation to academic achievement?
5. What was the nature of the schools they attended?
6. Was there a person (e.g.: teacher, parent) who may have had a critical effect upon their choice of science as a career?
7. Were there any role models from books or films?
8. Was there any special experience which acted as a catalyst?
9. What do the respondents think of the "genderization of science" concept, as applied to Japan?
10. What are their problems as women scientists in a male-dominated society?
11. How do they view their own situations: job, lifestyle, etc.?

12. What do they think is the reason many women don't enter science as a career, despite ability and/or interest? Perhaps the respondents can relate specific examples from the experience of persons they have known.

Chapter II

Women in Professions

Hennig and Jardim, in the study (1976) that became the popular book The Managerial Woman, point out that, since organizations nontraditional for women have been founded and populated by men, they, quite naturally, are bastions of male thinking. Part of the strategy for entering them must be to take into account the kinds of differences one might expect to find there. Hennig uses an analogy for women's entry to male-dominated organizations stating that, just as a stay in a foreign country can be made much more pleasant if the language, behaviour, currency, and history are learned, so women's entry to the "foreign" culture of male-founded and male-dominated organizations can be facilitated by a similar study of their distinctives and parameters (Hennig and Jardim, 1977). Hennig and Jardim mention, in their analogy, that to have a guide or mentor, to be willing to struggle to learn, to work hard, to anticipate some initial frustration, to not feel guilty over initial inadequacy, and to hold an optimistic view of the outcome would aid in the understanding and enjoyment of the new experience.

Hennig and Jardim indicate a number of differences in the thinking of men and women about job and career which have become evident through their research findings and those of others. Although they focus on women in organizations, some of their findings are rather general ones and could be extended to other areas.

Men, they indicate, tend to focus on the whole picture or continuum, in their work: they think in terms of career, rather than in terms of job. Women concentrate on the present situation, and rely upon others to change the status quo in their favour. Men integrate their careers into their lives; women separate their personal and work lives. Teamwork in boys' team sports has prepared men for the world of work in a way that women's one-on-one sports have not. Boys' sports emphasize winning whereas girls' sports emphasize playing. Team sports help people greatly by teaching them how to work together effectively without taking too many personal considerations into account such as whether they like the particular persons involved. Boys have learned to subordinate their own ego needs and personal preferences to the need of the team as a whole in order to cooperate in some way and win.

The corporate world has parallels to the world of team sports. Men recognize in it the same necessity to employ strategies, take risks, and to adjust personal roles to leadership expectations that they experienced in team sports. Women tend to be oblivious to these factors, and merely work hard, hoping that someone will do right by them in the end. Women will act in a manner less congruent with the informal side of organizations, will appear less motivated to get ahead and more reactive and intolerant. They may, therefore, be less likely to receive promotion.

Progress During The Past Century and a Half

Women have been involved in the healing aspects of science since Egyptian times (Bourdillon, 1988). Women of Science: Righting the Record (Kass-Simon & Farnes (Eds.), 1990), a recent publication, points, however, to the many modern and significant scientific contributions women have made. Women's colleges have played a very crucial role in nurturing such endeavours, but have also been ghetto-like in limiting these efforts. Scientific men of goodwill, such as the Braggs and Bernal, Hopkins, Rutherford, Rayleigh, Wierstrass, Gauss, Fieser, and Klyne, gave opportunities to women and encouraged them, unlike others who did not.

Rossiter's study (1982) details how women in America, after 1802, were given "education for republican motherhood," that is, education which would help them train children to become good citizens, with the tacit understanding that they would use it within the home, not in the workplace. By 1850, America led the world in education for women. Rossiter traces subsequent developments, showing that as women by the end of the 19th century, sought to enter the workplace, efforts to "professionalize," or to "raise standards," that is, to require a doctoral degree for faculty posts for women in order to keep them out of the male domain of science, began to be

made. Soon, women developed strategies, such as quietly infiltrating friendly university faculties or using "coercive philanthropy" to endow women's chairs in universities or establishing women's scholarships. Around the same time, a new idea arose: the more men on a faculty the greater the "prestige". Therefore, women were given only associate memberships in professional organizations, and, excluded from all but the most public events, they formed their own organizations. From 1910 to 1924, they prepared statistical reports to document their unequal status, but very little happened. "Prestige" became an even more pervasive idea in the 1920's and 1930's. Even brilliant women did not have much success except at lower levels (Rossiter, 1982). Many tried to become overqualified, working hard to become "exceptions," some at the expense of health. As most of these strategies had unsatisfactory returns, women often, then, resigned themselves to specializing in "women's" areas of science.

Territorial discrimination designated certain disciplines as female enclaves; hierarchical discrimination kept the lower strata of all other disciplines for women (Rossiter, 1982). The latter, however, became less of a refuge around the 1930's, when "tenure-track" began to eliminate these assistant professorships, etc., as lifetime jobs (Rossiter, 1982). The strategy of awarding special prizes for women was effective in making them more visible and more comfortable in science, but not in removing many barriers.

Today, A Similar, but Different, Education

Today, girls are said to be receiving a science education which is different from the the one which boys receive (Matyas, 1985a). The following sections will attempt to demonstrate this.

Different Activities.

Despite the fact that they may be studying in the same classrooms as boys, girls come from a different background, one which has not laid much foundation for science learning: if the theoretical is approached immediately, girls will have no practical experiential basis with which to develop an understanding of it. For boys, the situation is quite a different one, since their interest in science has often already been established from their leisure time activities, which may include making paper airplanes and thus learning about air currents, angle, pressure and weight; or casting fish hooks and catching outfield flies, thus obtaining a "nonverbal, intuitive understanding of distance, space, and direction" (Fischer, 1982, p. 72).

Sometimes, however, the situation is the opposite one. Boys may come from backgrounds lacking in foundational

experience, and when this is the case, they, too, also experience difficulty in understanding science (Kahle, 1985b). And recently, Grade 6 girls who had been conscientized to their scientific surroundings through science club activities surprised MIT contest participants by being on the cutting edge in a robot competition (Travis, 1993). Around the world, in recent years, the problem of insufficient practical scientific experience in the background of girls has been recognized, and attempts have been made to redress this imbalance. In the United States ("Getting Messy", 1993), Canada (Baker et al, 1982), Norway, the United Kingdom, the Netherlands (Haley-Oliphant, 1985) special programmes have been helpful to girls and young women. The former Soviet Union has had the greatest success in training women physicians and engineers: the three critical factors in encouraging girls and women to enter science there have been shown by research to be academic study, work experience, and propaganda (Haley-Oliphant, 1985, p. 178). A national project in Thailand for developing scientific expertise has also included girls (Kahle, quoted in Haley-Oliphant, 1985). These initiatives have been necessary mainly because their unequal background experience has not been taken into account in most ordinary classrooms.

Different Tools.

These experiences also provide familiarity with laboratory materials. A girl often lacks this knowledge, and her experience might be analogous to that of an adolescent boy who, for instance, must prepare a full meal and be graded for it:

> He is in competition with female peers who, though they have never done this particular task, have considerably greater facility with the equipment required. Perhaps by this analogy we can understand the apprehension of the adolescent girl deciding whether or not to take high school physics. (Matyas, 1985a, p. 38)

Androgyny and Empowerment

Aside from experiences that focus specifically on science, other kinds of experiences have been thought of as helpful antecedents to science entry. Androgynous activities have been found to be a decided plus, probably because present-day stereotypes with regard to the female role are often inimical to science. Girls are often stereotyped and rewarded in relation to their "goodness," neatness, conformity, gentleness and emotionality, thus reinforcing only a passive approach to learning. These stereotypes may not aid them, since they may be encouraged to avoid risk:

> Previously successful patterns of behaviour are repeated in preference to the risky, more challenging business of attempting new solutions to more difficult problems.

(Fischer, 1982, p. 69)

And third-grade girls were found to be conditioned, in relation to toys, to accept them as they were, and not to manipulate and/or change them; this conditioning would be unhelpful to science, especially to physics (Torrance, cited by Matyas, 1985a). In general, girls are presented with toys which are already assembled, thus encouraging the passive role in which they appear to have specialized.

Women engineers appear to be an example of androgyneity, on the other hand. While not more likely to be feminists than other groups, they do have distinctives.

> ...there is an important area of difference--in how women in engineering think about gender and define their own femininity and masculinity. (Newton, 1986, p. 41)

They place high on both femininity and masculinity scales, and therefore could be considered to be androgynous. It is to be borne in mind, however, that the definitions of the feminine and masculine stereotypes have been those used to inform the definition of "androgynous" in this section; and may have nothing at all to do with femininity or masculinity as such.

Formal Schooling: General Factors

In general, the school is an agency which is very influential in science learning. It tends to send different messages to boys and girls at the present moment, but it can be trained to do differently, and a new programme by Kahle is

attempting to do just that:

> In 1991, she studied the teaching methods of every fourth- and fifth-grade teacher in a school just outside Cincinnati....
>
> "It wasn't that the teachers were overtly discriminating" said Kahle, who directs Project Discovery, "but both the boys and girls picked up on these differences." Girls were more often praised for neatness or timeliness in completing experiments; boys were recognized for scientific content of their work. Girls were asked, "What is the correct answer?" Boys, on the other hand, were asked, "How did you get that answer?"
>
> Many of the teachers attempted to be equitable by placing boys and girls together when doing group experiments. However, they failed to monitor the groups, and, more often than not, boys did the experiments while girls recorded the data, giving boys the edge in critical hands-on experience.
>
> To remedy this inequity, Kahle and her students ran gender-equity training sessions for teachers.... Following the training, Kahle observed dramatic changes in classroom dynamics.... Many teachers stopped using mixed-sex groups, finding that girls did better working with other girls. ("Teaching the", 1993, p. 415)

The lack of background which girls have, mentioned in a previous section, has often been unwittingly reinforced by the school, thus adding to the problem, except in instances where intervention such as gender-equity training has been given to teachers, as in the example given above.

Problems at elementary school level.

Three other problems, beyond general ones mentioned, are particular to the elementary school level. First, teachers are non-specialists (Matyas, 1985a). Second, equipment is poor (Matyas, 1985a). Third, early entry may foster peer-

dependency (Bronfenbrenner, cited by Moore, 1982).

Problems at secondary level.

Other expectations bear upon girls of secondary school age. They experience several two-way pulls. There is the one with regard to being non-conformist at a time when conformity is valued (Matyas, 1985a). There is another with regard to being "masculine" when femininity is being discovered and emphasized (Matyas, 1985a; Fischer, 1982). There are also two other conflicting emphases: the one, to do well in school and get good marks; the other, to not do too well in school, and beat the boys (Smith & Stroup, 1978). The solution to this is therefore evident: do well, but only in the "feminine" subjects (Smith & Stroup, 1978). The role of the scientist, however, is not thought of stereotypically as feminine. When 4807 children were asked to draw a picture of a scientist, only twenty-eight were of women (Matyas, 1985a). Perhaps for this reason all-girl schools have been found to work better in terms of both selection of science courses, and participation in them (Fischer, 1982; Matyas, 1985a). They probably give the advantage to girls of avoiding the kinds of "situations where high academic achievement leads to awkward personal relationships with boys, especially between the age of 12 and 14 when sex typing is strong and quite rigid" (Fischer, 1982, p. 71).

But there are factors other than boy/girl considerations which inhibit girls from choosing and/or enjoying science: Birke (1986) suggests that experiments and examples in the science class be made to appeal more directly to girls' experiences. Chemistry could, for example, be related as easily to facepowder as to gunpowder. She also adds the following:

> Girls... are more likely to view nature in terms of relationships and of its relevance to human needs, while boys are more likely to view science in abstract terms, for its own sake. The difference in perspective is one which will inevitably affect motivation for the kind of science that is currently taught..., and which is, on the whole, a science taught extensively in abstract terms. Girls tend to become alienated from this other-worldly, abstract image of science, and to see it as possibly less relevant to their everyday lives (p. 189).

It has also been suggested that science must be made "beautiful" to girls, or they will pass it by (Selby, quoted by Kahle, 1985b, p. 74).

A study by Kahle underlines the fact that there is, in fact, much less female attrition in classrooms using such a contextual approach. Approximately fifteen characteristics (Appendix B) have been identified in high school classrooms from which significantly larger numbers of girls have gone on to higher science studies (Kahle, 1985b). These characteristics are not emphasized in the typical classroom. In general, they emphasize a very "hands-on", visual, contextual, and personal presentation of science by a highly skilled professional who has an intense interest in the subject of science, presenting lessons in a non-sex-

discriminatory manner, giving science career information and the opportunity to meet scientists who are invited to the classroom from time to time (Kahle, 1985b).

A recent report shows that "good grades in high school, encouragement from teachers and a desire to be self-sufficient are important influences for women in deciding to go into science" (Ubelacker, 1992, p. A9).

Another reason has been suggested for the attrition of girls in science classes: a lack of self-confidence which causes females to enrol, despite obtaining grades comparable to male students, in fewer math and science courses in each grade as they progress from grade seven through high school (Alper, 1993).

It is evident that in all of these matters the role of the teacher cannot be overemphasized (Matyas, 1985a).

Counsellors were found to be important, also, especially in relation to informing girls of career options, and of prerequisites which would be necessary for science entry (Matyas, 1985a). Mathematics, in particular, is the "critical filter" (Matyas, 1985a, p. 32) for science entry, in view of the fact that those successful in math-related careers average at the 90th percentile level on SAT-Math tests (Chipman and Tomas cited in Matyas, 1985) and the need for sufficient courses in this subject is an especially important emphasis.

There are four abilities which are particularly necessary in mathematics: spatial visualization ability,

Quick Word Test performance, perceived usefulness of mathematics in one's future, and confidence in learning mathematics (Matyas, 1985a, p. 33). All of these abilities can be improved by training. Girls, however, tend not to develop most of these abilities in school. Fischer (1982) points out that higher visual-spatial scores are characteristic of independent children who usually have less protective mothers than do passive children.

Problems at university level.

Young women enter university and graduate schools with at least as high marks as do young men: GPA and GRE scores, required to enter the two levels, respectively, demonstrate this equality (Matyas, 1985b). It is thought that the stereotype which designates women as being "less-committed" to studies and research may be causing the considerable attrition in women's enrolment numbers at these levels.

Some recent research from the University of Guelph has shed some additional light on this problem. A study tracking 1200 students showed that women's marks slumped during the first year, but picked up again from the middle of the second year of university studies. Through questionnaire and interview, it was established that this "slump" had much to do with the cold, sterile atmosphere experienced by the women in

science classrooms, and with some overt sex discrimination on the part of professors and male students. The report mentions that relationship and caring are important attributes to women, and they are less likely to tolerate their lack than men (Ubelacker, 1992).

The "science nerd" image of those who enter the math/science stream has also hurt enrolment. One college in the United States has sought to overcome this handicap by including in its chemistry curriculum courses of a rigorous, but contextual nature, changing the image of chemistry on the campus, and making it a part of general campus culture. Many more non-science major students now elect to take the courses. More women also now enrol ("Shedding Chemistry's," 1993).

Mentoring has added the personal, caring touch elsewhere. Graduate students have been installed in a dormitory for women science students at Rutgers University, thus enabling undergraduate women to have advice and counsel available on a twenty-four hour basis. The undergraduates, in turn, acted as role models and mentors to girl high school students in the community ("Around-the-clock," 1993).

The Role of Parents

It has been suggested, in terms of facilitating the option of science career choice, that parents can help in three ways: by supplying adult company so that the daughter avoids peer-dependent attitudes (Bronfenbrenner, cited by Moore, 1982); by selection of a wider range of toys and games (Newton, 1986); and by the inculcation of scientific attitudes.

The literature indicates considerable influence on the part of parents, and suggests that professional families are more likely to support a nontraditional career choice (Newton, 1986). Women in non-traditional careers, such as the sciences, have often been either particularly close to a father, sharing his research interests, or have modelled themselves after a working mother who combines career with family (Newton, 1986).

Literature about women in nontraditional fields has investigated parents, backgrounds and socialization of subjects. One study, done by Hennig and Jardim in 1976, looking at top management women in business corporations, reports results and patterns which have relevance to this study since they reveal a pattern of parenting which permits less sex-stereotyped types of vocational choices, and a kind

of balance of skills which permits progress once the woman has entered her field.

Many other observations were made by these researchers, but perhaps the results of their study are more interesting yet. They studied 25 women who were in very high executive positions in corporations, and found many commonalities amongst them. They had come from happy homes and had been very close to, and influenced by, their fathers, to the extent that they had wished to enter a world of work similar to theirs. Nevertheless, they had not been treated as sons by their fathers, but as daughters. They had been presented with a traditional role by their mothers, and although they had not rejected this role, as teenagers they had wished to extend it to include some of the competitive and causal activities taught to them by their fathers. They had shelved the feminine side of themselves during the first decade of their careers, but had later incorporated it into their personal and work lives. This decision, interestingly, had allowed them to pass beyond the role of supervisor in which mostly controlling and masculine-type skills were needed to the higher, executive role, in which collegial and interpersonal attitudes and actions were more important. A control group of women, similar to the first group with the exception that their fathers had treated them like sons, were found to have been "stuck" in middle management, embittered and disappointed, since they had learned only the skills related to controlling

others and being controlled themselves. In short, a concentration on the "masculine" only had served them well only to a certain level (Hennig and Jardim, 1974, p. 151). This study of women in a nontraditional field appears to give further substantiation to research that emphasizes the themes of "well-roundedness" and "androgyny" as helpful antecedents to women's entry to science. It also emphasizes the importance of good parenting.

One woman mathematician says: "A lot of the women I know usually had a father who was very important in it all" (Gibbons, 1992, p. 1368). Another emphasizes, "When I was a child, my mother and aunts instilled in me a sense of my own worth and because of that there was very little that could have shaken my confidence (Morelli, 1992a, p. 1388).

Glynnis Breakwell, in her investigation of the origins of a positive ("Pro-Grab-It") attitude towards technology found that

> the nature of their mothers' jobs proved ineffective as a predictor of attitudes. Their fathers' jobs were predictive. Regardless of sex, those with "high-tech" fathers were likely to be more pro-Grab-It.... The strong impact of the technology context of father's jobs implies that this attitude is fostered in the home at least as much as in the school (Breakwell, 1986, pp. 37, 39).

A Japanese woman scientist describes how her father modelled an approach to science which she, today, follows in quite a different science discipline. She also describes how, on a different front, her mother encouraged her to become

independent as a woman (Yagi, 1991).

The Marie Sklowdowska Curie story affords information with regard to the socialization of the then future scientist. Her teacher father had a great influence on her attitudes:

> ...Wladislaw with his pedagogical skill awakened his children's intellectual appetites. (Woznicki, 1983, p. 13)
>
> ...a successful and caring father... saw the budding genius of his children and set them on their quest for success. He was always saving some extra money to buy the latest books and pamphlets and then pass them on to his children. (p. 30)

Newton (1986) found fathers to be exemplars to engineering women, supporting their daughter's choices, but not suggesting them. Walton (1986) found that, while women scientists had diverse backgrounds, they had developed habits of independent thought at an early age, often seemingly fostered by parents, sometimes inadvertently.

Science Career Choice: Some Suggested Antecedents

Some research, again underlining the fully-dimensional background of nontraditional women suggests that

> high-ability feminist women who are achievement oriented appear to be strongly career oriented and quite strongly family oriented; this career-family orientation appears to lead to career choices that tend to be high in prestige and nontraditional for women (Fassinger, 1985, p. 147, quoted in Guilbert, 1986, p. 38).

In Guilbert's doctoral study (1984) the subjects were 401 women students of McGill University, some enrolled in traditional female scientific disciplines (nursing,

physiotherapy, and ergotherapy), and others in non-traditional disciplines (architecture, engineering, and dentistry). Statistically significant differences were found between the two groups. Non-traditional women had more often been born outside of Canada, came from a family with a higher socio-economic level, had not worked part-time, had higher scholastic aspirations, had been influenced by a man in their career choice, had found intrinsic and concomitant work values less important, and had chosen a continuous career. Traditional women, on the other hand, had more often been born in Quebec, had come from less elevated socio-economic levels, had worked part-time, had lower scholastic aspirations, had found intrinsic and attendant work values most important, and had envisaged an interrupted career (Guilbert, 1987).

Guilbert believed that the reason that the one group of women had made traditional choices was because those choices were the ones with which they had been familiar. The higher socio-economic status of the nontraditional women's families, in addition to making their choices economically feasible, had also exposed them to more options. The fact that they had, also, been planning on continuous careers from the beginning had left them free from worry about hypothetical familial constraints, and free to aspire to whatever academic heights they now wished (Guilbert, Celine, 1987).

