Introduction

In the Spring of 1983, education became a political issue in the United States. The National Commission on Excellence in Education (NCEE) issued its report, entitled: *A Nation at Risk: The Imperative for Educational Reform*. It spoke of "a rising tide of mediocrity that threatens our very future as a nation and a people," and concluded that "we have, in effect, been committing an act of unthinking, unilateral educational disarmament."1 Yet this was only one of a series of major reports in the space of a few months, all of which described an appalling state of affairs and sought to identify remedies.2 In these reports there is substantial agreement concerning a massive decline in the performance of American students in mathematics, science and English in the past twenty years. Lower levels of achievement are traced directly to weakened curricular requirements. The reports have prompted considerable discussion in the media and among politicians as well as professionals in education. Yet the harsh truths were not welcome news, contradicting as they did certain views cherished by the general public. Thus, to soften the impact of these reports, one Scripps-Howard newspaper3 optimistically entitled an article on the subject: "America's brightest rate with best." The reference is to an Educational Testing Service report that noted that although the top 4 or 5% of U.S. high school students "compete 'reasonably well' in science and mathematics with the brightest in Japan and Europe," the average American student performed much below those of other industrialized countries. The ETS's William Turnbull is reported as stating that "the pool of young men from middle-class families who traditionally study science and math is declining, so the climate is 'unusually favorable' for persuading young women and students from disadvantaged backgrounds to prepare for science careers. 'Their present underrepresentation is an educational and social tragedy,' he said."
In recent years, substantial concern has indeed been expressed, both in this country and abroad, regarding the low rate of women's participation in science and technology as well as the lower levels of both participation and achievement of girls in science education. Some efforts at change have been made and there has been considerable pointing with pride at what are offered as striking examples of achievement. At the same time, in spite of a voluminous and growing literature on these and related subjects, the causes of the problems are far from fully understood.

The present concern with the state of education encourages us to reconsider the matter and to propose an analysis which, we believe, differs somewhat from earlier approaches. Specifically, we argue that a cultural approach to an understanding of the situation of women with regard to science is warranted, and that some earlier studies which found little support for a cultural explanation suffered from a lack of specificity or breadth in the utilization of that concept. We propose a developmental model for the understanding of how individuals arrive at career decisions, and we find some preliminary support for our model in a review of the relevant literature and in some exploratory research with students and faculty members at the Ohio State University.

The Problem

In the past fifteen years, there has been a great increase in higher education for women. According to the U.S. Census Bureau (October 1980), in 1979 women for the first time exceeded men in college attendance: 5.5 million men to 6 million women. This difference was largely due to the return to college of women who were over age 35, suggesting that an educational "deficit" in the female population was being made up. In 1978 women comprised 49% of
undergraduate enrollment. In the eleven years between 1964-65 and 1974-75 the 
percentage of undergraduate degrees awarded to women doubled, from 21.5% to 43% 
(Rose et al., 1978). In 1980 it reached 49%. The percentage of doctorates 
received by women rose from 10% in 1955 to 23% in 1976 and 29% in 1980. In 
science and engineering, it rose from 7% in 1965 to 17% in 1976 (cf. data 
summarized in Rose et al., 1978).

According to NSF5 the number of women enrolled in doctorate granting 
institutions also increased at an average annual rate of 8% between 1975 and 
1979, while that of men declined at 1% per year in the same period. In envi­
ronmental sciences and engineering the growth of female enrollment was even 
greater, 15% per year. This in spite of the fact that 36% of the women relied 
on their own financial resources6, compared to only 28% of the men. With regard 
to federal support, NSF reports that it was received in the same proportion by 
men and women.

Growths such as these are indeed impressive. Yet statements in terms of 
percentages may be misleading, for in many of the science areas, the initial 
numbers of women were very small indeed. An extreme example illustrates this 
point vividly: the graduate program in the Ohio State University College of 
Veterinary Medicine reports a 1500% increase in female enrollment for the period 
1971-80: from 1 woman in 1971 to 16 in 1980. In spite of the substantial gains 
made, the numbers of women active in science and engineering in the United 
States are very small. Indeed although women make up a little more than half of 
the U.S. population, only 15.6% of the nation's scientists7 and less than 3% of 
the engineers are women8. Furthermore, the percentage of women among the 
postsecondary faculties actually dropped from 27% in the inter-war period, 
1919-40, to 24% in 1975-76 (Rose et. al. 1978).
This state of affairs has frequently been deplored. Richard M. Krause, Director of the Institute of Allergy and Infectious Diseases at NIH (1979:3), writing hopefully of a "new burst of enthusiasm in the search for knowledge," added, "Women must play their part in that. The search for knowledge is far too critical and far too central to the salvation of our society for this work to be the domain of any exclusive male club."

In a 1981 editorial in Science Malcolm (1981:137) argued that "science has not been served well by our past prejudice and discrimination: we have lost time, talent, and ideas," and goes on to protest "cuts in programs for developing the capabilities of women and minorities, not only for the sake of these groups but also for the sake of science and for the sake of our nation."