Challenges After Science Entry

There are many challenges after science entry. One appears especially important:

> Avoiding interruption is a critical factor in the development of a successful career. Research indicates that receipt of the doctorate at a later age, whatever the reason, is detrimental to status attainment and research productivity (Perun, 1982). After receipt of the doctorate, women scientists face lower salaries, fewer promotions, lower status positions, and fewer opportunities for tenure positions than males have. Although such inequities frequently have been attributed to women's interruptions of scientific careers for marriage and childbirth, research indicates that lower research productivity, underdeveloped collegial relationships, accepting a token role in the scientific community, and lack of job mobility are more likely to affect their overall achievements and subsequent status. (Matyas, 1985b, p. 85)

There are said to be "invisible colleges" in academe. They are informal networks of communication between scholars which enable the scholars to become aware of trends and progress in research long before it is published formally (Mullins, 1980). This awareness is very helpful to them in positioning their own research in the mainstream of scientific progress, and in choosing projects which will not duplicate others. Reading alone will not suffice, since, as Derek Price suggests, the number of scientific publications doubles about every fifteen years, which makes it impossible to monitor the flow of papers within a discipline. He further suggests that

> On the whole, one can keep up with a colleague group that has an effective size of a few hundred members; one cannot possibly keep up with 10,000. (Price, cited in Mullins, 1980, p. 57)

It is, therefore, important for beginning scientists to make contact with these "invisible colleges". If one is the protégé of a senior professor one will have this contact automatically.

On another level, relationships with peers are important, also. The importance of collegial relationships, according to Reskin, lies in sharing, evaluation, technical assistance, instruction, collaboration, advice, encouragement, potential competition, and social companionship (Cited in Matyas, 1985b, p. 92).

Several researchers have suggested that women are not accepted as full members of the scientific community (Cole, 1981; Reskin, 1978; Liss, 1975; Lows, 1975; Young, MacKenzie and Sherif, 1980, cited in Matyas, 1985b). If this is the case, then many young women scientists are academically isolated. Discrimination within their fields has been given as one reason for this (Matyas, 1985b).

Attitudes of Male Scientists towards Women Colleaques

Some women have reported that they have been welcomed by men:

> ...they actually enjoy the difference of working with women, or they just frankly like women. (Morelli, 1992c, p. 1387).

In certain fields, however, blatant and overt discrimination is still reported. General complaints have had to do with

stereotyping of women, the view of a choice for marriage and children by women scientists as an evidence of "weakness" and "lack of commitment", open hostility, and the "glass ceiling" which seems to be in place preventing women from obtaining promotions beyond a certain level.

Specific complaints have included a lack of encouragement by male scientists, sexual advances on the part of mentors and a suspicion that women cannot succeed in science without sleeping with men (Selvin, 1992, p. 1382). Because of the last complaint, many women avoid co-authoring papers with men in fear that sexual rumours will arise. Another complaint has been the lack of invitations received by eminent women scientists to be speakers at scientific conferences, a kind of invisibility which mitigates against their obtaining tenure and promotion (Amato, 1992, p. 1373) These complaints, though mentioned by women, have also been perceived as valid by some male scientists in the field as well. Women scientists say that they must tread a very narrow line in terms of their general behaviour, since assertiveness on their part tends to be labelled as "brassiness" or "pushiness," whereas a softer approach will be labelled as "too feminine" (Barinaga, 1992, p. 1366-1367).

Mentors

Having a mentor confers benefits beyond networking:

> Research indicates that among graduate women a productive professor-student working relationship is positively correlated with positive self-image, higher career goals, more publications, and lower attrition rates (Feldman, 1974, cited in Matyas, 1985b, p. 82)

Because, however, of the discriminatory factors mentioned above, and the fact that men comfortable working with men are unlikely to choose women and thus disturb the status quo (Gibbons, 1992b; 1992c), women have some difficulty in obtaining mentors. Some recent efforts have been made to remedy this: University of Washington (Gibbons, 1992b) in academia, and Corning (Culotta, 1993c) and Eastman/Kodak (Culotta, 1993b) companies in industry have made notable efforts in this respect).

Some unconventional mentors have been found, also. One source has been husbands, fathers, and brothers with scientific knowledge. Another has been the computer network for mentoring women known as Systers (Gibbons, 1992a). But the ultimate solution, according to Gibbons, is to have more senior faculty women in science:

> Graduate students with advisors of the same sex, compared with those with opposite-sex advisors, published significantly more research (Goldstein in Speizer, 1981). In addition, female faculty advisors of women graduate students provided positive role models by showing how they balanced their personal lives with their professional careers. (Mokros, Erkut and Spichiger, 1981, quoted in Matyas, 1985b, p. 83)

Tenure

Tenure has also been a difficult area for women, because

they are relatively isolated, and because of the prejudices with regard either to their "lack of commitment", or to the entrenched attitude that they are less able in science (Gibbons, 1992c).

The fact that women in science are, on the whole, less competitive and productive than men also mitigates against their obtaining tenure, since the quantitative factor may be taken into consideration more than the qualitative one (Barinaga, 1993).

Degree of Underrepresentation.

Women's attrition in science becomes very evident when one looks at the statistics with regard to their representation at higher levels. In the United States, for example, the field of neuroscience has been described as a leaky pipeline for women. While 45% of persons at the graduate level are women, only 18% on tenure track are women (Barinaga, 1992). The field of mathematics shows a very low percentage of women at the top levels: for 300 tenured men, there are only 2 tenured women (Selvin, 1992).

Tokenism in academia in relation to the hiring of women is not very helpful in increasing their numbers, since it tends to limit the flow of marginal groups into the dominant one, and prohibit any change of the system by the new group (Laws, 1975, cited in Matyas, 1985b).

Productivity.

Women scientists are, on the whole, less productive than men, although their publications are cited more often. They also tend to edit, rather than write, books and journals (Matyas, 1985b). This lesser productivity has been attributed to the intrusion of their childbearing and childrearing responsibilities; nevertheless, research has shown that women with children are more productive than those without (Gibbons, 1992). A lack of confidence which causes women to submit first-grade papers to second-rate journals has been observed however (Selvin, 1992).

> Although female compared to male graduate students have higher entrance GPAs and equal numbers of publications, they are less likely to rate themselves as among the best students in their classes or as a 'scholar' and 'scientist' (Feldman, 1974). Furthermore, negative self-image, which may be reinforced by 'microinequities' and/or blatant sexism, may cause female graduate students to contribute less in class, to avoid seeking help outside class, and to lower their career aspirations. In addition, such factors would undermine self-confidence of women hoping to excel in science (Project 65, 1982). (Cited in Matyas, 1985b, p. 84)

Since men and women bring differing attitudes to science, men attributing their success to talent, and women, their success to effort, another variable, the milieu in which women work, may be an important factor in their progress:

> ...an environment of acceptance and encouragement may be critical for women scientists. In the 'masculine' field of engineering, research has already shown this to be the case: while male engineering students stated that extrinsic rewards were their prime motivators for remaining in the engineering field, female students indicated that encouragement and support from others were key motivators for their continued study. (Matyas, 1985b)

Solutions.

Prevention may be as effective as cure. Her athletic career was cited as a source of confidence by one woman scientist:

> ...one of the things that helped me in science was my athletic career. It teaches you to compete physically and also psychologically--in the face of outside pressures, you have to perform. (Morelli, 1992b, p. 1388)

Affirmative action is often considered an undesirable strategy in bringing gender equity to the workplace. In the case of science in academia, however, it can be positive, according to some sources, mainly because decisions which marginalize women are often political, rather than worth-based, ones, It has been said as well, however, that affirmative action alone will not suffice: science has to become a true meritocracy.

> Women scientists must become active members of the network of communicating and collaborating scientists before they can make equal contributions to their fields (Matyas, 1985b, p. 98).

The problem of difficulty in obtaining tenure also has solutions. Some institutions have changed the timing, in order to accommodate interruptions due to home responsibilities. Harvard, in one case, granted tenure for teaching (Selvin, 1992).

Fellowships, visiting professorships, and endowed chairs have been extremely helpful to women. Examples of these are the Claire Booth Luce professorships, the Visiting

Professorships for Women, the Faculty Awards for Women, and some National Science Foundation awards, in the United States (Holden, 1992).

Social Problems.

There are several problems which relate to social matters. Marrying has been viewed by male scientists as evidence of a "weak commitment" to science on the part of women scientists (Amato, 1992, p. 1373). The double commitment is not without its strains, apparently, since statistics show higher marital disruption rates among women with six or more years of college (Feldman 1974, quoted by Matyas, 1985b).

Percentages indicate that having a scientific husband is very much the norm for women scientists. But at least some of the domestic responsibilities must be transferred to other persons: a lack of ability to do this can inhibit women in science (Birke, 1986). Marriage and family, despite constraints imposed, have not, however, been found to be key factors in impeding women's progress in science, not even in matters relating to timing of the marriage, childbearing, or family responsibilities. It has also been shown that marriage does not affect women doctorates remaining employed. Moreover, married women, even with children, have greater productivity than single women, and married women are not less productive than males in the years immediately before and

during childbearing. The main negative effect of marriage has been shown to be lack of mobility, especially that of moving to smaller population centres (Matyas, 1985b). A disproportionate number of scientific women live in large cities, and since job-switching is the key to success in academia, the "two-body" problem presents, that of finding two jobs in the same city or area, so that the husband and wife can live together (Gibbons, 1992d, p. 1380; Selvin, 1992, p. 1382). Unless both the husband and wife are "superstars," this problem can become very difficult if they are, as is often the case, in the same field (Barinaga, 1992, Science, p. 1366). This problem has had great impact on women's attainments in science. It is believed that this is the probable reason that women often stay for a long period of time in postdoctoral positions (Matyas, 1985b). These positions have been found, however, to be significantly and negatively related to entry level positions for women in the field of chemistry (Matyas, 1985b).

Childbearing

Timing in relation to childbearing presents a logistic problem to the woman scientist. Reports indicate that women induce childbirth to fit academic schedules, utilize sick leave, vacation leave, and sabbaticals in order to accommodate it, and in industry, try to decide whether to have the baby before the promotion, and possibly lose the promotion, or have

it afterward and be overwhelmed with responsibilities (Culotta, 1993c, p. 401).

Childrearing

Scientific parents find that they can no longer work a 70-hour week (Amato, 1992), and must coordinate calendars so that they are not absent at the same time from the home (Gibbons, 1992d). The day, also, must center around a five o'clock stop at a daycare by a parent, usually the mother, and this constraint can cut into the opportunity for valuable shop-talk with colleagues (Barinaga, 1992). Some workplaces have been disinclined to tolerate breastfeeding of on-site babies (Amato, 1992). Some scientific conferences have not allowed children on the premises, making it difficult for women with children to keep up with current research (Gibbons, 1993).

Family and Time

Families have found various solutions to the matter of time. Some positive solutions have presented in relation to childrearing: they are flextime, childrearing leave, childcare given at scientific conferences (Amato, 1992), and on-site childcare at the workplace. Swedish scientists consider their country to be "family-friendly," since legislation allows for up to a year of leave after the birth of each child, to be

shared between the parents (Kahn, Patricia, 1993b). Former Soviet-bloc countries have developed day-care systems including after-school clubs for older children in order to aid women with long hours of involvement in the workplace, and have provided camps for the children in summer (Bogouslavskaya, 1985).

Women have solved the problem of accomplishing both their domestic and career responsibilities in various ways: keeping a lab small to give more time for family (Barinaga, 1992); electing to become entrepreneurs or consultants, working from home (Culotta, 1993a); pruning aspirations, and remaining at lower levels of academia and industry; accepting underemployment; and shelving their careers temporarily, until children were grown (Culotta, 1993c). This last option presents the problem of catching up with the new research techniques and findings which have occurred during the woman's absence (Matyas, 1985b). Some have attempted to "have it all," while others believe this is impossible:

> If the job requires that you travel and put in long hours, and you don't want to because of family, then I'm sorry, you shouldn't expect it. Life is a series of choices. (Culotta, 1993c, p. 401)

The development of children is, according to research, greatly enhanced by intense personal attentiveness. In a Harvard study (Lundberg, 1974) of three-year-olds, only one type of mother out of five types produced a superior child. When considering alternative care and her own and her spouse's involvement, the scientific mother is challenged by the

question of quality involvement and whether or not the dimensions of total care, particularly at early stages, will include the practices of this type of mother, one who

> is constantly teaching the child and elaborating upon his experiences but who enjoys him at the same time. She is especially interested in developing the child's language. However, she does not push him unduly in any area and frequently follows his lead. (Lundberg, 1974, p. 35)

If the mother has satisfied herself that this is the case, she then may feel that she has met a responsibility in this regard. The scientific woman, therefore, is not acting only in relation to tradition when she commits to home and science with equal seriousness, and she is not evidencing a "weak commitment to science." She is taking a cold, hard look at her decisions. She must make a true evaluation of the amount of time that each area requires, and consider it in relation to her physical and psychological stamina, the roles that she fills, her ability to change roles, and the current status o her family's needs. An extreme version of workplace participation has proven to be detrimental to children in the Soviet Union, despite the good care provided for them. Mikhail Gorbachev spoke to this problem, ironically arising from the genuine attempt to provide equality for women and men, stating that his country was looking for means to provide women with greater amounts of time in the home since, according to a Soviet woman sociologist, their problem was that of having "two jobs" (Piper and Grudem, 1991, p.372). While the solution to this problem might not mean that women

must never work outside the home, it is evident that such work, carried to extremes, and without compensating factors, has sometimes been found to be detrimental.

In the case of the choice to have it all, however, some women have found having a scientific husband an asset:

> There's always been a complete understanding of why I work a 16- to 20-hour day, 7 days a week.... Having an intellectual companion, somebody to talk to who can share your concerns, is wonderful. It's almost hard for me to imagine you could work out a successful marriage otherwise. (Gibbons, 1992d, p. 1381)

Some women with scientific husbands, perhaps bearing in mind the needs of workplace and family, have found job-sharing an ideal solution, although this presents a problem if the wife is given unequal credit for equal contributions (Matyas, 1985b). Sharing of household responsibilities by a husband has been a new plus in North America:

> Among dual career couples, women worked in the home 1.2-2.8 hours per day more than men in the 1960s, yet they averaged only twelve minutes per day more than men by the mid-1970s (Matyas, 1985b, p. 96)

All in all, a woman in science is presented with many questions which beg solution. All of her logical skills will be needed if she is to find creative ways to manage her life, and meet the challenges presented by science within the parameters of a lifespan made up of twenty-four hour days.

Japanese Women in Science

Science in Japan

The growth of science, in Japan, has shown the same trends as those of the West, doubling its size every 10 to 15 years (Yagi, 1974).

Women's Progress in Science

For centuries, in Japan, there has been the opportunity for women who so wished to pursue the solitary life of a nun or scholar (Dilatush, 1976).

The medical profession has been accessible to women for about a century but natural sciences did not open up until later, after the social sciences had become accessible.

The end of World War II brought co-education:

> ...The change on the basis of the Fundamental Law of Education issued in 1947 was a revolutionary one since this law has assured equal opportunity for education regardless of race, creed, sex, social status, economic strata, or family background, and has admitted coeducation of men and women at all the levels of education. Consequently, women's participation in higher education in ages 15 and over has shown a remarkable increase (Hara, 1985, p. 2).

For women, two barriers remained: first, the patronage and discipleship system, which favoured men; second, the strong societal constraint for women to remain at home after marriage (Dilatush, 1976).

At least two ways have been identified for women scientists to reach their academic goals: first, the women's track, that is, attending women's colleges and institutions in which it would be relatively easy for a woman to remain to teach and/or research. This choice gives certain other advantages:

> It is a well-known fact that a higher proportion of graduates of women's colleges have a better position in our society than women graduates of coeducational universities. One reason for this is that at coeducational universities, men are much more likely to become leaders of extracurricular activities, and women often resign themselves to supporting roles. On the other hand, at women's universities, women have the opportunity to take leadership roles, with the responsibility of seeing projects through to completion. (Yagi, 1992, p. 9)

The second choice, the equal opportunity track, would mean attending co-educational institutions which might be larger and have a wider range of courses. This latter choice would, however, present the limitations of the patronage and discipleship system (Dilatush, 1976).

Pioneer women in science had neither option, but still managed to begin studies at universities, often as special status students (Yamashita, 1981-1991). Some of them had to make their remarkable achievements before they were allowed to study within these institutions (Yamashita, 1981-1991). At least two difficulties presented themselves: first, the prevailing idea of the time was that women were rather silly, weak creatures without a rational outlook, who could not do well in science, and second, high schools offered watered-down

mathematics courses to girls, and these women had to make up the deficit on their own (Yamashita, 1981-1991). One woman scientist, Yoshie Katsurada, (1911-), gained a world-wide reputation as a mathematician, but felt that remaining single had been a necessary condition to guarantee the solitude necessary to her discipline (Yamashita, 1981-1991). Another, Toshiko Yuasa, Japan's first woman in experimental nuclear physics, became a professor at Ochanomizu Women's University, nevertheless, most of her training opportunities occurred outside Japan. She had been influenced by the Joliot-Curie's nuclear research, went to Paris, studied under F. Joliot, and worked in various important institutions in France (Yagi, 1993). Had she not established herself outside of Japan first, her career opportunities within the country might have been fewer.

Societal Views

In Japan, men and women have been thought of as suited to different types of work (Pharr, 1980). Despite this stereotype, there are relatively high numbers of women in professions such as law and medicine. In the case of medicine, however, they are more concentrated in the "female" areas, such as obstetrics and gynaecology (Dilatush, 1976).

The Physics Teaching Crisis: a Source of Discouragement

The fact that, in international evaluation, Japanese high school girls have placed among the highest in their scores in physics, suggests that they potentially have much to

contribute to the store of human knowledge. Recently, however, there has been a severe decline in the enrolment in physics classes in high schools by both male and female students. The Ministry of Education examination and individual college entrance examination have been becoming progressively more difficult in every subject, in order to get an extreme distribution of marks. In this way choices between candidates for entry to particular tertiary institutions are more easily made. Because physics is a more difficult science subject, students do not wish to penalize their average by including it as one of the sciences. They are, therefore, avoiding it, and are choosing other science subjects instead.

These examinations (Appendix D), in addition to keeping potential enrollees out of physics, are causing a style of teaching of science in the high schools which is reductionist in the sense that it is oriented only to examinations, not to empirical learning, intrinsic interest, or critical and analytical thinking. The example with regard to physics is given as the extreme one, but all other science subjects suffer examination constraint. Hirata (1992) maintains that secondary education in this subject has really been designed for prospective university physics majors: because of this focus, textbooks are replete with mathematical formulae which will, presumably, be helpful later. The image of physics as a subject, however, becomes a very odd one to those who have not entered it as yet: they think of it as a memorization

course. Physicists would not envision their subject in this way, but when they attempt to promote physics as a suitable subject for nonmajors, they are met with rejection because of this known emphasis. It is possible as well that incoming science majors, such as girls who have done well in science at earlier levels, may be deflected from the idea by viewing such an approach to physics, and to other science subjects which may suffer from the same type of exam constraint.

That the approach is not helpful to conceptual learning has been demonstrated in recent research by Yasuo Hara, who with a working group examined 4,500 students in about ten national universities. He concludes, "These results indicate that some students can learn to solve many problems without understanding the physics concept behind them" (Hara, p. 54).

Aside from examination considerations, some teachers avoid teaching through empirical methods because their own understanding of physics has been one that emphasizes only a logical, rather than an experiential consideration (Masuko, 1990). They themselves learned as undergraduates largely by logical rather than empirical methods, with almost no time for creativity or analytical considerations (Masuko, 1990).

Even creative teachers of science in Japan are bound by the constraints of the national central examination. It is well known which high schools send more students to which universities, and teachers can scarcely teach without reference to this fact. The textbooks are exam-oriented and,

in the case of physics, are full of formulae which can be conveniently "plugged in" to a suitable question to produce the correct answer, without much in-depth understanding of the concepts involved. "For many students learning in schools means learning to get a good mark on tests and nothing more" (Masuko, 1990, p. 54). According to a 1985 investigation, only 30% of physics teachers were using experiments actively in physics classrooms, although 50% conceded their importance. They had various reasons:

1. They did not have enough classes to warrant teaching the national curriculum;
2. They had too many students (usually 45-50 per class) to be able to supervise in detail throughout experiments.
3. They did not have enough time to prepare experiments.
4. They lacked instruments and facilities.
5. Teachers and students were extrinsically motivated by the exams, and preferred to do "just enough" for that purpose.
6. Students thought experiments useless in relation to exams. (Masuko, 1990, p. 53)

Professor Tae Ryu, a teacher in Sophia University, vice chairman of the Physics Education Society of Japan, and one of the few at the tertiary level who has an understanding of the secondary level, when asked how teachers of secondary science were able to get job satisfaction under the circumstances replied that it was only in the science clubs which they sponsored in the high schools that teachers were able to enjoy teaching (personal communication, July, 1992). One 62 year old male teacher, frustrated at the type of teaching he was doing, retired early and arranged a Japan-wide "youngsters'"

(mainly high school students) science festival. At this festival, held in Tokyo in August, 1992, few participants were girls. Numerous teachers of science were present, but only two or three that were women (Personal observation, August, 1992). It is probable that girls who are not entering the secondary school science classes are also not entering the science clubs, which promote the very "girl-friendly" approach to science which the classes, with their exam orientation, fail to give.

The following example in the life of Professor Nakamura, a woman teacher in the School of Human Sciences at Waseda University in Tokyo demonstrates that such a visual, "hands-on" approach can have a dramatic effect:

> In a chemistry class at the University of Tokyo in 1950, her professor showed her a picture of DNA. She recalls, "I had never seen such a beautiful molecule before. I started to make a model with my classmates from clay and bamboo sticks. It was 2 meters high. I think it was the first model in Japan of DNA."

It is perhaps not surprising that Nakamura herself is now involved in a project which will allow the public to watch scientists do research on stage at the Biohistory Research Hall of Takatsuki (Koppel, 1993c, p. 391).

Physics Teachers

In a journal article (1990) about the education of high school physics teachers in Japan, Professor Ryu stated that "Many teacher training courses in science faculties seem to be

ineffective to train good teachers" (Ryu, 1990, p. 44). One reason offered is the lack of cooperation between university instructors and high school teachers, which Professor Ryu attributes to the fact that the former are buried in their research specialties, failing to recognize the needs of high school teachers. She also observes that 59% of teachers had only experienced two weeks or less of practice teaching (Ryu, 1990).

Some people have suggested solutions to some of the above problems:

> Many teachers complain that they are too busy... for university entrance examinations. They say... no time is left for experiments and concept formation. A counter argument... was expressed... that attractive experiments and... formation of... concepts help very much in passing the examinations. It may take [a] long time that such [an] assertion will become admitted by many high-school teachers. (Workshop 3, Buturi Kyoiku, 1992, pp. 72-73)

Also,

> Through teacher-teacher interactions, it is really expected to liberate their minds for charming physics... full of interesting experiments and useful applications.... In contrast to U.S. and China, the contact of Japanese professors with high-school teachers is very limited, except for those who are working in a faculty of education (Buturi Kyoikuku, 1992, pp. 72-73).

Present-day Women Scientists

What is the present-day situation in relation to women's entry to science? Professor Hiroko Hara, in a report given to a UNESCO Meeting of Experts at Wrocaw, Poland, in December, 1985, noted that while greater numbers of women had begun to major in the natural sciences during the prior ten years, there had not been a corresponding increase on the teaching

staff of universities, or in their administrations. However, some universities previously closed to women had opened their doors to them. Hara noted, also, that a woman meteorologist specializing in chemical physics had been elected as the first woman member of the Science Council of Japan (established in 1949), and that three other women had subsequently been given membership. [Details will be given in another section, below].

The following recommendations were made for the future:

1. "A National Plan of Action," which came out of the United Nations Decade for Women should be maintained;

2. Teachers and administrators in tertiary institutions should become conscious of training women as professionals;

3. Childcare should be provided for students, teaching staff, researchers, and administrators in higher education;

4. The condition of women in the lower echelons of teaching staff should be looked into from time to time in case they were being overlooked for promotion;

5. Women's universities should be encouraged as a stop-gap measure for providing role models for young women, and a haven for them where they could show their capabilities, until societal conditions became more conducive to encouraging women.

6. Companies should be encouraged to employ more of the trained women coming out of universities with various levels of achievement (Hara, 1985, Summary).

Women scientists in Japan have shown a different pattern of productivity from men scientists. Their research productivity is affected by the childbearing and childrearing years (Shimizu, 1990). This finding has implications for physics and mathematics where more original work is done early.

Japanese women scientists have organized to share professional interests by holding meetings and publishing newsletters (Yagi, 1988). An example of such an organization is the Women Physician's Association found in almost every city, where members meet, regardless of their ages or universities of origin. Another organization is the Women Physicists, who have a newsletter and meetings, and a larger group, the Society of Women Scientists of Japan.

Few Awards

There are few special awards for women in science in Japan, but one exception is the Saruhashi award which recognizes an established woman scientist (Yagi, personal communication, 1992) and is designed "to highlight the capabilities of women scientists" (Normile, 1993, p. 424):

> Saruhashi, 73, retired from government service after a distinguished career as a marine geochemist.... clearly a role model herself... was an undergraduate at Toho University during World War II.... In line with Saruhashi's interest in broadening recognition of female scientists, recipients get more acclaim than cash. There is a cash award, but at $2,400 (Y300,000) it isn't in competition with, say, the Japan Prize.
>
> "We thought it would help pay the way to a conference overseas," Saruhashi says.
>
> "It would be nice if it could be larger, but the fund is pretty small." (Normile, 1993, p. 424)

Of course, Japan has its general awards, and the Japan Science Academy (Nihon-Gakushiin), although it has had, as mentioned earlier, no women members thus far, did in 1985 give a prize to Professor Tomoko Ohta, a woman biologist who will be mentioned later for different reasons. Another more general academy which includes both social and natural scientists, and is therefore less a male preserve, the Science Council in Japan (Nihon-Gakujutsu-Kaigi), has had women members, including Professor Saruhashi, mentioned above, who was a member from 1981 to 1985. The other three members (1991-1994) were from social science, economics, and domestic science (E. Yagi, personal communication, April 5, 1993).

Few Elite Positions

The following is a group of statistics from a recent publication of Science (March 13, 1992) with relation to women in science at the very prestigious Kyoto University which supports the contention that, despite a sizable minority of women holding advanced degrees, there are few who also hold positions commensurate with these:

Table 2

Percent of Women by Faculty and Rank

	Science	**Engineering**
Undergraduates	6%	3%
Master's students	5%	3%
Doctoral students	10%	6%

Assistant professors	---	---
Professors	---	---

The publication points out, also, that

> Japan's Science and Technology Agency estimates that almost 8% of that nation's scientists and engineers are women. Yet women are barely represented in the elite institutions. These figures are from Kyoto University, which has produced many of Japan's Nobel Prize winners. (Science, March 13, 1992, p. 1378)

It seems that the situation is somewhat analogous to that in America in the late 19th and early 20th centuries when women were allowed and perhaps encouraged to study, but not to obtain good positions. Koppel explains this phenomenon by reference to a recent interview with population geneticist Tomoko Ohta:

> Ohta believes many barriers to women in science remain in Japan.
>
> "Young lady scientists choose a very hard way if they want to become professional scientists.... Until graduation from university, boys and girls are very equal."
>
> But after that, she says, barriers appear when women need to "be hired to do professional work. That is very difficult. And then to get promoted and do their own work is a second barrier."
>
> In addition, women are still subject to social pressures to get married and have children, which are often seen as incompatible with a career. Although there have been reforms--outlawing outright gender discrimination in hiring, for example--the culture is slow to change.
>
> "People are not changing," she says. The reason: "How we think is very difficult to change." (Koppel, 1993b, p. 403)

Fumiko Yonezawa's experience seems to confirm what Professor Ohta says. Now a full professor at Keio University, her experience was as follows:

> Just as her career was taking off, in 1966, she had a daughter; two more soon followed.
>
> "I worked very hard. I had to bring them to nursery school; I had to do the shopping; I had to cook. My husband didn't help me in any way at all. He is a typical Japanese husband," she says. Furthermore, she says, one reason she stayed in academics is that the doors to industry were slammed in her face. Despite being consistently at the top of her university class, "When we tried to find jobs in companies, they all said, 'Only boys, no girls wanted....'
>
> After that kind of reception, she returned to the academic world, spending a few years at Yeshiva University and City College of New York.... Then she returned to Japan and in 1981 was named professor at Keio University's new department of physics....
>
> For her success, Yonezawa gives much credit to her mother, who was forbidden to attend university by her father but began teaching Yonezawa geometry when she was still in kindergarten. And she thinks parents generally hold the key to the cultural barriers that exist for women in science in Japan.
>
> "Parents say girls are not good at mathematics, and they don't want to spend a lot of money educating their girls in science. I think girls are conditioned since they are very young. Generation after generation has been conditioned like that. It will take generations to correct that." (Koppel, 1993a, p. 422).

An Impediment

Sharon Traweek, in her observations of scientists in Japan, noticed that women were never seen at the late-night collegial dinner sessions frequented by male scientists. She believed that the women might therefore experience difficulty in keeping up with current developments within their scientific disciplines (Traweek, 1988).

Summary

The points brought out in the studies cited in this chapter, although relating in some cases to women in science in the West, have been important ones to consider in relation

to Japanese women's entry to and continuance in, science. It is evident that, in Japan as in America, there has been strong territorial discrimination with regard to women in science in the past. Nowadays, the discrimination is, for the most part, hierarchical, as has been seen in some of the statistics given from Kyoto University.

In many ways, the idea of a "different" education for girls is more widespread in Japan than in the West, and passivity in the laboratory is even more likely to be reinforced. In Japan, it is therefore even more important to ask the question, "Given the separate roles of girls and boys in Japan, how did the respondents of this study become active in science activities? What foundational experiences did they bring to the activities? Who, or what agency, helped provide these experiences?"

Insofar as their educations are concerned, we may ask, given the non-specialist character of elementary science teachers in Japan, similar to that in the West, "What fostered the positive response of these women to science? Did they happen to meet one of the few elementary teachers who happened to have a mini-expertise in science? Or were there persons outside of the school who, during the respondent's elementary school years, provided some kind of experience for them?"

In relation to high school experience, we must ask whether the women of this study experienced a warm and caring atmosphere in science classes, or if they had a contextual,

holistic, "hands-one" education there. In short, was the process a "girl-friendly" one? What role, if any, did teachers and counsellors play?

Was the atmosphere of these respondents' universities cold and sterile? If so, how did they overcome this? And what made them able to surmount the "masculine" image of science?

What was the role of their parents? Were these women like the well-fathered and well-mothered executive women of Hennig and Jardim's study who mounted the ladder of success in nontraditional areas with ease, incorporating both the "masculine" and "feminine" aspects of themselves? Or did some other factor aid their progress?

After science entry, did they enjoy an interrupted career? How did they avoid academic isolation? What was their perception of male scientists' view of them? How were they enabled to deal with life in a male-dominated field? Did they have mentors? Was there an environment of acceptance and encouragement?

In general, what gave these women confidence? Was science in Japan a true meritocracy for them? What role did such matters as scholarships, fellowships, and foreign study play?

Of course, women in Japan marry, and there are even greater implications in relation to this event in Japan than there are in the West insofar as science career entry is

concerned. What about our respondents? Were scientific husbands a factor in their success? Did lack of mobility, or their husband's mobility, affect the women? How did childbearing and childrearing fit into the picture? Did these women "have it all" in Japan, in science? Were there any "family-friendly" situations? What were their specific strategies in relation to domestic responsibilities of one kind or another?

All of these matters have already been researched in terms of other times and places, and findings there may inform the present investigation, in cases where situations are similar, and may motivate the question, "What is the situation with regard to these concerns insofar as women in science in Japan are concerned?" It is entirely possible, however, that there are constraints particular to Japan that could not possibly be examined by reference to research done in other countries, situations which are culturally or historically bound, and these situations would have to be addressed using other frameworks. All in all, whatever the case, the answers to the various questions should prove to be interesting ones.

Chapter III

Methodology

Pilot Study

A small pilot study with women scientists was done in Tokyo in 1991, involving the use of a group interview, and was held after a meeting of the Society of Women Scientists of Japan. About eight women attended the interview and shared their views on fairly general questions, such as: "Can a woman scientist have it all (work, marriage, children, hobbies, etc.), in Japan? If so, are there any particular situations which facilitate this?" The atmosphere was good: there was consensus on some matters, and a good deal of diversity in situations was revealed.

Sample Selection

The particular sample used was found in a serendipitous manner. A quest for literature on women in science in Japan had begun with a search at Sophia University in Tokyo, had led to the Women's National Centre Library in Saitama Prefecture, and, finally, to the Institute for Women's Studies of Ochanomizu University in Tokyo. There, a woman professor of science with additional interests in both the history of science and in issues pertaining to women took an interest in this project, setting in motion plans which would lead to the cooperation of The Society of Women Scientists of Japan, and

other individuals who could inform the development of the inquiry, either by their participation as volunteers, or by their supplying of information and practical help in relation to the development of a questionnaire and interview protocol which would be appropriate in the Japanese context.

The questionnaire was given to 28 women volunteers. The first of these were members of the Society of Women Scientists of Japan. They had been contacted by personal note written by the woman scientist in advance of one of their meetings, and had been told that they would have an opportunity to participate in the survey, and also, if they so wished, in an individual interview later.

Many of the women who attended the association meeting (about 15 or 20) filled out questionnaires and some took away additional copies to other women colleagues of their acquaintance, or at their workplaces.

In addition to this group, a number of women from scientific disciplines who gathered at the Institute for Women's Studies at Ochanomizu University one or two weeks later for a seminar about women and science in Japan also wished to participate in either the survey, or in both the survey and interview. These women, on the whole, were a younger group than the first group, but would add another perspective to the survey, since their background experience was more recent, and would take account of certain societal, educational, and familial factors which would have changed

since the time that the more established scientists had made their vocational choices. One or two of these respondents were still students, but they were likely to carry on through the PhD level. It was impossible for them to be established yet, in the same sense as the Society women, mainly because of the time element, but it would be impossible, also, to get a fair picture of the current situation without their responses.

In addition to the respondents named above, one other woman respondent was found in North America. She would add an intercultural aspect to the study, since her career decision had been animated by a stay in the United States, and she had the comparative experience of having lived in two cultures.

The idea was not to find a representative sample, however, but to develop a profile of Japanese women in science through the experiences of several such women.

Instruments

Both questionnaire and interview schedules were used in the research.

Questionnaire.

The results of the group interview, together with the findings from the literature, were used to formulate the final questionnaire, and to refine a protocol for use in individual interviews.

The questionnaire had four sections. It began with information concerning the background of the woman scientist.

The next section dealt with her informal, non-formal, and formal socialization. Another set of questions related to the specific circumstances, experiences, persons, etc., who had affected her decisions. Finally, there were questions on her opinions concerning gender differentiation coping strategies and the advantages and disadvantages of being a woman scientist.

The questionnaire was presented in Tokyo at a meeting of the Society of Women Scientists of Japan. It had been written entirely in Japanese, in the usual page format used for such enquiries there, although it was a little longer than Japanese questionnaires of the same type.

It was given with a covering letter explaining the research. The women of the survey were disinclined to use a subject consent form, since greater freedom would be possible without names being used. Therefore, a formal signature was not made obligatory.

The participants were assured of confidentiality. They all willingly participated and were explicitly given the option to refuse to answer particular questions according to their preference.

The Interview.

The interview was given to about 10 women from the questionnaire group of 28. They were ones who had volunteered to be interviewed, especially those who had not participated in the group interview. Although, basically, the same paths

of enquiry were followed as had been taken in the questionnaire, the questions were often more open-ended, or more detailed, and allowed for a more subjective answer and richer data. For example, one questionnaire query relates to whether the respondent had been encouraged by a family member: this question only elicits a "yes" or "no" and a specific pointing to the member of the family who might have encouraged her. However, in the interviews, as a respondent describes her early situation, the "how" of the situation often becomes evident. A father, for example, is teaching the children of the family to observe nature while on outings for nature drawing. Data found in this interview, therefore, may add considerably to the relatively skeletal picture given by the questionnaire. Data from one interview may certainly not indicate how all of the questionnaire respondents were "encouraged by a family member," but they do show possibilities. Replies by other interviewees add other details, thus rounding out a profile of the Japanese woman in science. Of course, particular responses of individual interviewees to the questionnaire which they had previously answered were kept in mind as the interview was conducted.

The individual interviews were planned to be conducted in Japanese, by a good translator, with the researcher present in all cases possible (except where logistics of some type prevented it: e.g.: a long-distance telephone interview). In the case that the respondent was fluently bilingual, and also,

wished to reply in English, a copy of the interview protocol was supplied in Japanese for clarification.[1] In two cases, a Japanese interviewer questioned the interviewee, and received her replies in Japanese in the presence of the researcher, sometimes informing the researcher, at that time, of the general tenor of the discussion, so that the interviewer could ask particular questions of the respondent if she wished, could keep an empathy with the procedure, etc. These interviews were audiotaped. In another case, a Japanese interviewer in Montreal telephoned a respondent who had volunteered after the researcher had left Japan, conducting the interview in Japanese, and recording answers on paper: this particular interview was done in two segments. In two other cases, where a Japanese interviewer was not available, the researcher took a Japanese-language copy of the questions to a respondent: the respondent, fluent in either English or French, would clarify the intent of these questions in either of these two languages where necessary, then answer them in Japanese into a tape-recorder; small-talk, introductions, etc., were done in either English or French. Three respondents, extremely knowledgeable in English, two of them because they had done foreign study at a graduate level in the United States, elected to reply to interview questions in

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[1]There was one exception to this, which occurred before the protocol was fully developed, and another, where the person was, in addition to being a respondent, a translator, and familiar with the protocol already.

English. In all cases in which replies were given in Japanese, these answers were later translated for the researcher by an extremely competent Japanese translator with a knowledge of the scientific milieu, in Montreal.

Particular attention was paid to Japanese cultural factors in the administration of the questionnaires and in interviews. For example, the interviews were conducted in a relaxed, unhurried setting, such as that afforded by a post-dining, or post-cafe, situation. The Japanese need some assurance that they are more than mere observed phenomena being held under a microscope. Usually, an opportunity for them to ask questions of the researcher does much to allay fears that only a one-way communication is involved, and that persons are, indeed, valued for their personhood.

Sample Description

Who are the women surveyed (their demographic data, attainments, professional liaisons)? [all women]

Birthplace

Data in this section were obtained from the questionnaire, and therefore pertain to both questionnaire and interview, respondents.

The 28 women in the survey were born mainly in large cities. There was a particular concentration in Tokyo, not entirely surprising in view of the fact that the questionnaire survey was presented there. It is also a common practice to

remain to teach in the university in which one has studied, which could, especially in the case of a large metropolitan centre, be situated in one's home town. It is interesting, however, to consider another possible scenario which could also end in a large city, that of being born in the small towns or rural areas adjacent to Tokyo or to other large cities of Japan. The fact of being born in such a rural area or small town would not negate the fact that one would probably relocate to study in a large city, given that most of the universities would be located there. The women of this survey, however, in hardly any cases migrated from small towns or rural areas to cities. They were already present in the cities, having been born there. This is in accord with the general pattern, worldwide, of women scientists, who have tended to come from cities. Male scientists, on the other hand, have in the main, come from small towns (Traweek, 1991, seminar at Ochanomizu University).

In general, most women grew up in the prefecture in which they had been born. In one or two cases, however, the fathers of women had jobs which required them to transfer every three or four years.

Placement in Time:

Central to the consideration of data given by these women is their placement in time, since there are distinctive experiences which pertain to various eras which might have affected the opportunities and outlook which they would have

had.

In general, the women of this study could be divided into four groups: Group A is the pioneer group which would have been born in the years 1910-1925. There would have been no official coeducational opportunities for this group at college or university level; it would have been necessary for them to attend special women's colleges, or to gain special permission to audit classes in men's universities as special status students, without necessarily gaining the opportunity to write examinations or gain credit there. This study has one woman in this group.

Group B found a somewhat changed situation. These women, born from 1926 to 1932, graduated in the years 1941 to 1950, at the time that sweeping educational changes were taking place in the educational system. Many of these women would have come up under the old system, however, which had a weaker curriculum for girls in the area of mathematics and science. At the time of the change, education was made non-discriminatory: these women, therefore, were permitted to attend university on an equal basis with men. They usually, however, attended women's colleges and universities at the undergraduate level, because their families would have preferred this at their then tender high-school-leaving age. However, once they had reached the doctoral studies level, they often elected to attend a coeducational university, if it met their academic needs. At this stage, they would have been

at an age where their families would have been less protective, and, in any case, they would already have proven their ability to survive in the adult world (Hara, personal conversation, 1992). There are eight women in this group.

Group C. born from 1933 to 1954, would have graduated from high school after the war, and would have come up through a system of primary and secondary education which was completely of the new type. During the years that they were growing up, more and more girls were attracted to schooling, and they became less and less of a minority within the school system. There are ten women in Group C.