In the current situation, the economic problems of students as well as of colleges and universities loom large. These difficulties, which may significantly limit access of talented women to training for science careers, constitute what may be called "second level problems" for women, that is, they have a devastating effect on women who would otherwise opt for science careers, who have overcome, or are prepared to overcome, non-economic obstacles. The first level is illustrated by data such as the following: In 1978 less than half of the women students entering college were prepared to take college level mathematics courses, compared to 63% of the men. According to the Ohio State University College of Mathematical and Physical Sciences, monitoring the qualifications of entering students, the gap between males and females continues to widen.
Women's Career Choices: A Developmental Model

The low rate of American women's participation in science and engineering fields has generally been explained as due to one of two sets of factors: either women are said to be biologically less able to achieve in technical areas, particularly mathematics and physics, or there are cultural factors which are found to limit their participation and achievement. Evidence for both of these claims is reviewed in the following pages. Regardless of whether women are as able or less able than men to acquire mathematical and scientific training, sociocultural factors are at work in America, and other industrialized societies, that the ablest of women must deal with in order to succeed in these fields.

American women face a variety of barriers, or, in Cobb's (1979) apt phrase, "filters", at various points in their personal and intellectual development. Each of these constitutes a potential fork in the road. For those who pass through a given filter, the road leads to further opportunities and to further obstacles to be overcome. Viewed in this manner, career decisions appear as the final result of a lengthy process and as the outcome of the interaction of multiple antecedents. Arrival at a career decision may consequently be represented by a model of the individual developmental process, which we call the "career decision time path." This consists of four identifiable stages as depicted in Figure 1.

At stage 1 (preadolescence) ideal choices or goals are set; although they cannot be implemented for some time, they may determine certain pre-preparatory activities. These range from choice of play activities at age 8 or 10 to participation in hobbies and extra-curricular activities at 14. Where avail-
able, choices with regard to school subjects will also be affected, and will, in turn, lead to further choices and assessment of interests and abilities. How much divergence in schooling is there in this early period between the sexes? How much difference in mathematical and science related performance and achievement? What is the impact of parents, teachers, peers, and media on these early goals and their effect on choice of activities?

Insert Figure 2 about here

At Stage 2, (in senior high school) course choices and extra-curricular activities are affected by these goals. Youngsters will revise goals or, those who did not formulate goals earlier, will do so now, particularly with regard to possible college attendance. Beginning in junior high school (about age 13) and increasingly later, pressures surrounding dating and "popularity" affect young people, and for girls these are often exerted in contradiction to scholastic excellence, choice of mathematics and science courses, and careers. With exposure to new influences (teachers, counselors) including new peer pressures and new role models, the original goals may be reformulated or dropped, or new goals set.

For those who move on to college, Stage 3 represents a period where career choice is more formally established as reflected in "choice of major." At this level, the individual may discover that a) earlier preparation was inadequate; b) the definition of the major does not correspond to earlier images of a career, and c) that new interests are stimulated, or earlier goals are perceived as unrealistic. Non-academic reasons, economic or personal, may interfere with the development of career goals, so that the career choice is modified, abandoned or postponed. If, however, none of these filters have blocked the process, the career choice may be fully implemented upon graduation (e.g.,
employment as an engineer) or advanced to a further stage through the pursuit of graduate training. If this hurdle is also passed successfully, career goals may be actively pursued (Stage 4).

The process is developmental and cumulative, in that earlier choices, activities and experiences affect the possibility of exercising later options. Eliminations occur at each step along the way. The outcome of the process appears in career choice implementation but also in the effect of the process on the survivor's attitudes, self-image and motivations.

Career decisions, then, are the final outcome of a sequence of choices beginning in the preadolescence period and ending with a greater or lesser degree of actualization in adulthood, influenced at each stage by the interaction of a complex, interwoven set of variables. Consequently, they must be studied from a systems perspective including the following: a) Interacting biological (B) and psychological (P) factors that characterize an individual, both affecting and affected by the socio-cultural context (S/C) in which career options emerge and mature, b) factors which block (i.e., "filters" in Cobb's sense) or reinforce career selection, leading to c) a net balance of factors advancing or impeding a science career, that is, the sequence of choices made by the individual in response to the above circumstances. The final product, d) is a science career or a "nonscience career" -- that is, a choice of other life options. This, then, constitutes our Consolidated Model of Factors Advancing or Impeding a Science Career (Fig. 4).
As the model indicates, becoming a scientist involves decision making all along the developmental path. This differs from the type of decision making processes studied by anthropologists and others (e.g., Slovic et al. 1977, Quinn 1978, Young 1981) in a number of important ways: Although at each point in time we are dealing with a single decision or complex of decisions, the end product can be understood only as the outcome of a long chain of choices, extending over a decade or more. Also, for a major portion of the process, the central actors are children or immature individuals. Only some of the choices are made by them, many or most by other actors, particularly parents. The range of later options will be enlarged or limited by the choices adult actors make for them: choice of toys, of play groups fostered, choice of extra-curricular activities, choice of pre-schools and even schools, and so on. Where early choices are made by the central actor, factors that affect the decision making of children or immature individuals are likely to differ from those influencing adults. For example, young people's sense of time and their concern with the effect of present actions on future opportunities as well as their ability to calculate them differ importantly from those of adults. Nevertheless, studies of health care decisions such as that of Young (1981) may provide useful suggestions for the investigation of individual decision making processes regarding careers: If health care decisions are affected by classifications of illness, are career decisions affected by classifications of careers? Also, where health care decisions are affected by variables characterizing actors, career decisions are likely to be similarly affected (e.g., class, parents' education, parents occupation, race/ethnic group, etc.). Finally, the descriptive studies of health care decision-making can be paralleled for career decision-making. We can ask: what choices do actors see as available to them? And what factors
affect their perceptions of choice (e.g., how much money is required? how much potential conflict with significant others does a given choice involve? etc.).