Group D, born from 1955 on, and entering senior high school from the year 1970 onwards, would have encountered high school classrooms which, on average, had more female than male students in them. The school system had become, indeed, very coeducational. There are nine women in this group. A summary of this information is given in Table 1, below:

Table 1

Women of This Study

Group/No.	Year born	Schools	Sr high entry	Univ entry
A (1)	1910-1925	Old	1925-1940	1928-1943
B (8)	1926-1932	Old/new	1941-1947	1944-1950
C (10)	1933-1954	New	1948-1969	1951-1972
D (9)	1955-	New	1970-	1973-

Colleges Attended

The Group A respondent attended a "special" women's

college. Group B had, perhaps, the most elite experience, since four of its members attended, at one point or other, Tokyo University, which has highly competitive entrance requirements, and at least two of the women in this group did foreign study. Most of the women in this group had attended a women's college, however, at the undergraduate level. Group C shows a similar pattern, but only one person passed through Tokyo University, and one listed foreign study. Group D lists a number of universities. No one from this group has yet attended Tokyo University, but, because of age, some are still at the pre-doctoral level in their studies. One woman in this group, however, attended a "science City" university, a recent type of development.

Doctorates

The Group A respondent has a doctorate. In Group B, five out of eight respondents do; in Group C, nine out of ten; and in Group D, only one does, so far, although another is about to receive hers. Several of this group are still students, and were included so that current high school and university decisions for science could be included with ones made in earlier years.

Kinds of doctorates

The Group A doctorate is in Life Science. Group B's are in science, agriculture, and one (foreign) is listed simply as a PhD; Group C's include five in science, two in engineering, one in a specialty of medicine, and one in pharmacy. The two

doctorates (one pending) of Group D are in a specialty of medicine and in an interdisciplinary field (this last respondent has changed from a totally natural science focus to one which is interdisciplinary).

Majors

The majors of these groups express their exact interests more clearly, in several cases. The Group A major in a branch of life science also included a focus on an adjacent branch of that field. Group B includes three persons in pharmacy, three in physics (not so traditional for women), two in agriculture, and one in mathematics. This group has more persons in physics than other groups. It should be remembered that around the time these persons were entering university, Hideki Yukawa, a Japanese scientist, received the Nobel Prize in physics; also, the American movie Madame Curie, mentioned by many respondents, was current, and, in fact, Curie herself had died only a little over a decade before, which means that she had been contemporary with Group B during a part of their lifetimes. One respondent credits these persons as having been influential in her decision to enter physics:

> After seeing the movie about Madame Curie and knowing the fact that Professor Hideki Yukawa was chosen as the Nobel Prize winner in physics, the first Japanese winner, I decided to study physics at college.... (Yagi, 1991, p. 1).

Physics had been a more visible field of science during these years for the reasons mentioned above, but also on the negative side, because of its use in wartime. It may be that

one of the respondents, like many Japanese women, a pacifist who wished to specialize in physics in order to "change the world," had the idea of using it in some way that would encourage peace.

Group C manifests the greatest variety in its majors, perhaps proving that women were beginning to feel at home in the universities, and were beginning to tailor their decisions more precisely to their talents. The majors include biology, molecular chemistry, textile engineering, pharmacy, animal reproduction, physics, chemistry, and biochemistry.

Group D's majors are varied, also, and include insect pathology, quantum chemistry, plastic surgery, psychiatry, and endocrinology. One respondent has not yet decided about a major, but it will relate to pharmacy.

Apart from those who are presently inactive in the academic community, or those who are the younger students, most respondents belong to a number of academies. The Group A subject belongs to four. Group B's belong to an average of three, as do Group C's. Group D's affiliations are the most varied in number: for example, one subject belongs to eight academies; one to four, one to two academies, one to one, and two (students) to none.

Occupation levels vary according to group. This variation is to be expected, since the older respondents have had a longer time to achieve their goals. The Group A respondent has full professor status, and in fact has been the

dean of a faculty. Group B has four full professors, and two heads of laboratories (either now or before retirement). In addition, there is one respondent who works in a pharmacy, and another who is second in her laboratory. Group C has one full professor, two associate professors, two assistant professors, two who are second in their laboratories, and two research assistants. One of the associate professors, however, has two earned doctorates in her field, so it is possible that she is underemployed in terms of status. Group D includes one engineer, one ordinary researcher, one university lecturer, one person who practises a medical specialty in a hospital, one who is a part-time assistant of a professional association, and two students.

In general, there is someone of almost every rank in science represented here, and someone of almost every age. A number of the respondents are married, and a number are single. Some have children. One of the respondents is a Japanese expatriate living in Canada, so there is an intercultural perspective. Some of the respondents have done all of their studying in Japan. Others have done some foreign study. A good range of disciplines is represented. Perhaps conspicuous by their absence, however, are astronomy and geology. This survey was made from Tokyo, and as a result does not have a country-wide perspective. The range is, however, sufficient to provide some variance in perspective.

Chapter IV: Data Presentation

1. What are the characteristics of the respondent's birth families, including their socio-economic and educational levels?[1]

All of the respondents came from families which could be considered to have high socio-economic status. At least four fathers of the respondents were graduates of Tokyo University, which has extremely competitive entrance standards. There appears, however, to be somewhat of a democratization which occurs as the respondents get younger; the older ones came more often from families in academia or in the civil service (an elite corps, in Japan) or in the medical profession. The younger groups include some of these, but also have as parents entrepreneurs and company white-collar workers, and persons in education. In the younger groups mothers were more likely to have been involved in gainful work. However, none of the groups include farmers or fishermen or other blue-collar workers as parents. The three respondents who specialized in agriculture were not, for instance, farmers' daughters, but rather, were from the middle class just as the other respondents were. There was a fish middle-man's daughter in life science, but not a fisherman's daughter; a rice

[1] When [interview] is not specified, data can be assumed to be from the larger, questionnaire group of women, which includes, of course, the interviewed women as well, and also, women in the pilot study, most of whom filled out questionnaires.

merchant's daughter in science, but not a rice farmer's daughter.

There was found to be a high incidence of causal and instigative persons in birth families of the respondents, such as a grandparent who wrote a book, or took out a patent, or started a business; a father who pioneered activities, or who invented; a mother who "fixed" things, one who enjoyed working with technical apparatus, or one who introduced a school uniform. The word pioneer was also mentioned by respondents with regard to a school and college attended, and an area of the country in which two respondents grew up is considered the pioneer area of Japan.

Some other characteristics were found in the upbringing of the scientific women interviewed:

a) field-independent thinking, with reference to universal, more than to local, values: [interview]

> *He [father] emphasized... "Pursue the truth: ...whatever the truth [is], is the most beautiful thing in this world, you know, and that's what he emphasized a lot.... We were in such a free atmosphere that we could talk about anything, you know. Well, I think it was a very nice atmosphere, home life.*
>
> ***
>
> *I don't think anybody taught us, but our family atmosphere was such that we had our independent opinion, not to be influenced by others. Even my mother was not really paying attention to what her neighbours were thinking, but rather, she was behaving based on her own judgment.*
>
> ***
>
> *My parents were aiming for free ideas. Theoretically, they valued the non-traditional. However, as I grew*

up, I began to realize that they were adhering to the old [prewar days] values.

***

I think our household was very free; it was quite free for us.

***

Q. Is your family open to unusual patterns?
A. *Oh, yes. I think so. I think so.*

***

Q. Do you think you were more independent in your thinking than other children?
A. *I think I was always free.*
Q. Do you think that is because of your experience or your family?
A. *Maybe both, I think.*

b) a less arbitrary relationship and greater verbal interaction between parent and child: [interview]

He usually had dinner with us, like any other family in those days. During the dinnertime, we used to talk about many things. After the dinner, while my mother and maid were washing dishes, my father would come and play with us. We used to play various card games hand-made by my father. I even recall that we had a sort of pop-out book hand-made by my father and the children that appeared in this pop-out book were we. He used to play with us, and also, he used to answer our questions, such as, "How do plants grow?"

***

Our family was quite intimate when we were young children.

***

When we were young, he [father] always wanted us to get together whenever he was home; he wanted us to be around him.

***

c) The respondents often, also, came from families who had an interest, either academically, professionally, or through hobbies, in science. The following are examples:

mother: nurse

father: scientist

father: medical doctor

father: naturalist hobby

mother: medical doctor

uncles: medical doctors

father: high school biology teacher

mother: Bachelor of Science degree

uncle: professor of technology

father: producer of chemistry products

father: pharmacist

father: in agriculture

uncle: medical scholar

d) They often had teachers or researchers in their family, either in a scientific or non-scientific field:

fathers: Japanese literature; medicine;

uncles: mathematics; Japanese history; medicine

elder sisters: junior high education;

younger sisters: agricultural economy; physics; English literature; junior high teacher

mothers: medicine; elementary education;

literature;

grandfathers: education; electricity; economics;

entrepreneur; bank and railroad; law;

younger brothers: physics; entomology; psychology

aunts: economy; Japanese history.

e) They were often encouraged to observe, especially in a visual way, the environment: [interview]

They would take us to the museums, or things like that.

***

We painted together, but my paintings were not as good as his.

***

A. *Remember, in my childhood days, our entire family used to go out and find an orchard to draw, such as trees and plants. While I was drawing, my father would come and make a comments, such as, "Don't you think that it is more detailed here than in your own drawing?"*

Q. Oh, I see. That means you received an education to observe precisely and accurately, through drawing?

A. *Yes. For instance, when you see a white object, there is a dark part to it, but a little child would paint it white all over. Then my father would come and say, "Look carefully. There is a degree of whiteness from one to ten."*

***

Yes, he brought it [the microscope], *and he said, "Look at these red blood cells; look at the shape."*

***

f) They had sometimes been given instruction in mathematics. [interview]

My brother and I were given college-level math lessons privately.

My mother taught me some math.

The maid taught a form of math.

***

My mother explained math to me.

***

We took soroban from the third grade on.

***

I took kumon math lessons.

2. What sorts of attitudes had the women scientists developed regarding male/female roles? [interview]

Before looking at the attitudes of the respondents, it seems appropriate to consider the attitudes within their families. One of the respondents came from a typical Japanese home which had division-of-role [separate areas of work for males and females]:

> *Economically speaking, my father was the only provider of our family. He didn't take care of us too much. He left most of the care to my mother. It was a typical case.*

One family appeared to have two views going. The elder brother of a respondent stated that science entry was not suitable for women. A sister, on the other hand, encouraged it.

Another noted a double role within the family itself:

He [father] *was the main provider in our family; at the same time, he took good care of us.*

***

Another respondent mentions that such a division-of-role applied, in her home, only to the parent generation. The mother had had to take complete charge of the home, but the daughters had been allowed greater latitude in their activities.

As far as my father was concerned, he didn't particularly limit what we, the girls, should do. For example, when I wanted to get a driver's licence, my father didn't say anything particular, so, in my family, there was no discrimination according to gender. However, at the same time, my father expected us to be able to do certain things as women, for example, flower arrangement or tea ceremonies: we were to take lessons. Beyond this, if we wanted to do research, he had no objections.

Significant Females

Significant females in the lives of these respondents were not those who exemplified a passive role. Mothers are an especially interesting consideration, since they are usually the first female exemplars in the lives of daughters, and are often quite influential. The women mentioned below were anything but passive. In addition to this, some of them also exhibited some androgyny in their choice of activities:

However, in those days, it was right after the war, and we were lacking in food My mother was cultivating our backyard, providing food for us. My mother used to

knit and sew, but I don't know whether you can call this a hobby or not, because she was making clothing for us.

In those days, this elementary school didn't have any uniform, so what my mother did was to modify the uniform of the former school, and bring it to this elementary school. It was accepted, and thus the uniform was introduced to this elementary school.

Q. Maybe economically, she was dependent on your father, but mentally, she was quite independent?

A. Indeed, she was the type who would have become a chairman of the PTA.

***

mother was a very determined woman; she wouldn't send money unless respondent would take the course she chose;

***

mother was very, very independent; unlike other Japanese elderly women, she refused to live with her children when she became old;

***

Personally, she is quite an independent kind of person in a sense. [She] was quite a tomboy in her young days.

***

At home, she was very independent and managed most of the household.... In her school days, she had a desire to enter broadcasting college.

She gave her consent to my decision of going to the university, and also to living in a rooming house. In fact, she wanted me to do whatever she could not do.

***

A mother emphasized to enter an occupation which would be lucrative enough that the respondent could be spiritually and financially independent;

A mother, in her youth, had chosen to study medicine because it was the longest-lasting course in the university; by studying it, she assured herself an independent income, but also, ensured that she would not be arranged into an early, forced marriage;

***

A mother repaired many electrical and audio-visual appliances. Her uncle, a technology professor, had played with her when she was young, and had taught her many technical things;

***

A mother founded a company and became its president. This was not a typical thing for a Japanese wife and mother of five to do. However, she did this in a way that minimized any criticism on the part of Japanese society. Respondent describes her as a "very strong and independent" mother:

She didn't want us to be single and career-pursuing, but at the same time, because of her experience, she wanted us to have some kind of skill... in case something happened, we could always get a job, or we could support, you know, the minimum. That she wanted to be sure, so my sister, she hated science, you know... so she majored in literature, English literature, but, also, she went ahead and went to secretarial. She took a secretarial course so that she could get sort of like a certificate. Yeah, in case something happened, she could always use it. That's my mother [her influence], *you know.*

***

My sister studied music, but not only that, she attended a French school, and she learned French. She worked in a company, but required the knowledge in French, and thus she supported our family. She also did some tutoring to support us.

***

A mother thought that, in future, it would be better for women to support themselves, in case their husbands couldn't support them, or died.

***

A mother showed much dedication to her work in the home; respondent admires her for that, although she doesn't think she would like to do the same thing.

***

She was a perfectionist when it came to the household management. She used to sew our clothes, to prepare home-made miso, to do research before shopping, to keep books every day, etc. She was very skilful (manual dexterity).

***

Q. Did your mother give you the injections?

A. *Yes, that was just a kind of vitamin injection, something like that. My mother always said, "I will try to get you under the best medical care." At that time, you know, I was a kind of guinea pig for my mother.*

***

She was a very protective mother, maybe overly protective. Also, wanted to raise her children in a very idealistic way. She worries a lot.

Male/Female Roles [interview]

Several other respondents mention details of their domestic situations which shed light on male/female roles:

My father was not quite a sexist.

He [father] *brought my brother and myself to ____ Heights during summer, collecting [organisms] and guiding his students, that sort of thing, what he was doing.*

She [mother] *worked mostly full-time. So we had a maid helping us.*

Q. Would you say that you are over-fathered, or over-mothered, or under-fathered or under-mothered...?
A. *My father was not so powerful in that sense. I think mother was...*
Q. Powerful?
A. *Powerful.*
Q. Was she the central figure in the household?
A. *I guess so.*

***

Sex-stereotyping [interview]

When asked about sex-stereotyping, respondents reply as follows with regard to their homes:

A. *Almost none.*

***

A. *Not very much, but once in awhile they [said] that girls shouldn't be behaving this way, or something. Once in awhile.*

***

A. *When I became a high school student, my mother asked me to do some household chores (dish-washing, etc.), while she never asked my brothers.*

***

A. *Yes, in a sense, because we, the girls, were taking lessons such as music lessons and dancing lessons....*

Androgyny [interview]

Respondents themselves, however, despite whatever constraint, show evidence of having developed a certain amount of androgyny, either in their choice of male friends, or in their choice of activities labelled as masculine, coupled with their participation in the usual activities stereotyped as feminine. One respondent describes her sumo wrestling with small boys as an ailing preschooler:

> *We had a very good place to visit: one of my friend's houses. His parents were working nearby as farmers. Everybody was kind of welcome. Ten of us gathering there--mostly boys, you know. Their parents were working as farmers nearby, so maybe they just came back for lunch.... So we always played there, even on rainy days...and sometimes went out to do bad things on the lake or something like that.*

Later, this respondent enjoyed, with boy buddies, putting coins to flatten on track rails at a dangerous railway site in Tokyo:

Q. High risks bring high returns?
A. *I didn't notice that kind of profile, but I just enjoyed doing that. I think I was just kind of "bad." I was a sort of bad girl by the standards of the day... because, during my girlhood, and*

even today, a girl must be a certain kind of girl.

Q. A doll-in a-box? [kimonoed doll in glass box]

A. Something like that.

Q. How did your mother feel about that...?

A. I think she... wanted me to work as an independent person..., so she wasn't forcing some kind of girls' activity, like playing with dolls. But I had the minimum number of dolls, because these were presents, too, from my grandmother, maybe, and my uncle ....

Q. Did you play much with these dolls?

A. No.

Q. Put them up on display?

A. Well, I enjoyed their beauty, but I was not interested much in playing with them. I liked beautiful things anyway, such as flowers, insects . [This respondent has some interests, also, which could be stereotyped as feminine, such as ballroom dancing, in which she has participated for twenty years; tango, for ten. She also enjoys German cooking.]

One respondent mentions that most of her high school friends had been boys. They had shared with her an enthusiasm for computers and for computer science. On the other hand, this respondent also, now, manifests a keen fashion sense, an ability often stereotyped as feminine.

Another respondent mentions that her older brother had been her best friend. She had enjoyed playing with his toys better than playing with her own, girl-designated toys. When he died, familial expectations fell on her.

Yet another respondent reports causal types of activities: these are sometimes stereotyped as masculine. With her siblings, both male and female, she optimistically disassembled a pendulum clock. They also built a primitive Japanese house right next to their home. This respondent, on the other hand, also made dolls' clothes. Another

respondent reports two kinds of activities:

> *My brother and I used to do fencing (chambara) with branches of trees. Also, [we] played with stones. Some stones changed in colour by rubbing. My mother used to make dolls for us to play with.*

In general, these respondents do appear to enjoy a wide range of activities, including ones stereotyped both as masculine and feminine. This shows some congruity with the profile of androgyneity which has been observed elsewhere in studies of engineering women (Easlea, 1986) who tested high on both "masculine" and "feminine" characteristics. It also fits the profile of well-roundedness (Traweek, 1992, seminar contribution) with reference to female scientists.

3. What values were significant to them?

Education [interview]

Education appears to be one value that respondents had absorbed from their families, since they seem to have followed through in taking it up in the same manner. Their comments about their families' attitudes to it are as follows:

> *She* [widowed mother, somewhat lacking in funds] *seemed to be assuming university attendance....*
>
> ***
>
> *My family have been scholars and teaching all kinds of things--well, up to the Edo period, they taught learning. Before that, Chinese learning. So many things.*
>
> ***
>
> [Higher studies] *If we wanted to, we could do it. There was an unspoken assumption that everybody studied hard.*

***

I think that my environment was very education-oriented. They emphasized the importance of education.

***

I think my mother inherited my father's spirit, the importance of education.

***

The importance of education was highly respected. I think it is related to the fact that both my parents had [had] higher education.

***

Humanitarian [interview]

Another value which some respondents either had, or understood, in relation to science, was the humanitarian one:

I wanted to change society by studying [science discipline].

***

I wanted to choose an occupation that would contribute directly to humankind, and that was either to become a doctor or a pharmacist.

***

Quantum chemistry is not close to our everyday life, but we are made from molecules and atoms, and if we learn about those, maybe we can help [humanity].

***

Yes, but at the same time, I think any career could be humanitarian; it all depends upon the attitude of the individual.

It is possible that a good number of other respondents had been conscientized to humanitarian values, particularly those values related to science, since a number of the women were physician's daughters.

4. What had been expected of them in relation to academic achievement? [interview]

One respondent says that her father, who was a very busy family doctor, had encouraged her to be one, also. Her mother had thought that, in future, it would be better for women to support themselves, in case their husbands couldn't support them, or died. Another respondent's mother had high aspirations for her daughter: she thought she might become a concert pianist. In another two respondents' families, expectations which had fallen on the first son now fell on the first daughters. In one case, the first son had died; in the other case, the first son had been rather ill, and, coupled with that, the first daughter resembled her science-teacher father in character, and was expected to enter a field like his. Other respondents mention expectations, as follows:

> *My father? I don't know that he ever said [it] in a direct way, but he was hoping, because my marks in science and math weren't too bad, and so, I think he was hoping I would aim for it* [science].
>
> ***
>
> *Actually, I wasn't expected to be a scholar at the time, because, really, a girl's career as a scholar hadn't been established when I was just a child. From my mother's side, I was expected to be a medical doctor. From my father's side, I don't know --mainly, that you can do well anything you are interested in.*
>
> ***
>
> *I don't know how my mother found financial means to support us to take lessons. In those* [immediately post-war] *days, there were very few people who would pursue their education to a higher degree, but it seemed to me that my* [widowed] *mother*

was almost assuming that it was the due course.

***

The expectations of my parents for me were relatively high, I think, because I was the first child. As for any special expectations, we who were brought up in Tokyo in the 1960's were all expected to aim for higher and better educations.

***

[My mother] *wanted me to be a thoroughly domesticated, one hundred per cent family woman.*

Special Frameworks

The expectations, situations and traditions of parents and others, in some cases, advertently or inadvertently, included tacit permission to enter science or some similar endeavour, or, at least, to achieve. Some examples are given below:

A respondent was more like her father [a biology teacher]. Her older brother was ill, and familial expectations became focused on her.

***

I've been teaching science: a family job, you know--along my father's line. I'm quite a traditional person, and the exception just is, I'm a woman. Subjects have been changed, but teaching for bread and butter is a kind of family tradition.

***

A respondent became the eldest child when her older and only brother, the first child, died. This may probably have focused familial expectations on her.

***

The father of a respondent died. Her mother then counselled the grieving girl to take the science stream (possibly in his memory) in high school.

***

The parents of a respondent said: "Nowadays, women also have to study science."

***

The mother of a respondent said that science "seemed suitable" as a vocational choice for her.

***

The parents of two respondents agreed with their choice for science because it **was** their choice.

***

The parents of a girl enjoyed science themselves. They thought it would be an interesting field.

***

The sister of a respondent encouraged her to enter science, because she herself had not been able to do it.

***

The parents of a respondent encouraged her to enter science because it would be advantageous for getting a job.

5. What was the nature of the schools they attended?

Elementary [interview]

A variety of schools were attended by the respondents. In general, most of them do not remember an especially noteworthy experience in science at the elementary school level:

> *During my elementary school days, I preferred literary courses to scientific courses. We didn't have a great deal of science until high school.*
>
> ***

In some cases, the respondent compares the elementary school experience with the education given by the home:

> *...a primary school teacher is not a specialist in anything, but some teachers are very, very interested, or have some talent to teach, but not our class teacher.*

Q. So her talent did not really lie in science?
A. No, I don't think so.
Q. What about attitudes in science?
A. I would say, more from the family.

***

A. *Yes, there were times the teacher would give us homework of drawing some insect or plant. When I was working at home on these projects, my father would come and show me the detailed drawing of the plant or animal out of the university textbook. So I think I received the utmost education from my father at home.*

***

One respondent remembers her elementary school more for its other courses than for its science ones:

A. *During my elementary school days, I preferred literary courses to scientific courses. We didn't have much science until high school.*

Another respondent remembers "very poor equipment," and yet another remembers "nothing in particular." However, one or two respondents did spend a profitable and enjoyable time in their elementary school science classroom:

In the third grade, we did an experiment, using a blue print and putting it on a leaf under the sun light. It was quite exciting to see the print copied on the leaf. ...we did a dissection of a fish.

***

Also, my elementary school teacher. I don't know whether he exactly encouraged me or not, but [he] was, I think, a good teacher that made me interested in science.

***

Math experience in elementary school appears to have been more memorable. One respondent says, "Math was like a extension of having fun." Many respondents, in fact, report mathematics as having been their favourite subject, both in

elementary school, and at the junior high level.

Secondary

In junior and senior high school, respondents report many more such experiences, and teachers who taught "passionately," and who were very knowledgeable. Some respondents had a very decided advantage, because they attended high schools which had just recently become coeducational, and which had retained some of the distinctives of boys' schools. One such example is this: a respondent's high school was virtually a boys' one (M:F ratio= 48:2), and it was the top secondary school within a large area. University entrance from this high school was known to be an easy matter for boys or girls, since the preparation was so good. The respondent enjoyed this school so thoroughly that she began to enjoy being in institutions which included male students:

> *However, because of the fact that I attended the high school where most of my classmates were boys, and I got used to it, I didn't have much of a desire to go to women's college.*

On the negative side, one respondent says that at least one male teacher would not answer a girl's questions in science class, openly stating that it was "because she was a girl," whereas he would answer a boy's questions. This respondent also received vocational advice that, among other factors which should discourage her from science

entry, her marks or ability were not good enough for it [Interestingly, she later took an advanced degree in Tokyo University, an institution which would have required elite marks merely to enter!] There is a possibility that the teachers, in this case, had been trying to reinforce the stand of the parents, who did not wish their daughter to enter science because of her history of ill health, and the fact that a recurrence of it could render her unmarriageable during the time-frame that "matches" could be made.

Another respondent talks about the fact that some areas of science were rarely made "beautiful" by the schools:

> *I think logic is a kind of beauty. I think that in every subject, you have to go beyond the memorizing thing. Beyond this stage, then you enjoy the beauty, in most cases. I hated biology, you know. It was really a down subject. Presently, it is heading [towards the presenting of its "beautiful" aspects], but when I was a child, "There are how many leaves here?" "Colours there?" "How are the flowers conserved?" Memorizing something* [only for] *how it looks, how it's constructed. That kind of thing. Not quite a living style of biology, I thought, you know. Like, a cut flower--that's not interesting to me.*
>
> Q. Did you ever find that [problem] in any of your other subjects, chemistry and physics? Were they presented well?
>
> A. *Better than biology. Chemistry looked better, and physics sounded better...than biology. More search for reasons. My father said school biology might not be ... interesting, but research ...would be quite exciting. But I said, "No thanks!"* [N.B.: this respondent had enjoyed very much, on the other hand, going on biological expeditions with her scientist father].

School Sports [interview]

Some respondents mention team sports, cited by Hennig and Jardim as important to the development of competitive attitudes helpful in male-dominated fields. One mentions having been sub-captain of a rather successful soft tennis team in university. She now sometimes tries to relax when playing tennis, but really enjoys the competition, so cannot! Another respondent mentions having played volleyball during her secondary school years.

6. Was there a person (e.g.: teacher, parent) who may have had a critical effect upon their choice of science as a career? [interview]

One respondent mentions an outstanding junior high teacher, who advised the students: "Science is not memorization: think for yourself." Whereas science had been a difficult subject to memorize before, under the tutelage of this particular male teacher, it became easy, because the respondent now understood the subject. The teacher gave them many experiments in order to prove or disprove statements which had been made in the class. The teacher also encouraged the students. The respondent remembers a very successful home experiment of her own which had centred, by default, on cockroaches, her chosen insects being uncooperative. The teacher displayed it on the classroom wall.

The same respondent met her first female biology teacher in senior high school. This woman was "marvellous, and nice to talk to about science," and both boy and girl students liked her, since she was able to recommend books which would help them learning certain science concepts. The respondent remembers learning about DNA from this teacher, and about books detailing how frog chromosomes had mutated after Hiroshima. The respondent says, in relation to the two outstanding teachers in junior and senior high: "If I hadn't met **him** [the junior high teacher who had established a good foundation in scientific content and attitudes], I wouldn't have understood **her** [the senior high teacher who built so well upon that base].

The two teachers, mentioned above, were critical in laying a conceptual foundation in the respondent's science learning using empirical and contextual methods. However, as soon as the respondent saw the female biology teacher in senior high school, she, in her own words, "woke up" to the realization that she wished to challenge such a field.

Another respondent remembers:

> *The science teacher (m) of my junior high school showed me the interest* [fun] *of science. And the math teacher (m) of my senior high* [likewise].

Persons with critical effects upon respondents were not always teachers, but included some family members, as well. Some of them gave advice. One mother suggested that

her daughter try an entrance exam for a specific college. The daughter did, successfully, and eventually became a lab head. The mother and father of another respondent both gave advice. The mother said, "Become a medical doctor, and spiritually and financially independent as a woman," and the father said, "One does best the thing one is interested in." The respondent took the latter two parts of her mother's advice, rejecting the first, and, perhaps, in so doing, followed as well the advice of her father. Some other critical persons in respondents' lives are noted, as follows:

> A mother was an exemplar to her daughter in taking the less familiar path: she was exceptional in being a "techno-freak."
>
> ***
>
> Q. Was your mother a role model for you?
> *A. Mm-hm.*
> Q. In what way?
> *A. She was able to take care of the five of us; but, on top of it, she was able to take care of the company.*
>
> ***
>
> *In my childhood, my father taught me science. For example, we used to gather flowers to collect juice, and he showed me that the colour changed by dropping vinegar, etc. My father used to teach us the names of plants, clouds, etc., in a very casual manner, based on his knowledge as a biology teacher.*
>
> ***
>
> *They said that for a woman to go abroad was very dangerous. However, it was my father who supported the idea, and backed me up to do so. I am still very thankful to my father that he let me do whatever I wanted to do: he supported me.*
>
> ***
>
> Q. Your interest in science was more-or-less built

by your father?

A. Yes, I think we can say that. In the agricultural college, there were 27 of us in the class, and many started to work in the same kind of institution. I did, but I was the only one who came to be a researcher; I know a couple of people who became teachers of botany or of biology, but I am the only one who became a researcher.

***

Significant females, mentioned in a previous section, should probably be included in the list of persons with critical effects upon the respondents, since most of these females were mothers.

A Warm and Friendly Science [interview]

It is important to add here that most of the interviewees of this study mention a person, often a family member, but sometimes a teacher, who introduced science to them. A recent study (Ubelacker, February, 1992) has shown that women find the atmosphere of science classrooms "cold and hierarchical," and that that is one of the reasons for their noncontinuance there. Persons introducing science to the respondents of this present study had anything but a cold and distanced relationship with them. Here are some examples of these teachers, formal, non-formal, or informal, and their relationship to the respondents:

A mother who had high aspirations for her daughter, a respondent, and who expected the daughter might become a concert pianist;

***

A father who made pop-out books for his children, including a respondent, in which they were featured

as the characters;

***

A father, who always wanted his children, including a respondent, around him, even when his guests came;

***

An older brother, who allowed a respondent to play with his toys, and who was a "good friend" of hers;

***

A cousin, who did an example of radiography;

***

Some boy pals, computer enthusiasts, who entered university with a respondent;

***

A father, who always took his children, including a respondent, on his summer ecological trips;

***

A father who went gathering juices for berries with his children, including a respondent, teaching them the names of clouds, etc.

***

A father, who took a respondent hiking, telling her the names of the flowers and plants and animals;

***

A father who encouraged his daughter, a respondent, to study medicine and come into practice with him;

***

A father who was "close" to his daughter, a respondent, and supported her non-traditional choices.

***

A teacher, who brought out the "fun" of her subject.

***

Mentors with Broad Interests

In addition, it might be added, the person introducing science to the respondent was one with

interdisciplinary interests, one who could model the idea that one could have science without losing other areas, one, also, with whom the respondent could identify:

> *She likes to play cards, too, all kinds of cards: trump, or the Japanese kind.*
>
> ***
>
> [He was] *a "Sunday painter."*
>
> ***
>
> *His hobby was reading. He has read an enormous number of books.*
>
> ***
>
> *He liked painting, but at the same time, he liked kabuki* [theatre]. *He enjoyed watching kabuki theatre, but painting he liked to do himself. Also, he liked to watch Japanese dancing (nihon buyo). Photography he liked to do himself.*
>
> ***
>
> *He used to play with us. His hobby is reading books-- various kinds of books.*
>
> ***

In addition to these examples, one of the math/science stream teachers deemed important by one of the respondents was also her volleyball coach. A university teacher was admired for his interest in the general welfare of scientists. One of the scientific fathers was also rather linguistically talented, it would seem, since he acted as a translator during the early years of the Occupation. Yet another was one who liked to play cards at the end of his meals.

Role Model Theory states that the role model must be perceived as having something in common with the person who

chooses him/her: in one case, a teacher who was very impressive in the view of a respondent seems to have the same type of subject-enthusiasm as she:

> [re: teacher]: *He was so immersed in his work he would forget to eat, so-to-speak.*
>
> [re: self]: *I wanted to work in that lab to thoroughly immerse myself in all the grotesque animals and plants.*

7. Were there any role models from books or films?

Some of the role models from literature, film, and radio broadcasts had the ability to combine various aspects of life successfully. Marie Curie, in the view of one respondent, had this characteristic:

> Q. Why did you admire Madame Curie?
> *A. She was a cultured, elegant Frenchwoman, and also a scientist.*

Another respondent mentions another factor which elicited her admiration. Her statement is reminiscent of the Role Model theory which states that the chooser of a role model usually perceives the role model to have something in common with him/herself. It is interesting that one of the respondents who mentioned Madame Curie (11 did) as having impressed her, did her graduate studies in Paris, just as Madame Curie had done, albeit in a different discipline. Another respondent mentions the following:

> *Mme. Curie was extremely impressive. She was the type of person who overcame her difficulties by endurance. When the allowance from my parents was not sufficient, I thought of her.*

***

Hideki Yukawa, the 1950 Nobel Prize laureate in physics is mentioned by one respondent along with Madame Curie as being somewhat of a catalyst for her entry to science:

> *After seeing the movie about Madame Curie and knowing the fact that Professor Hideki Yukawa was chosen as the Nobel Prize winner in physics, the first Japanese winner, I decided to study physics at college.*

It is probable that the two role models mentioned had many characteristics in common with the respondent. One was a woman, as she was. Another, a Japanese, as she was. Both were in physics, as she later was, etc.

Albert Schweitzer is mentioned by a respondent who later entered a branch of medicine. He is a very good example of combining of interests. Albert Schweitzer was distinguished as a great humanitarian, but what is less widely known is that he had earned doctorates in three disciplines: music, theology, and medicine, and had written reference works in the first two. He was, therefore, highly interdisciplinary in his interests, which were obviously intense ones.

One respondent mentions that a person with a very critical effect on her was Dr. Wyzeppa, the elder brother of a famous statesman. He resolved the respondent's quandary, that of being attracted by both the social sciences and the natural sciences, by stating, on an NHK [national radio]

broadcast that, in order to understand philosophy, one should first study physics. The respondent recalls, "I saw social science and natural science coming together."

Another impressive person from literature mentioned by a respondent was Rosalind Franklin:

> *The book that affected me was **Double Helix**, by James Watson. The reason why it affected me was because of his description of Rosalind Franklin. Rosalind Franklin did the X-ray crystallographic analysis of DNA, and because of her work, this model of DNA with the double-helix was greatly supported. Her contribution was enormous, and yet, in that book, the description by Watson about her was not very good, and I think the reason why he didn't write very favourably about her was because she was a woman. Although he devoted a full page at the end of the book, I still felt that. I was a bit resentful about his male chauvinistic approach, and at the same time I admired Rosalind Franklin greatly. In spite of this type of environment, she pursued her work as a scientist, and did very top-notch work, and, as a scientist, I felt she was even greater than Watson himself.*

8. Was there any special experience which acted as a catalyst?

Aloneness [interview]

Some educational researchers, in recent years, such as Uri Bronfenbrenner (Moore, 1982) have shown how too much exposure, at an early age, to peer opinion may foster peer-dependence on the part of children, mainly because their cognitive development is not mature enough to deal with such input successfully. Some of the respondents found

themselves in circumstances in which they would have been exposed to minimal peer contact for a time, during their early years. Presumably, this solitude may have aided them in avoiding peer-dependency, an attitude inimical to science:

> [I was] *alone, because in elementary school I was living in the very centre of Tokyo, so not so many playmates.*
>
> ***
>
> *Being alone became a way of life for me.*
>
> ***
>
> *Our house was very large: we seldom went out to play outside the house. Rather, as a family, we stayed and we played at home.*
>
> ***
>
> *We moved, when I was in elementary school. In my new neighbourhood, there was nobody of my age. I had to commute by train, alone. Those days, I often went to the library and read books* [prior to this, the respondent had seldom been alone].
>
> ***

Atmosphere of an Epoch [interview]

One respondent believes that the atmosphere just after World War II was somewhat of a catalyst for her thinking:

> *In the summer of 1945 the war was over. This brought us great freedom and [a] critical way of thinking. Our generation could not trust adults or authorities since they changed from being anti-American and British to being pacifists just overnight... During this period ... I enjoyed the free atmosphere of the just-after-war education in Japan. At that time, our country planned to be one of the cultural nations in the world rather than a so-called "economic animal."*

Nature [interview]

Some respondents find exposure to some aspect of nature a gave impetus to their scientific interest:

> *I enjoyed identifying flowers and I enjoyed looking at the crystal shape of snow, because I was in Hokkaido at that time. I thought these crystal figures of snowflakes were so beautiful and interesting. And, also, I liked to see the shapes of flowers as in flower petals. These organizations and tissues were so interesting to me.*
>
> ***
>
> *We used to stay in the mansion of... a very famous scientist and writer. His house was very large, with bamboo trees, nature forests, and even a pond that was exactly like the one described in his novel. I think that this kind of childhood, that was so rich in plants, was one of the major factors that influenced me to go into science.*
>
> ***

A Protest [interview]

One respondent chose her present field, somewhat different from the one she started in, because of a critical experience. Some fishermen in her home area were protesting a nuclear plant with potential for future leakage. Since the respondent had studied radio-biology, she was well aware of the particular consequences. She began to take a critical view of science activities, including ones being done in order to teach biology in university. Although she had no aesthetic qualms about cutting up animals, she began to ask herself whether all of the killing of animals was necessary, and came to the conclusion that it was not. For this reason, she changed from taking a pure science major,

to taking an interdisciplinary one, even though that would take longer. By doing this, she could use her journalistic talent and her scientific knowledge to study problems and alert the public to them. She thinks that people in science should be cautious about risk from radioactivity, and stop progressing dangerously. At the same time, she realizes that science is controlled by economics, politics, etc., so she wishes to analyze all of this, but hopefully, her writing could have an effect.

The Loss of a Child [interview]

In the case of another respondent, the critical experience of her mother was passed on to her:

> Q. So she was widowed before the war?
> *A. Yes. And in those days, women didn't have any protection. She had a small baby. Her baby was taken, and she was more-or-less kicked out of the household, the baby taken away* [by the in-law family].
> Q. Oh-oh... did she ever get the baby back?
> *A. No. ...I think that made her very strong and independent, and made up her mind that a woman has to be independent. You know, she had hard times, she was all alone, so she knew that a woman has to be very independent. Otherwise, you never know what is going to happen. ....now, you know, she has five kids, you know, with this new marriage, but that made her very independent. I think because of that experience, she more-or-less, uh, told us... (she has two daughters, my sister and I, you know), that one always has to have something, in case something happens.*

How Skills Help in Hard Times [interview]

Another respondent mentions what a critical experience it was to view the aftermath of war:

> *My experience was, that, right after the war, Japan was in such a state of confusion, and I was living at that time in X_____, and there were so many Japanese people who returned to Japan after having been stationed abroad, and I noticed that those people who had special skills could get jobs much more quickly than the others, so I came to realize that to have a special skill is a very important factor in one's life.*

A Formerly Boys' High School

For one respondent, the type of high school she had attended had been a kind of critical experience for her, which had shaped some of her future decisions. She had been in a virtually male institution, and "didn't have much of a desire to go into women's college." She entered a coeducational college (such a choice made science a much more viable option, given that women's colleges are much less likely to carry it as a specialty). Her mother had hoped for a women's college choice, but the father supported the respondent in her own choice.

Another respondent, in the pilot study group, mentioned having attended a formerly boys' high school, as well.

A Chain of Events [interview]

A major critical experience for one respondent was the death of her father: her mother then counselled the grieving girl to take the science stream (possibly in his memory, since he had been in science) in senior high school.

Another circumstance that encouraged the same respondent to stay in science during high school was the

fact that, towards the end of the war, all high school students apart from the ones in science, had had to join the war effort full-time, working in factories. Her choice of science allowed her to spend at least part of the time at school.

Yet another critical experience was the fact that, following her sister's example, her very usual habit, the respondent tried to enter a famous national art school, but failed to pass the entrance examination. At this point, her mother saw an advertisement in the newspaper for a new science college. She asked the respondent, "Why don't you try that exam?" The respondent tried it, and easily entered the college. Only after entry did she realize that her father had given her a science education that had been greatly foundational in relation to then her current activities.

Still later, a professor to whom she had been a lab assistant received a new post as head of a government laboratory, and asked the respondent to go along as his assistant. She did so, and eventually, when he left for yet another post, she became lab chief herself.

A final critical experience was her marriage. Her husband, somewhat her senior, and in the same field, became her study leader, and encouraged the respondent to do her best.

The death of her father was, perhaps, the factor

which had the most profound affect upon her. The respondent says, now:

> *It is ironical to say this, but, if my father had been alive, I might not have majored in* _____ [discipline of science]. *One never knows.*

Domestic Rejection [interview]

Another respondent mentions something which happened in her childhood, which seemed to be typical of the direction in which she was being pulled, or in this case, pushed:

> *We had a maid helping us, and this person was very, very clever, and, I think, a teenager at the time (18 or so), and she worked hard at cleaning up rooms, and she wanted to keep that cleanness, and let* [had] *my brothers and myself get out of her territory, so I couldn't actually play in my house, mostly in the garden, so I had to go out of our house, anyway.*

It seems, in this respondent's case, that she was being pushed, at an early age, out of the domestic sphere to the world of exciting discoveries beyond it. The same respondent had already had one critical experience which would have impressed upon her the value of scientific knowledge and applications of it. Her survival, as a premature infant, and as a frail, young child, had depended a great deal upon the ministrations of paediatricians, one of whom had been her mother, who had used state-of-the-art medications and treatments to help her gain strength.

A Foreign Perspective [interview]

One respondent had never found herself compelled by circumstances in Japan, but when she left for a six-month's stint in the United States, she found a different situation:

> *I didn't have any intention of getting any higher degree than a BSc. But I went to work in the United States for six months, as a technical assistant, and there, that department chairman encouraged me to go get the degree, and everybody around me in the United States was very supportive that I get the degree, but in Japan, I really never was getting any positive encouragement.*

A Practical Choice

Several respondents felt attracted by other fields:

> *I was thinking of going into art, or science, which would I choose? But everybody advised, you know, that in art you can't support yourself.*

Another respondent, similarly, was strongly attracted by journalism. At junior high level she had won third prize in an all-Japan writing competition. Her subject had been a sociological one. Her literature teacher had also advised her that a career as a writer would be compatible with marriage and home. She thought about it, and decided that, realistically speaking, she could not really live on writing.

Another respondent in the group interview noted that she had begun her tertiary studies in the arts faculty, but, after widowhood, she had realized that she could not support her young son through those studies, so she had then changed to mathematics. Had her original situation continued, though,

she might have become a social worker.

9. What do the respondents think of the "genderization of science" concept, as applied to Japan? [interview]

One respondent is inclined to agree that science is genderized:

> *If I am to say "yes" or "no": Yes --it is rather "male-thinking." This, I think, is a result of the "division -of-role" concept (yakuwari buntan).*

One respondent is not sure, since "most histories are written by men, and most scientists are men." She believes that the concept of genderization is one generated from the Christian viewpoint, and understands that it implies a cutting off of the observer from the observed. The respondent says that culture is, in fact, quite important, since technology, as an example, is a product of European (i.e., Western) culture,

> *But, nowadays, things have been changing a lot, you know, so it's very difficult* [to know] *the typical style of science or technology.*

One respondent disagrees with the idea that science is genderized:

> *First of all, I don't think there are "male-thinking" or "female-thinking" approaches in science. I think, in order to understand science, one needs to be objective, but, at the same time, one has to be very dogmatic.*
>
> *I feel that in order to put forward one's own dogma, one needs to be creative, and, to a*

> *certain extent, subjective, but at the same time, in order to push forward your own dogma, you have to be very determined, and, also, aggressive.*
>
> *When it comes to this aggressiveness and determination, maybe the Japanese women don't have it as much as the Japanese men. Therefore, I feel, for Japanese women to make a contribution in science, it would be in a supportive role.*

Another respondent believes that women may have something special to contribute to science:

> *For example, there may be a way of approach that only women can think of, and men are not aware of.*

10. What are their problems as women scientists in a male-dominated society? [interview]

Before going into more specific responses given by the women scientists, it might be important to note that women in the pilot group interview in Tokyo mentioned that they had had good, positive relationships with significant males in their families: brothers were sometimes very good friends. If their comments are representative of the rest of the women, some of whom also reported good relationships with males, it is probable that these women did not come with particularly negative expectations to a male-dominated field. Nevertheless, some of the women are aware of certain inequities in science. One respondent believes that when the ability of a male and female scientist is the same, the man has the greater advantage. When the woman is clearly superior, there is no trouble for her to get promoted. One other respondent expresses it as follows:

> *If a man and a woman have the same degree, the man will be ahead.*

Hiring policies, according to this respondent, made her very cynical about applying for a particular post:

> [The hiring] *professor said, "If there are four student applicants, (two boys, two girls) who score the same, I'll take the boys!" For that reason, I didn't apply for that job.*

This particular respondent goes on to say that, if one were a woman, and an average student at the master's level, one would not be able to get a "decent job." If one were a man, even if one were a less-than-average student at the same academic level, one could still obtain employment. It is evident, also, from one respondent's statement, that hiring policies are not necessarily improving over time, but rather, deteriorating; as women resign from a university department, they are replaced by men. At this point, she is one woman researcher amongst five. Formerly, at the same university, one-half the faculty were women:

> *The only position women can get nowadays is something like research associate. Yes, I think it [the field] is male-dominated in certain aspects: it is difficult for us women, because we are the minority.*

It is probable that this particular respondent knows more about this inequity than most. Although she does not comment on this, her position as only an associate professor, despite her two earned doctorates, appears somewhat of an anomaly, given her probable seniority in the university where she works. She is, furthermore, a single woman without familial constraints. In an interview about other matters, Professor Ryu of Sophia University (personal conversation, 1992) mentioned other, similar cases which she knew, where a woman with a doctorate and numerous years working in the university, was still at assistant professorial level.

When asked about conditions which prevailed in the laboratory, in cases where women were, in fact, hired, there

were diverse viewpoints. A younger respondent, not yet working gainfully, speculates that

> *Maybe they are men and I am a woman, so they would take me as a stranger, a little bit strange.*

Another respondent, in her forties, who has worked for some years in a laboratory, agrees that, in fact, male co-workers do sometimes view female scientists as "girl-jin," i.e., somewhat of an oddity by normal standards.

Another respondent has a different view:

> *Yes, when I was working in Japan, there were mostly men, but it was not problematic for me.*

A second respondent says, "It hasn't been a problem for me." She recounts a recent meeting between herself and some former, male classmates:

> *Incidentally, last week I attended a symposium of the _____Society of Japan, and I met several former classmates.... We had dinner together. The men and I discussed my recent proposal, how I'd like to have more women professors at national universities, and education. They were very, very sympathetic about the present situation.... At that time,* [perhaps during the respondent's student days] *it wasn't so bad, either, because, in their case, they can easily produce a man's world, you know. No problem to them. If I approached them, they used to be kind, though. I still have many friends. The reason there was no problem, I guess, is because women started to be educated after World War II. Most people are equal, even at college. It was part of the enlightenment period after World War II.*

A third respondent also echoes the thought of there being no particular problem, at least in her case:

> *Well, in my case, it was natural. I didn't experience any special setback being a woman. ...I was always*

> *playing a secondary role to this professor... Then I became the top in this lab.*

The last three respondents, incidentally, are those who were most clearly included in their father's world, both of science and, also, of other pursuits. Their families were, as well, scientific, and in at least one of the cases scholarly. It could be argued that their experience might be different, not only because of their expectations due to past experience, of being included, but also because of the expectations of others. Because of their family backgrounds, they might be acceptable exceptions to the general rule of-thumb that women do not do science, or, at least, do not do it very well. When asked about a woman's social or ability standing in relation to how she might be treated by male colleagues in science, one respondent (not in the group just mentioned) replies as follows:

> *...I would say that if a woman were of a higher social status than the man, then, probably, it would create some problems. But as to the talent level, I don't think it really makes any difference. It's totally dependent on the woman's attitude, and, also, the relationship.*

Asked if a woman from a background known to be scientific came to work in a lab, another respondent responds that it might be easier for her. One of the younger respondents agrees with this view. And the easiest

relationship in science is that between a younger female and

an older male, says another respondent, because a combination of seniority and male dominance prevails there.

One of the above respondents believes that relationships in a laboratory evolve:

> *It all depends on the stage of growing-up [maturity] in a scientific field. Of course, at the beginning, one would see the man/woman relationship as father/daughter, but later on, like brother/sister, and on to professional/egalitarian.*

A respondent points out that particular disciplines may have their own traditions:

> *In the physician's world, the modernization process is retarded. Therefore, the concept of the division of role (by sex) still prevails. It is very difficult to be frank and communicate with male colleagues at work.*

It is obvious that many situations are present in the scientific world. One respondent, having noted that there were some inequalities between men and women where she worked, posited a caveat, that in her experience and despite some notable exceptions to this rule, scientific men on the whole were kinder to women than other men were.

Late Night Dinner Discussions [interview]

One respondent believes that attending the late-night dinner/drinking sessions which are customary among male scientists, and at which shop-talk occurs, could be either a good or bad idea:

> *For those who know how to socialize skilfully, it is an advantage. However, my experience is* [has not been] *very positive: for example, sexual harassment. However, as long as I accomplish whatever I need to do, and am able to publish in journals, it won't be much of a disadvantage.*

Another respondent considers these gatherings "difficult for women to penetrate." A second respondent says that neither she nor her scientist husband ever attended the dinners. Yet another, although she does not frequent them, finds them of decided usefulness, since she is able to carry out the Japanese custom of nemawashi very effectively at such times. She explains this custom [that of preparing people beforehand, rather than bringing surprises to bear], and why it is helpful, and how it fits into the framework of the dinner:

> *Generally, in Western-style discussions, you are just informed there* [at the meeting], *and discuss* [it]. *Many* [people] *have to offer opinions, and then you vote, and whatever is decided, you have to follow.... In Western style, they compromise at that time. In Japan, they don't compromise at that time, but explain beforehand. There are many styles of doing* [this] nemawashi. *Nemawashi is kind of an important thing for us, for the Japanese* [person's] *survival. So I do a little bit, but not so seriously.*
>
> *Nemawashi is kind of confidential. When I think, "Let's promote X," for example, I have to ask senior professors within our department. Even other departments..., though not all departments, have some kind of power.*
>
> *"Uh, I'd like to, uh, let one of my followers [people] be promoted for the next year" (something like that). "How do you feel about that?"*
>
> *[I] kind of ask opinions... before the final meeting, personally. I think I have found this necessity of diplomacy. I wouldn't go every night to drink* [with the male colleagues]. *I don't like to drink all the*

> *time, because I have too much to do--my o t h e r research, and also, I'm more interested in activities. In most cases, I try not drinking with them. But I really do this kind of nemawashi. After-work-thing: eating together and drinking together. Not all the time. Occasionally. Well, it's not so many, uh, times, anyway. Once a year, or less than that, maybe. Once in two years, or once in three years.*

In addition to using the custom of nemawashi, and of occasionally appearing in the evening dinner groups, this respondent, the first woman on the science faculty of her university, has found two other policies important to her survival as a woman in a male-dominated field. One is the policy of neutrality:

> *There are all kinds of small sections, and there are groups, there, and I observe them, and [try] not be involved so seriously. I try to be always neutral to the groups.*

In addition, the same respondent has found that trying to live in peace with everyone is important.

Tatemae and Honne

Equal rights for men and women, in Japan, may be the framework within which both men and women voice their views, but there is another aspect to consider, according to a respondent whose area of science takes relational matters as well as matters of natural science into consideration:

> *In school days, men and women are equal; however, once married, , men prefer their wives to stay home. The tatemae and honne are different.*

This respondent is making reference to two things: tatemae, the first, is the general principal, or rule, applying to a

situation. Honne, the second, is the other, concealed aspect within it, such as hidden motives, etc. (Doi, Takeo, 1985). In this case, although men may agree in principle to some kind of gender equality, and abide by it in certain public situations, they may feel uncomfortable with it if it involves upsetting their traditional role in the home or elsewhere. This difference may explain why "elderly men of distinction," according to one anthropologist, Nakane (Walton, 1986, p. 20), were the greatest help to women in Japanese society. They could abide by the general principal without having to endure any personal consequences from it: they had already won their laurels, and had nothing to lose. It is probable that the sympathetic male former classmates who met with one of the respondents, above, were mainly in this category, since the respondent in question was, herself, at a similar level.

The dichotomy presented by tatemae and honne also affects the decision of women concerning career and family. The constitution of Japan is very fair to women: they have equal rights. Institutionally, also, there is little if any discrimination with regard to women studying. In addition, new labour-saving devices have enabled women to do housework in less time. As one respondent said, in her young womanhood, one had to choose between marriage and science. She chose science, and gave up the possibility of marriage. She says that now, women can have both. In theory that is true, but on

the other hand, society's norms and husbands and families say something else. One respondent explains why she does not believe it is possible for women in science in Japan to "have it all":

> *No, I don't think so, but, as I said before, for women to pursue any career, not only science, any other subject--to pursue a career is very, very difficult. In Japan, the woman's role is still relatively well defined, and that is to become a good housewife and good mother, to raise good children, which will be the future generation of Japan.*

Asked if she had ever seen a case in which marriage and science had been successfully combined, in Japan, the respondent replies:

> *I've seen people like that, too, women...., and also, I think, the younger generation is changing. They tend to be more and more... they engage in research together, they tie it together, or something.*

Choices Endorsed by Respondents

Doing science while maintaining a home is obviously difficult, if not impossible. Those who have done it have found strategies and choices that work.

Two respondents mention that pharmacology is a favourite scientific field for women to enter in Japan, because it gives a diploma which can be used not only throughout one's life, but, also, for part-time work in almost any neighbourhood. One professor of pharmacology states that most of the female graduates of her specialty eventually use their diplomas, even though they may take a number of years off for childbearing and childrearing. Of

course, many women do not go on to a graduate level in pharmacology, but, if they did, this would not negate the fact that they would never need to be completely unemployed. They, too, could always work at the local pharmacy, even though they might have to be under-employed in relation to their advanced skills. Not every scientific field offers this assurance of an almost-guaranteed income source during years of time-constraint.

Respondents of the group interview in Tokyo tend to agree that teaching rather than research would be the best choice for women with husbands and/or children, mainly because of the compatible time-frame. One respondent, some time back, found that she could combine the two areas of life more effectively by moving out of a national university and into a private one where there was greater flexibility and where there were other "couple-with-children" situations. She has found, however, that there is greater discrimination against women, as a general principle, in private universities, so is now hoping that national universities will someday develop the flexibility of the private ones.

Another respondent describes what she believes to be an ideal situation for married couples in science:

> *It's probably ideal if you can share one job as a couple, and one person works for bread and butter for six months, while the other researches. Then the other works for bread and butter the other half year while the first does research. If it's well-paid, uh?*

With regard to the relative situations of married and single, she also gives her observations:

> *Oh, I don't know. Single is easiest, I think, but even if you had a family, you could do it. Many children: that could be difficult. I wasn't so strong a person, so I selected, by my choice, to be single, but if you were a healthy person, and had ordinary energy, maybe, then, it wouldn't bother too much, a career, I guess. For example, from age 15 to 20, or something like that, you can use them* [children: to help]. *Over 20, they'll be independent.*

Another respondent has doubts about the possibility of "having it all." She comments as follows:

> *I think it is very difficult for women to have everything. A lot depends upon the husband. In school days, men and women are equal; however, once married, men prefer their wives to stay home. In some cases, it is possible for women to pursue a career and have a family, for example, if they own their own hospital, and the children are healthy, or they can afford to have a special baby sitter, etc.*

Another respondent refers to the difficulties of working in two cities (the "two-body problem" referred to in the literature review, where work cannot be found for both husband and wife in the same locale, a commuter-marriage resulting). This problem is now occurring in Japan. The respondent thinks it a difficult one, from cases she has heard of.

Apart from the difficulties of finding work together, having a scientific husband is thought the ideal situation by one respondent. This might even be the critical factor with regard to whether the wife could successfully pursue her work. He would understand her need to work late at

a laboratory. His friends, likely to be colleagues, would also understand. A husband in a different occupation would likely be asked, without being able to reply as satisfactorily, "Why is your wife not home at a decent hour?"

Another respondent credits much of her success in becoming a lab head to her husband. He was four years older than she and in the same field, and became a study leader for her, "pushing" her on to yet greater heights.

Several respondents think that working as a researcher would be impossible for a married woman.

One respondent, a widow, notes her strategy for getting a regular schedule during her childrearing years: she took employment with a science textbook company, writing for children's textbooks.

Another respondent thinks that women in science can, in fact, "have it all." She comments as follows:

> *Yes. I think so. At least, I have done it. There are women in science who are only pursuing careers. No family. No hobby. Those women look kind of cold and inhuman.*
>
> Q. Objectively speaking, what made it possible for you to do both?
>
> A. *I think owe it greatly to my husband... and one thing sure is, that I didn't devote my time totally to research. When I was raising my family, I was totally away from research. But as you know, these male researchers do have hobbies, such as playing tennis, playing the game, goh, or sometimes, watching stars. So, in my case, instead of playing...games, I was raising my family.... As a matter of fact, I enjoyed it very much, although it was exhausting.*
>
> *Do you know the story of the man who discovered DNA? They say he got an inspiration*

while playing tennis. I wonder if devoting 100% of your time to research is as efficient as devoting 50% of the time?

Sometimes, I even think that those who devote 50% of their time for research may even do better. The important thing is to be able to switch your mind from one to the other.

11. How do they view their own situations: job, lifestyle, etc.? [interview]

One respondent has experienced much frustration insofar as her domestic situation is concerned, since there has been no sharing of responsibility within the home. Her husband was a typical salariman, who came home at midnight from work. The respondent thought about "giving up" many times, but dare not do so because of her children. There was no time for fun or hobbies, since she was raising a family.

She visited her children's schools, on an average, once a week. Her husband never went. He didn't know, she said, which schools they attended. She went once a month to the PTA, since she never wanted to miss. She made the obentos (boxed lunches) for her family, and got groceries on the way home. She could not even sit down for a moment, since everyone was starving by the time she arrived from her distant workplace. Her stress level, she says, was not so high, however, because she never had time to worry. Her husband needed only one-half hour to travel to work whereas the distance to her work required two hours. They are now living separately because her husband found the distance to his

particular workplace too far. There was some trouble in relation to raising children under such circumstances. The respondent took a year off from her work when one of them developed a school phobia [somewhat common in the Japan of the 90's], and refused to go to school: experts had suggested that she do so. After her husband took up separate lodging, the youngest child developed some problems, and experts suggested he live with his father since they felt that was what the child needed.

Other respondents report frustrations, also, of different types. One feels there is unnecessary animal-killing, in biological teaching demonstrations, and that there is too much radioactive waste. Another finds job conditions not to her liking. There is a surfeit of bureaucracy in her laboratory, and human relations are not good. As mentioned before, another respondent finds it difficult to be frank and communicative with male colleagues. A respondent mentions the lack of creativity that she often feels: the difficulty of trying to do new things. Another gives an explanation of several constant concerns of those in science:

> *The frustration, of course, is mainly technical. You have certain ideas, but technically, you can't get what you want. Or sometimes, you get into technical troubles, and you can spend weeks and weeks checking what is wrong, and that is quite frustrating, and also, to make sure that each step you do is correct, because there are so many things involved, and sometimes, it is easy to miss one point, and if you realize that some time later, it is quite a failure.*
>
> *Also, to keep up with the literature.... Also,*

that what you are doing is situated in the right part of science progress, so-to-speak.

Some respondents have had discouragement some time back, and report how they overcame it:

Of course, I've had a serious discouragement many times, but once, I remember very vividly the article I read, written by a Nobel Prize laureate in mathematics, a Japanese, and anyhow, in this he was writing that what... distinguishes one man from another, is how you overcome ... difficulty... when you are feeling you are in defeat. How to overcome it makes [marks] *the difference in man. So each time I feel discouraged, that comes back to me, and I am determined to overcome it, and sometimes, people come to help me, or, sometimes, I find my own solutions. Whatever. I am able to overcome it.*

Another woman scientist remembers her discouragement:

There was a time when I felt like quitting the research, because the more I studied, the more things puzzled me. However, as I came to realize the greatness of nature, it encouraged me. There were times I had some doubts about the merit of pursuing research on _____. However, the thought that someone had to do it kept me going. As my involvement deepened, my interest grew. Later, I became aware of the fact that such study was useful for the identification of the [pathologic factor], *as well as for the investigation of _____.*

Another relates how a particular circumstance helped her:

About two years ago, I visited the Ochanomizu Culture Center for Women. This experience liberated me from the social pressure of role-division in my workplace and gave me confidence.

Some special pleasures in science

Some respondents experience philosophical joys in science, finding new areas of meaning:

The greatest satisfaction is that you sort of discover the new truth no matter how small it is. When you do experiments, and you get certain results, and you analyze them, and when it sort of fits into the puzzle, you feel that you find a new truth that will fit into the puzzle, and that is a satisfaction.

***

At present, I am enjoying my research, which would uncover the mystery of great nature, little by little.

***

I find it fairly satisfying... as a scientist, to pursue truth.

Other respondents find that the humanitarian aspect of their work is satisfying:

I do have a particular interest in the _____ [type of addict] *among women. I carried* [out] *a special research on it.*

***

I'm able to interpret physics to others, especially to the young.

***

I wanted to choose an occupation that would contribute directly to humankind, and that was either to become a doctor or a pharmacist.

***

One respondent feels satisfied with her career because it is "important and valuable". Yet another respondent is satisfied with her vocational choice, because, "although the responsibility is large, it's worthwhile pursuing [it]."

A third respondent takes satisfaction in the ability to return and contribute to her alma mater by teaching young women there.

Practical considerations are also important to two respondents:

I can be independent. [There is] the ability to have time for my *own research [besides teaching].*

Some respondents find self-actualization in terms of achievement a personal satisfaction:

[My discipline] *is an art. I'm happy to have done what so few women have been able to do.*

***

My present work requires the technique of finely tearing apart tissues. Sometimes, people come and ask me, "Would you please teach me the technique?" At those times it is really a great pleasure for me. In many other areas of science that have recently developed, such as molecular biology, and so forth, they only shake up solutions, so there are fewer and fewer people who have this technique. It really gives me great pleasure to find that I can do certain things that so many other people never managed to do.

...to work and be fulfilled.

***

Rather than noting achievements which have brought them satisfaction, other respondents focus on the subject itself, or on the joys of discovery and of gaining new knowledge:

I love physics.

***

Because I have a lot of curiosity, I love to know everything in this world.

***

I enjoy the excitement of discovery, of thinking of it, perhaps, when I'm in the shower at night.

***

I'm ecstatic when the part I design [software] *works just the way I'd planned it, when I've started with a concept, and, little by little, that dream has come true.*

***

...the romance of creating new things....

***

...top-notch results from international cooperation.

A final area of satisfaction mentioned by respondents is related to the people with whom they can work in science:

> *I can meet nice professors, nice researchers* [and] *can work with people:* [I] *enjoy working with people.*
>
> ***
>
> *I like time spent with young people* [the respondent is referring to her teaching duties].
>
> ***
>
> *Nice atmosphere. Other couples in the same situation.*
>
> ***

Frustrations

These take various forms. One relates to job discrimination:

> *...human relations, especially when I hear a story such as that of a male scientist getting credit for the work done by his female colleague.*

Another concern is ecological. One respondent experiences some frustration in science when she uses radioactive materials, then later has to dispose of the waste. She thinks, "Was it necessary? Why did I make that garbage?" She also believes there is an unnecessary amount of animal-killing in the teaching of biology.

Another respondent refers to frustrations such as keeping up with the literature, avoiding small, but costly mistakes, and situating one's research appropriately. Yet another

refers to anxiety about her future post. Work politics is a frustration of one respondent, and another refers to "too much bureaucracy/bad human relations."

12. What do they think is the reason many women don't enter science as a career, despite ability and/or interest? (example of friend or acquaintance?) [interview]

One respondent believes that Japanese women are socialized to enter a family, not to enter a career:

> *Well, I don't know... to me, I feel that a fair number of women are entering science, but whether it's to pursue it as a career or not is another question, and many Japanese women are not career-oriented. They emphasize a lot the importance of family life, especially the women's role in the family is very, very important in Japan, and I think it's the reason why.*
>
> Q. Do you think that it may be that [it's because] the age at which M.A.'s tend to take place is also marriage age?
>
> A. *Yes. Yes. I don't think that any teacher would dare advise taking a career at the sacrifice of marriage.*
>
> Q. So...., in the case of girls who are going for an M.A. or doctorate, these days...., what do you think the usual circumstance is?
>
> A. *In Japan, I was working with those women who were pursuing higher degrees--and I get the impression that they..., first of all, I think they must have been very good students, extremely good, and, second of all, I don't think it was their parents who were pushing, but they must have been very ambitious themselves, highly motivated. I think not only my generation, but also, the schools I went to--there, you know, nobody talks about career, but about settling to a nice household, you know; the position of a housewife.*

A respondent relates the following case. Her friend, who was married, had a child who was somewhat unhealthy. She stopped her studies in order to care more

effectively for her child. The respondent thinks it was rather a waste of talent, in a sense. If her friend had had a healthy child, she might have been able to continue.

Another respondent takes an emphatic view with regard to women's underrepresentation in science. She believes that, not only in the scientific field, but in other fields, few women ask "Why?" "Why is A different from B?" She thinks that, in comparison with men, "Women wonder less." She also adds some further comments:

> *Nowadays, I see many women coming into the field of science, or coming into the lab after passing the exams. However, I have a feeling that those women seem to over-estimate themselves, just because they have passed the exam, and, in reality, they are not so capable as they think. In the field of science, to have good ideas, or to have an imagination is an important factor. There are people who don't do as well when it comes to having ideas, and I think one can say the same for men.*

A respondent says that those women in the present generation who choose science intend to work all their lives, whereas those who choose culture subjects may perhaps not. Most women do not like the idea of living by themselves [which might be easier in the scientific life]. Even some men in engineering departments find it easier to live alone rather than to get married, says the respondent.

She cites another reason for non-continuance in science. She has one friend, who, after becoming pregnant, began to abhor killing animals, therefore did not continue on to take the master's programme that she had planned.

The respondent teaches now in a junior college. She

asks female students, "Do you like biology?" More than half do not. The respondent thinks that perhaps their education has been bad. She thinks only half understand what biology is about. Also, she adds, women do not usually take a PhD if they want to get married. They will be limited, if married, in finding a good job, because of social conditions, such as the husband's transfers, and daycare situations. And if they do take a PhD and marry, the husband may be a critical factor in whether a wife can satisfactorily pursue science: if he is, for example, a fellow-scientist, he will understand her situation.

PhD course people are a special breed who, perhaps, always wanted to do research, according to this same respondent. They are "special girls." But most people who go into science have a monetary reason for doing so as well as an interest in the subject, she says. In Japan, if one chooses science or technology, one can more easily obtain a good job. The reason for entering science, however, she states, changes with each new generation.

One respondent believes that girls do not enter science because they have done poorly in it and mathematics in high school. She concedes, also, that the longer hours spent in science labs may dissuade some from entry, since it cuts into leisure time and its present interesting diversions, such as shopping.

Professor Ryu of Sophia University thinks the present interesting leisure for housewives would incline them not to return to a laboratory, especially since they might be required to serve under a superior. In the home, they could **be** that superior.

All ten interview respondents would enter science again. In the group of 28 women studied, most indicated that they liked their present jobs, suggesting that despite discouragements and constraints, science offers definite rewards to women who enter it.

Summary

All in all, the data in this chapter suggest that certain special circumstances have aided these women respondents in their choice of the nontraditional. Their birth families, to begin with, appear not to have shackled them with too great a number of restraints with respect to tradition or to male/female roles. The familial men were both instrumental and nurturing, and seem to have included sisters and daughters in some of their activities. The women were traditional and nurturing, but also causal and independent. The daughters were permitted a certain amount of androgyny, but not to a degree that would have brought them into public oprobrium. They perhaps, therefore, learned how to be individuals without divorcing themselves from society. These families also

presented examples of achievement and of independent and creative thinking. As well, the values and expectations of the families were not those which would have mitigated against science. And schools attended were those which would have prepared the respondents quite well, in most cases, for university science entry.

Interviews suggest that critical persons and events were fairly strong catalysts for science entry decisions. Despite having had a background conducive to science entry, given the traditional nature of the society around them these Japanese women appear to have benefitted by having "one more reason" to make the choice.

The views of the women themselves represent a fair variety of situations within science. Some have had to sacrifice marriage for science. One, at least, finds marriage to have been an indispensable asset in her research career. One or two have had situations fraught with difficulty because of the strains of attending to household and to career. Several have compromised at various points, finding a suitable situation which would accommodate both. These women acknowledge some gender discrimination in their field, but most commenting on it have experienced little of it.

It is obvious, from the replies to interviews and questionnaires, that women have found much that is satisfying in the field of science. It is equally evident that the combining of this particular career with home responsibilities

presents challenges which have been answered only in part, as yet, in Japan.

Chapter V: Conclusion

General Findings

The overall objective was to develop a profile of the Japanese woman in science. The general findings were that the Japanese woman scientist came from a home of high socio-economic level, had had an early contextual and friendly introduction to science and to the male world usually through the family, which had been encouraged at a later date by positive experiences in high school and university. She had also been inspired by role models from life or literature, and had been enervated, in some cases, by the particular times in which she lived. She has experienced some difficulties since her entry to science but does not regret having chosen it.

PROFILE FROM ALL THE DATA:

The typical profile that would appear to be posited by the results of this questionnaire is as follows:

The typical respondent is in a discipline in which she may or may not have received a doctorate, and, if she has, it may have been obtained after part of her work career. She belongs to an average of three associations if she is not presently a student; her occupation is most likely to be one at the level of associate professor, or its laboratory equivalent.

The family of the respondent was of high socio-economic standing: her father probably worked for the civil service, or had a good job in one of the professions or in a company. Her mother, probably very independent, was likely to have been a housewife, although she may have had some causal activities. Sex roles were fairly traditional, but not rigid, and there was probably some androgyny. Fathers and brothers were likely have been close to the respondent, and to have treated her in a not-very-sexist manner, by Japanese standards. Tradition was viewed fairly flexibly, although the minimum was done. There was probably a good amount of verbal interaction between parents and children. There was probably some universal focus in the family, and thinking was probably somewhat field-independent. Humanitarian views may have been espoused. Education was probably highly valued. The respondent was probably born and raised in a city, probably a large one.

There is about a two-thirds chance that there was a researcher in the family (sometimes the extended family). One or more members of the extended family of the respondent were probably initiative or causal in their activities. The respondent's family, either her father or both her parents, agreed with her vocational choice for science, usually during or towards the end of high school, often because they thought it would be interesting, or because they thought it was a good idea for her to make her

own choices: they may even have given her a rationale for science entry. No one in her family disagreed with science entry, per se, unless they were concerned with its effect on her health or welfare. It is probable that the respondent's family had some involvement with science, either as a vocation, or as a hobby, and may have taught her more about it, especially initially, than did her schools. The respondent may have been given private math lessons.

The typical respondent liked mathematics best in elementary school, or Japanese language and literature. Science was a poor third choice, although she probably took part in outdoor science activities. There is a 50 per cent chance that the respondent may have been encouraged to take part in these outdoor activities by a teacher; when this encouragement occurred, it was on the part of a male teacher that the respondent liked.

In junior high school, mathematics is most likely to have been the favourite subject, still, of the respondent, although there is one-half that possibility that science would have been the choice. The respondent's favourite subject was liked because it was interesting. Where science was the favourite choice, the chances are overwhelming that the subject would have been chemistry. There is about a 50 percent chance that the respondent would have had a woman teacher in mathematics, and about a 45 per cent chance that she would have had one in science. She seems to have had as

much of a likelihood of having had good math teachers as of having had good science teachers, even though she is much more likely to have enjoyed the math course better. Her teachers were liked, in general, because they were knowledgeable and clear and logical and easy to understand in their explanations, or because they taught passionately, and took care of the respondent. Two female teachers brought out the "fun" of their respective subjects.

In senior high school, the respondent's favourite subject was as likely to have been chemistry as it was to have been math. It was liked because it was interesting, or, less likely, because the respondent did well in it, in a few cases, because there had been a good teacher. The respondent is twice as likely not to have had a woman math and/or science teacher, as to have had one. If the respondent did have a female teacher in math or science, it was probably a math or chemistry teacher. The respondent chose science in senior high because of interest, probably, but it also could have been because she preferred it to the cultural subject stream with its loose ends, which she might not have found so clear. If she liked both science and cultural streams, she put the culture on hold, since she could pursue it as an avocation, later. Mostly, her advising teachers, twice as likely to be male as female, if she remembers them at all, gave her no counsel, or, if they did, said, "Go for science if you want to." These persons

were most likely in their 40's or 50's, and it is likely that the respondent does not remember their subjects. The respondent may have been affected by a role model, either someone she knew, or someone from literature or film.

Mentors or role models of the respondent are likely to have had broad interests in both scientific and other, different areas.

The respondent entered university, probably to a faculty of science, or, less likely, to a school of pharmacy. She probably chose this faculty because of a subject she wished to study: she may have had two subjects in mind, but her marks on the entrance exam may have tipped her decision in a certain direction. If it was not a subject which drew her to the institution, it was a diploma which would come at the end of the study, giving her lifetime security in a profession. A critical experience may have encouraged her entry to science. As far as the specific lab or course is concerned the respondent is as likely to have been in some branch of biology as she is to have been in a branch of chemistry or physics. The respondent's course was chosen for more individual reasons than was her faculty: she may probably have chosen it because she liked the subject or was attracted by the professor. There is also a small chance that she chose it because she had friends in it, or liked the lab, or wanted to work individually, or because it represented the right

amount of subject difficulty for her, or because the lab was in an isolated place, free from distractions, or because the specialty gave a clear result. Her department or faculty may have had only women students (45% chance), or it may have had a M/F ratio of up to 100:1. The respondent had a respected teacher in university. Her respect for this teacher was probably based on the character and thinking and integrity of the teacher in relation to his subject and to persons. The respondent was taught more often by male teachers in university. There is a two-thirds chance, however, that she had a female teacher she could respect.

It is not likely that books, movies, and films formed much of the socialization of the respondent, with the exception of the book/movie Madame Curie: there is a good chance that this book or movie did. If literature, other than this, had an effect, it was probably in the form of children's science magazines or comics.

The respondent probably did not decide to become a researcher until she had entered at least the bachelor's level of university study. Her decision was probably based on a lifestyle consideration, at this point. She either wanted to be independent, or avoid company work, have the lifestyle of study, make a career, or provide for her family, if a widow. Or there is a good possibility she was still carried by interest in the subject. She probably did not receive any advice on her choice, and, if she did, it

may have been about minor aspects only, or if not, she may have felt free to take or reject the advice.

The respondent may have taken her present job because it was there at the moment in which she needed a job, and/or it suited her current circumstances with regard to the logistics of the situation, such as being good for a woman, having research opportunities, being convenient for a married woman with children, or offering lifetime employment, or being congruent with the respondent's vocational desires.

The respondent is probably very happy with her job, except for some reservations she might hold. Her happiness is probably because of her independence and achievements as a woman, or because of the thrill of discovery, of finding meaning, of creating things that work, and the ability to be able to have time for research and to interpret scientific discovery to others, especially to the young.

If she is frustrated, it is because there is some inequality between men and women, or because she has some anxiety about her future post, or experiences too much bureaucracy in her lab. If she is married, she may be frustrated if she has no help from her husband in relation to her household; or, if he is a scientist, because she has to have a "commuter marriage".

She probably does not take part often in late-night dinner-discussions with male colleagues very often, if at

all.

She believes the non-entry of women to science has much to do with their socialization by the family, society, and educational institutions, and by the very prescribed roles which women have in Japan. She believes that work as a researcher is virtually impossible for a married woman with children, and that teaching is the more practical option.

She would definitely enter science again.

Summary

The profile of the woman scientist shows some congruence with the following characteristics given in the Conceptual Framework:

There is evidence of middle-class socialization patterns. The background of the woman scientist has, also, some "pioneer" characteristics, in some ways similar to the background of the immigrant daughters in America who have entered science. It also shows some similarity to the women of Guilbert's study of women in non-traditional science, who had come from outside the province or country. In addition to this pioneering factor, there is a history of achievement in the family, in some ways similar to the legacy of the aristocratic daughters in Europe who are typical of those who enter science there. The family of the Japanese woman scientist gave her strong mothering and fathering, with some permission for androgyny, in some ways similar to that given

by families of the executive women of Hennig and Jardim's study (1977). The Japanese woman scientist of this study has, usually, city upbringing, typical of women scientists worldwide (Traweek, 1991). Also typical of women scientists worldwide, she has a "well-rounded" background (Traweek, 1992). In the case of the Japanese woman scientist this has included access to both the arts and science, participation in cultural hobbies, the experience of war, and in some cases, foreign study. In the case of war, universal themes such as life, death, relative poverty, and struggle for survival may have encouraged respondents to build larger frameworks, including scientific ones, to aid in their understanding of these phenomena.

The Japanese woman scientist's profile shows some evidence of safety, social, self-actualization, affiliation, achievement and power concerns, as mentioned in Motivational Theories. It also shows some similarity in the profile of role models chosen from life and literature to her own profile, as suggested by Role Model Theory. She has had little difficulty in perceiving herself as a scientist because she met scientists or persons with scientific interest who had non-scientific attributes such as hobbies and viewpoints which were similar to her own, as suggested by literature. Very often mentioned (11 times) in role models from literature, was Madame Curie. This choice is one which, while clearly demonstrating the excellence in science of the

role model, also echoes the Japanese traditional ideal for womanhood, that of being a "good wife, wise mother" (numerous girls' high schools carry this motto, even today). Many of respondents had read the biography of Curie written by her daughter, Eve. In this biography, written by a family member, not only Curie's scientific achievements, but this familial aspect of the great scientist's life, was stressed. A Japanese woman socialized even in the most traditional manner would find little conflict between her background and an entry to science in the style exemplified by Madame Curie. In addition to this, Curie's obviously nonmaterialistic outlook in not patenting her discoveries, her excellence in achievement resulting in two Nobel prizes, her humanitarian labours during wartime, her endurance of privation during her student years also show character traits highly admired and inculcated by Japanese in general. Also, the two Curie marriages (Marie and Irene) present examples of happy husbands of high achievers, a model thought important by Birke (1986) for girls entering science.

The Japanese woman scientist's first positive introduction to science was similar in its style to that exemplified in "girl-friendly science" (Appendix B), and included a visual, hands-on, empirical and contextual approach. She had little difficulty in entering a male-dominated field because of knowledge of the masculine world given to her by empathetic males from the family or

community, similar to the experience of women in non-traditional vocations in Hennig and Jardim (1977). The benefits from this could have been twofold: first, she would have "known the ropes" with regard to male-dominated fields, having become familiar with such patterns as risk-taking, competition, team-work, and the job as a part of a continuum. Second, she may have manifested confidence, so that questions about her validity within her field would have had to come from outside, rather than from her own self-doubt projected to others.

The Japanese woman scientist shows evidence of having maintained caring values despite an entrance to science, possibly through contact with other women in women's science organizations. The use of networking and of associations appears to have been, in fact, one of the coping strategies that the she has used successfully. Much of the cooperative frankness of responses to this survey may well be due to the fact that cooperation with it had been endorsed by the membership of the Society of Women Scientists of Japan.

"Genderization" of science is a difficult question to approach in Japan, since subject/object distance in that country, as in most of the Orient, is not great, and japan itself, if viewed within the framework of the genderization debate, would be, by definition, a feminine-thinking country which is male-dominated. This question would therefore need to be reframed, taking into consideration Eastern culture.

In general, the profile of the Japanese woman scientist is, insofar as this small study shows, in the main, congruent with the profile of women scientists elsewhere. In most cases, the factors related to her science entry have come more from the home than from the school: these factors are transferable, in most cases, however, to educational situations.

Recommendations

High schools in Japan, because of the immense pressure generated by an orientation towards university entrance examinations, offer little of the contextual, relaxed, and enjoyable science experienced by the women of this study. This problem is difficult to remedy because there is little communication between secondary and tertiary levels of education. Some interventions could be made, however:

a) It should be very possible to transfer many of the following factors which have been helpful to girls and women into an institutional setting:

   i) A contextual approach: examples in the science class could come from sources known to girls and proximate to their experience.

   ii) A visual approach: a greater percentage of microscope use, and of illustrations and displays, could be encouraged;

   iii) Presentation of potential role models: knowledge of scientists should include their non-scientific attributes, such as hobbies and pastimes, so that girls can relate to them more readily. Some of these scientists should be women, or Japanese;

   iv) An empirical approach: experiments should be a large percentage of science instruction. If these cannot be done easily, they should be filmed at some central office, and distributed;

iv) A non-pressured approach: examinations should relate more to conceptual knowledge which is improved by discussion and analysis and critical thinking, than to mere facts and formulae, which can be memorized without being properly understood. Perhaps exams on experiments could be removed from the external pressure of the National Central Exam by requiring that they be passed at the local level as a condition for entry to these standardized situations, thus encouraging intrinsic enjoyment;

v) A confidence-raising approach: schoolgirls should be given activities which require them to be causal or instigative, using theoretical knowledge to solve practical problems. Orienteering and girl-scout-type activities, or others of the type offered in popular magazines (build your own computer, etc.) would seem appropriate.

b) Attention should be given to the social studies curricula of schools, in order that universal values can become accessible to all because of the kinds of generalizations students are compelled to make when more than one culture is known. Some moral and philosophical studies may enhance this. These subjects must be taught in a way which requires students' critical and analytical thinking, however, if

universal thinking is to be derived from it. "Why?" should become an important word in the vocabulary.

c) Efforts should be made to improve the image of science. Community projects which bring science activities to women in may help. A more frequent appearance of scientists in the media at a popular level may also help. Women scientists with a penchant for writing girls' literature might find the writing of novels featuring scientific heroines a good contribution to furthering the entry of young women to this field of endeavour, and a worthwhile project during times when they are not active in science due to childrearing responsibilities. Much general knowledge of some professions (e.g.: police and detective work) comes from popular literature and the media. Few books deal, however, with the subject of women scientists;

d) Science textbooks should be examined to determine if they are girl-friendly, i.e., that they are using an empirical, visual, and contextual approach.

e) Prizes to encourage and promote girls' continuance in science should be established.

f) Models of marriages and homes which have proven workable in the Japanese scientific community should be made available, both as a guide to those entering science, and to the general society, which may adapt its expectations for this particular situation. The

literature and this study have elicited the idea that having a scientific husband is usually the better situation for the woman scientist. Given that marriage choice is less a matter of time and chance and more a matter of determination in Japan, this possibility could be borne in mind, all other factors being equal.

f) Institutional support for science families could be established, especially in the new science cities. This support could allow women and families in science to devote quality time to both professional and home life. In order to do this, thought should be given to types of employment which allow part-time, yet crucial involvement during the childbearing and childrearing years, since it is inimical to the development of scientific attitudes in the next generation to have less than quality and quantity verbal involvement between parents and children. This support could include systems of daycare which could allow women to keep up with current research while in the home; to job-share where that was deemed most appropriate; to do laboratory work during hours that conventional daycare systems would not be operative. It could also include systems which could aid in domestic duties at a reasonable cost: this could include aids to home cleaning, marketing, meal preparation, and laundry, so that with a minimum of time, normal home routines could

be accomplished. Support could also include on-site daycare in workplaces and conference sites, as well as a liaison with schools which could allow women in science some flexibility as they fulfil their duties there.

g) Role models can be provided by maximizing the visibility of Japanese women scientists through awards, accounts in popular literature and film and through personal appearances. Models, especially female ones, of alumni achievement in any field, can be presented by schools as examples for present-day students to follow. These can help those without familial models.

h) Counsellors can present to girls a wide variety of vocational options in the field of science and ensure that they are aware of necessary courses. Career, as well as job, possibilities should be envisioned.

i) Girls need some knowledge of patterns commonly found in male-dominated fields if they are planning to enter them. They may need to know how to function in a competitive environment, and may need to learn this through team sports and other such activities. Father/daughter activities which might allow greater knowledge of workplaces can be sponsored by companies, and fathers can share their world with girls' schools. Male counsellors can also be called upon to inform girls of male perspectives on career.

Suggestions for Further Research

In an article in Science (October 23, 1992), Fred Myers recounts some recent brief conversations with Japanese women scientists (a half dozen or so), most of whom spoke of discouragement they had met with regard to their entry to science. It would appear interesting to research such a group, women who had met with discouragement, and to compare their backgrounds with those in the present study. It would seem appropriate to determine what were the major differences, if any, between the groups.

Some respondents have mentioned discouragement given by high school teachers. Another area for investigation might be high school teachers in Japan, their backgrounds, attitudes, and socialization in teacher training institutions.

Socialization patterns of particular social classes may impede the democratization of entry by women to fields requiring the considerations of logic. It would be interesting to investigate this area in relation to women's entry to science.

The connection between a wide access to culture and experience, as evidenced in research that suggests that "well-rounded" girls, worldwide, enter science could also bear further investigation. It would be interesting to investigate the specifics of this phenomenon.

Appendixes

Appendix A

English Translation of Questionnaire

Birth Date: AD___ Sex: M F

Birth Prefecture: ____ Grew to age 15 in _____

Educational History:

Type of school:

Old: ____ New: Jr. High____

____ High Schl___

____ Univ/Coll___

Most Recent Educational History and Year of Graduation

(e.g.: Ochanomizu Univ:1991. Graduate School of Faculty of Science. Master's) _____

_____

Do you have a title (doctorate)? If so, when did you receive it?

Yes (Year: _____) No ____

What type of title?

Sci Engineering Agriculture

Medicine Pharmacy Other (_____)

What was your major (e.g., chemistry, biology, etc.)? _____

Occupation:

Academic: Prof Assoc Assist Other (__)

Researcher at institute:

Lab head #2 Resrchr Other

School teacher:

Jr High High school (_____)

Motivation to Become a Scientist

1) Birth Family

1. Occupation

   Father (____) Mother (____)

2. Was there a teacher or researcher in your family or its relatives?

   Yes No

3. Who? Specialty?

   Father ( ) Mother ( )

   Gfather( ) Gmother( )

   Elderbro( ) Eldersis( )

   Ygr Bro ( ) Ygr Sis ( )

4. Did anyone in your family <u>agree</u> with your choice of science?

   Yes No

5. Who? When or in what situation? What reason given?

_____ _____ _____

6. Did anyone in the family <u>disagree</u> with your choice of science?

Yes No

7. Who? When or in what situation? What reason given?

_____ _____ _____

2) Elementary School

1. What kind of subject (one choice) did you like?

JLang/Lit Math Sci SocSt Other ( )

3. [sic] Did you do outdoor education in science?

Often Sometimes No Other

4. Was there a teacher who encouraged outdoor education in science?

Yes (M F) No I don't remember

5. Did you like that teacher?

Like Respect Not more than average

Dislike Other ( )

3) Junior High School

1. What kind of subject did you like?

JLit/Lang Math Sci SocSt ForLang

Other ( )

2. Why did you like it?

did well in it interesting

nice teacher other ( )

3. If you chose <u>science</u>, answer this: what kind of science did you like?

Phys Chem Biol Geol Astronomy All

Other ( )

4. Were there any women teachers in your math or science courses?

MA: Yes (___total teachers___women teachers);

No

SCI: Yes (___total teachers ___women teachers);

No

5. If you had a good teacher in mathematics or science, please write the reason and gender:

MATH:_____

SCIENCE:_____

4) High School

1. Which subject did you like best?

Math Phys Chem Biol Geol Geog

Other ( )

2. Choose the (best) reason you liked it:

did well in it interesting

good teacher other ( )

3. About your math and science teachers:

Any women? No

Yes (Specialty:____)

(Age of teacher:__)

(Specialty:____)

(Age of teacher:____)

4. Please tell the reason you chose science in high school:

(_____)

5 a. What was the advice from your advising teacher?

Encouraged me to go for science, considering future job potential.

Encouraged me to go for science, saying, "If you want to."

Said, "Women can't do well in science."

Discouraged science ("Consider the future: Your marriage").

Discouraged science ("You are not temperamentally suited to it").

Said, "Your marks are too low."

No advice from teacher.

Other (_____)

5b. About the advising teacher:

Sex: Male Female

Age (approx): 20s 30s 40s 50s 60s

Subject he/she taught: _____

5) University or College

1. What faculty did you enter? Subject?

Faculty (____) Subject ( )

2. Why? (_____)

3. To what laboratory (course) did you belong?

Course (_____)

4. Why did you choose this course?

_____

5. Student ratio in the deparment or faculty: M:F = ___:___

6. Did you have a respected teacher in university (undergrad and grad)?

Yes No

7. Why did you respect the teacher?

_____

8. Teachers: sex ratio

M:F = __:___

9. Did you have a woman teacher or woman researcher you could respect? Yes No

6) Did Other Informal Education Have Any Effect On Your Choosing Science?

Books:

	Title	When read
Biog	_____	_____
Book about sci by scientist	_____	_____
Science magazine(s)	_____	_____

Social News, such as "Apollo" or "DNA Double Helix"
(_____)

Film and TV Programmes:
(_____)

7) Job

1. When did you decide to be a science researcher? (_____)
2. Why did you decide to be one? (e.g.: I like to study science; self-support, etc.) (_____)

3. Did you receive any good advice/support when you made that career choice?

Yes Who? (_____)

What kind? (_____)

No

4. Why did you choose your present job?

(_____)

5. Do you feel satisfied with this job?

Yes No

6. Why or why not?

(_____)

Thank you....(etc.). Your name is not necessary, but if you are able, and wish to do an interview, please fill in your school name, and the date and place you wish to be interviewed:

Name:_____Occupation and Position:_____

Address:_____

Phone:_____

If you have a brother or sister in science who would also be willing to be interviewed, please fill in the section below:

Name:_____ Relationship:____ Occupation or Position_____

Address:_____

Phone:_____

Note. The numbering system of the original Japanese questionnaire was retained.

Appendix B

Characteristics of Classrooms Fostering Girls' Continuance in Science

From Matyas (1985, pp. 49-56)

Teachers in the United States with a proven track record in successfully teaching biology to young women were studied. Their classrooms were rural, urban, suburban, Eastern, Midwestern, southern, Rocky Mountain, Far Western, and included white, non-Hispanic, Black, and Hispanic students. Interviews, notes, messages of former students, trained observer reports, thousands of survey item responses, and a critical review of the literature were all used in this project. Many commonalities were found. In some cases these could be compared with the national average, since many of the items had been used on a national survey of science classrooms, generally, before this study was done.

Commonalities in the Classrooms

- visually stimulating
- well-equipped and maintained
- apparently well-supplied, since, compared with the national average, teachers did not report a need for more supplies.
- pleasant ambience
- more than one text used in all cases (national average: 52%)
- teacher-made materials had equality of men/women in

examples used

Commonalities in Strategies:

- 71% had invited female scientists to classes to discuss science careers.
- complete absence of sexist language
- Used lab materials much more often (over 80%).
- Used lab materials at least once a week (national average: 50%)
- All teachers found microscopes, models, balances, living plants, living animals, necessary (1/3 or more, nationally, found these unnecessary).
- The majority used filmstrips, film loops and slides at least once a month (nationally, less than 1/2).
- All considered videotapes necessary (nationally, over 1/2 didn't consider necessary).
- All: weekly quizzes (nationally, only 37%)
- less lectures than nationally
- more guest speakers/field trips than nationally
- more independent projects, library research, televised instruction
- Provided career information.
- Related biology to everyday life.
- unisex treatment

Commonality in Responses of Girl Students:

Over and over, girls responded, "The labs," to the question, "What do you like best about your high school biology class?" Perhaps it was expressed best by a 15-year-old girl in the Deep South, who said, "I enjoyed working with microscopes. We had a cow heart and we opened it up... looked in the microscope at the different parts of the inside of the heart and I enjoyed that." Instructional techniques that involve students also may encourage and excite young women to study science. As a minority girl in a large city school stated, "[Our teacher] always has discussions. We always ask questions, and we learn the most from discussions."

Commonalities of Teachers:

- Experience average: 18.4 years (nationally: 11.8)
- Degrees: all beyond bachelor's
- 5/7 held at least one biology degree (nationally: 54% advanced degrees).
- 86% women (nationally: 24%)
- Active professionals.
- Good academic preparation.
- Positive attitudes towards science as a discipline.
- 7/8 had attended a science-related professional meeting within the year.

- 86% had made presentations at professional meetings.
- Most involved in science activities outside of school.
- Several had science-related hobbies.

Appendix C

"The Greater Learning for Women"

Excerpts from Fukuzawa, Yukichi. (1988). Fukuzawa Yukichi on Japanese women: Selected works. Tokyo: University of Tokyo Press, pp. 182 210.

3. From her earliest youth, a girl should observe the line of demarcation separating women from men... and (not to speak of strangers) she must observe a certain distance in her [social] intercourse even with her husband and with her brothers (p. 182).

5. ....On every point must she inquire of her father-in-law and mother-in-law. Even if thy father-in-law and mother-in-law be pleased to hate and vilify thee, be not angry with them, and murmur not (p. 182).

6. A woman has no particular lord. She must look to her husband as her lord, and must serve him with all worship and reverence, not despising or thinking lightly of him (p. 188).

7. ....Should she lay herself open to the ridicule and dislike of her husband's kindred, she would offend her parents-in-law, and do harm even to herself....

12. In her capacity of wife, she must keep her

husband's household in proper order.... In everything she must avoid extravagance, and both with regard to food and raiment must act according to her station in life, and never give way to luxury and pride.

13. While young, she must avoid the intimacy and familiarity of her husband's kinsmen, comrades, and retainers, ever strictly adhering to the rule of separation between the sexes; and on no account whatever should she enter into correspondence with a young man.

15. Without her husband's permission, she must go nowhere....

17. However many servants she may have in her employ, it is a woman's duty not to shirk the trouble of attending to everything.... Ever attentive to the requirements of her husband, she must fold his clothes and dust his rug, rear his children, wash what is dirty, be constantly in the midst of her household, and never go abroad but of necessity (p. 207).

19. The five worst maladies that afflict the female mind are: indocility, discontent, slander, jealousy, and silliness. Without any doubt, these five maladies

infest seven or eight out of every ten women, and it is from these that arises the inferiority of women to men.... Woman's nature is passive (lit. shade). This passiveness, being of the nature of the night, is dark.... Such is the stupidity of her character that it is incumbent on her... to distrust herself and to obey her husband (p. 210).

Appendix D

Examinations

Excerpt from Workshop 5. (1992). The Proceedings of the Second US/P.R. China/Japan Conference on Physics Education, in Journal of the Physics Education Society of Japan, 40 (Supplement), 84-86.

National Center Test - Required of all students entering any national university and a few faculties of private universities.
Entrance Examination - Administered by each university, both national and private.

While all students applying to a national university must take the National Center Test, students must still take the Entrance Examination administered by the university of choice and specific to the intended major (called faculty in Japan). There is no passing score on the National Center Test. For entrance to a National University the total of both the National Center Test and Entrance Examination of the individual university must be above a certain amount. This amount varies from year to year and by university, and is somewhat dependent upon how many students take the tests and how well they do. The university admission in Japan is based on competition among candidates.

The National Center Test, for science majors, has several components: 2 sciences, 2 English, 1 Japanese Language, 1 social science, and 2 mathematics. Students may choose their two science components from 5 subjects; of course, prospective physics majors would choose the physics component. The five science subjects of the National Center Test occur in three sets: physics and earth science; chemistry and science 1 (general science); and biology. A student may elect to take any two tests from the paired sets or biology. If that set has two components, say physics and earth science, after entering the examination and reading the test, the student may elect which test, either physics or earth science, to complete for entrance. Science students must take two science portions, a student would then select a second test from another pair or biology. A student can not take both tests of the same pair. The physics portion is a 1-hour multiple choice test with a maximum score of 100 points [Appendix (b)]. There is no penalty for guessing.

Most private universities do not require applying students to take the National Center Test. These private universities require that the applying student take only one Entrance Examination for that university in the area of intended major. If a university offers majors in 7 subject areas, then it will have 7 entrance examinations, one for each major. Each entrance examination consist [sic] of 3 or 4 tests, including one test in the student's intended major field. For physics majors a typical battery of tests that comprise an entrance examination for a private university would be physics, mathematics, and English.... The entrance examinations may play a role in a student's career choice because a student may be able to pass only the subject area examination that was a second or third choice as a career field. The subject area examinations are given over a period of several days so that students may take more than one subject area examination....

The Entrance Examinations for both national universities and private universities vary considerably in quality and substance from university to university: from testing only student memory to testing concepts. The entrance examinations administered by individual universities are designed so that one problem offers a set of given circumstances followed by several questions to be answered, each correct answer contributing to the total score. In general, the examinations will have three or four such problems and test only four major areas of physics with all other areas remaining untested. Some tests are multiple choice and others are free response. Some of the tests are written in a format complicated to the point that figuring out the format becomes part of the test. In some cases, students put in considerable preparation for only marginal evaluation....

The National Center Test consisting of 18 subjects is written by about 380 university professors who are engaged two years as part time professors to make the problems. There is no input whatever from any high school personnel.... Whether for private or national universities, test questions for entrance examinations are never evaluated, piloted, or field tested prior to being administered. Once the tests are given the questions are published and used widely for practice. The National Center Test undergoes some evaluation based on test results after the test is administered.

Most high school teachers consider that the pressure of university admissions solely by examination is detrimental to physics teaching and learning.... It also emphasized memorization over concept formation.

Appendix E

Interview Protocol

Family

Family in General.

Any special family heritage or theme?
High expectations of you?
Focus on career/work aspect of life?
Freedom for traditional and/or non-conventional?
Valued education?
Any sex-stereotyping?
Valued home life?

Father.

Any special information? Level of education?
Home a lot? A little? Hobbies?
Provider? Caregiver? Vocational exemplar?
Advisor?

Mother.

Any special information? Level of education?
Home a lot? A little? Hobbies?
Protective? Not so protective?
Dependent? Independent? Caregiver?
Provider?
Vocational exemplar? Advisor?

Childhood

Alone?
Adult contact?
School entry: early? late?
"Why?" questions: acceptable?
Critical experiences?
Toys/games: take-apart? put-together? non-conventional?
Confidence with lab/science materials?

Socialization

To independent thinking?
To causality? problem-solving?
To learning of skills?
To risk-taking? commitment?
To intrinsic interest in science?
To the idea that girls need science in order to become competent people?

Elementary School

Any teachers with mini-, or more, expertise in science?
Good science experience?

Well-equipped science lab?
Did math seem useful?
Your first positive experience with science, or with a science-related matter? when?
When did you first see science as a possible career area for women?
Do you think 12-14 is a good age to make a math/science stream choice (as in Japan)?
When you were in elementary school, were there older children who were science role models for you?

Contribution (Relative) to Science Learning

	Parents		Teachers	Others
	Mother	Father		
Approval				
"Science is for you."				
Role model(s)				
Exemplar(s)				
Vocational advisor(s)				
Field trips				
Personal interest				
Meeting a scientist				
"Hands-on" activities				
Encouragement in science				
High expectations				
Discouragement of passivity				
Non-sexist attitude				
Visual aids				
Supplementary texts				
Good knowledge of science				
Displays/models				
Science-related hobbies				
Teacher with much teaching experience				
Make science "beautiful."				

Math: the "Critical Screen"

Any extra help on it?
Did you have enough math at university level to take the subject of your choice?

"Genderization" of Science

Does science in Japan have only "male thinking" approaches to its work (e.g.: objective; no room for subjectivity/creativity)?
Do you think that women have a special contribution to make to science work in Japan? If so, what?

"A Man's World"

In your field of science, are there mostly men? If so, is that in any way problematic for you?
Would it be more problematic if a woman were of a higher/lower social level than the man?

of a higher/lower scientific ability level than the man?

Would you describe most man/woman relationships in science as: brother/sister; professional and egalitarian; scientist/girl-jin (odd type of girl); father/daughter; other?

Did you happen to have any special preparation to give you confidence in a non-traditional area?

What about (in Japan) late dinner-discussions? Do these disadvantage women?

About You

Would you do science again?

If so, would you make any changes?

Was there another field that strongly pulled you?

What are your special satisfactions in science?

What are the frustrations?

Did you ever have a serious discouragement in science?

If so, what helped you overcome it?

Did you ever think a science career could be humanitarian?

Why did the book (movie) that you mentioned affect you?

Were there any activities in your life which gave you confidence? Which?

Why do you think many women don't enter science?

Can a woman "have it all" (marriage, children, hobbies) in Japan, as a scientist? Why or why not? Your sports? hobbies?

Did you ever have a friend with ability in science who stopped studying it? Reasons?

Appendix F

Women Scientists' Progress in Japan
From Yamashita files (1981-1991)

Year	Significant Event (university parenthesized)
1874	**Tokyo Women's Normal High School** founded (later, becomes Ochanomizu Women's University)
1897	**Ochanomizu Women's University** science section established
1900	**Tokyo Women's Medical School** founded
1901	**Japan Women's College** founded **Ume Tange** is first graduate from the Housekeeping Section of Japan Women's College
1913	**Three women** allowed to enter **Tohoku Imperial University** (including **Chika Kuroda**)
1914	**Kono Yasui** goes to USA (1913-15) for foreign study. Later becomes the first science professor at Ochanomizu Women's University
1927	**Yasui, Kono**: doctorate in plant physiology (Tokyo)
1929	**Kuroda, Chika**: doctorate in organic chemistry (Tohoku)
1930	**Hokkaido University** opens door to women
1931	**Kato, Sachi**: doctorate in physical chemistry (Kyoto) **Toda, Kuni**: doctorate in medicine (Keio) **Ide, Hiroko**: doctorate in medicine (Tohoku)
1932	**Tsujimura**: doctorate in plant physiology (Tokyo)
1935	**Tamae, Yuki**: first woman student in Faculty of Mathematics (Hokkaido)
1936	**Furuichi, Yurie** (née Yokota) and **Soetani, Akiko**: admitted to Faculty of Physics (Hokkaido)
1939	**Ogawa, Fumiyo**: doctorate in biology, physiology (Tohoku)
1942	**revision** to improve quality of girls' high school curriculum
1943	**Yuasa, Toshiko**: doctorate in physics (France)

1944 **Anno, Kimiko**: becomes professor at Tokyo Women's Normal High School

1947 **Takada, Masa**: doctorate in chemistry (Tokyo)

1949 **Anno, Kimiko**: doctorate in chemistry in Arts and Science Faculty

1957 **Saruhashi, Katsuko**: doctorate in geochemistry (Tokyo): first woman doctor of chemistry at the university
Ikuse, Masa: doctorate in pharmacy (Tokyo)
Tsuji, Kiyo: doctorate in organic chemistry (Kyoto)

1963 **Kamiya**: professor of psychiatry at Tsuda College

1965 **Mamiya**: chief researcher (National Meteorological Institute)

1966 **Kobayashi**: professor at Junior Nursing College (Tokyo Women's Medical School)

1967 **Yoshie Katsurada**: appointed professor in mathematics at Hokkaido University (first woman professor there: unanimous approval)

1973 **Anno, Kimiko**: Dean of Faculty of Science (Ochanomizu)
Ikuse, Masa: Dean of School of Pharmacy (Toho)
Saruhashi, Katsuko: Chief of Second Geochemistry Department (National Meteorological Institute)

1992 **Itoh, Atsuko**: Dean of Faculty of Science (Ochanomizu)

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