Our model leads us to predict, and a review of the pertinent literature confirms, the operation of a series of factors in American society that have variously been associated with women's career choices. These include the following: parental expectations, the influence of role models, a distinctive configuration of American values, the structure and functioning of educational institutions including the quality of teaching, the implicit as well as explicit philosophies and expression of attitudes about gender differences held by faculty and staff of the schools, interaction patterns between boys and girls at each developmental level, peer pressures, youth culture, and the media (specifically television, films, popular music, and reading materials). These factors operate either alone or in combination at each stage of the career decision time path. To the sociocultural antecedents we must also add for a full review the postulated biological bases of sex differences in behavior and brain function.

The Cultural Hypothesis

The model is sufficiently abstract to be applicable to all societies in which a segment of the population prepares for careers in science and technology. A cultural approach must explain phenomena observed in a specific society and it must also account for both similarities and differences among a number of societies. A. Kelly has noted that "the cultural hypothesis is the most widely advocated and intuitively reasonable explanation for the inferior achievement of women in science". It suggests that differences occur "because society does not encourage or expect girls to achieve as well as boys in
science". More generally, it asserts that "throughout the world in present-day society, achievement by women is neither expected, nor encouraged, nor adequately recognized when it occurs" (Kelly 1981:24).

As Kelly recognizes, such broad assertions are of little research utility. She therefore offers a narrower definition of the hypothesis which is implied in the argument that science has a specifically masculine connotation and that girls are "socialized away from science at an early age." The masculine connotation is presented to children in the situations in which they are most likely to meet science and scientists: books, films, television. The expectation would then be that as socialization varies, so would girls' science performance.

Kelly discusses the cultural hypothesis in these different forms in the context of a review of the findings of a multi-country study conducted by the IEA9. One very striking finding which she addresses concerns the fact that, for 14 year olds in biology, chemistry and physics, in all countries boys exceeded girls in tests of achievement. However, the specific performance of girls in some countries exceeded that of boys in another: Girls in Hungary and Japan "did better in biology than boys in all countries except Hungary and Japan." In chemistry "Hungarian and Japanese girls achieved better mean scores than boys in all other countries." The mean score in physics for girls in Japan "was comparable to that of boys in other countries. This single result is of crucial importance because it illustrates that, with a suitable mixture of cultural background, attitude, motivation, and teaching the mean score of a group of girls can exceed the boys' international average score in physics" (Kelly 1981:25-6).
The IEA study reveals not only the constant sex difference in performance, which is interesting and remarkable in and of itself, but also the fact that girls' average level of performance as well as boys' can be higher than it is. We are not dealing with differences in capacities, but differences in performance which are affected by an array of factors. With regard to the United States, we note that, for the total science test, both boys and girls rank 7th in their own sex groups in international standing. Indeed American boys rank lower in biology than both boys and girls in Hungary and Japan, with boys ranking third in biology among boys, girls 6th for girls. In physics, U.S. boys rank 10th for boys and girls rank 8th for girls. The conclusion is that the evidence shows that in a comparative framework, there is room for a lot of improvement in U.S. science teaching, and that if overall science teaching is given greater importance, girls as well as boys will improve in performance.

Data on cultural differences within the United States are also relevant to this discussion. In California, Sells (1982) found major differences in state-wide mathematics achievement tests by cultural group as indicated by language spoken in the home. Unfortunately, these figures are not broken down by sex.

<table>
<thead>
<tr>
<th>Language</th>
<th>Grade</th>
<th>Percentile</th>
</tr>
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<tbody>
<tr>
<td>English only</td>
<td>third grade</td>
<td>54th percentile</td>
</tr>
<tr>
<td>plus Chinese</td>
<td>99th</td>
<td>96th</td>
</tr>
<tr>
<td>plus Japanese</td>
<td>97th</td>
<td>94th</td>
</tr>
<tr>
<td>plus Spanish</td>
<td>16th</td>
<td>14th</td>
</tr>
</tbody>
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6th grade

57th percentile

96th

94th

14th

As Sells writes: These very large cultural differences in mathematics scores raise important questions about cultural differences in biological, psychological, sociological and economic variables affecting ability, participation and achievement in mathematics. How do these cultures
differ in ability to motivate students to hard work in school, and to excel in mathematics? How do the expectations of parents, teachers, and society differ for Asian, Anglo, and Hispanic children? (Sells 1982:19)

As the above table indicates, the ethnic differences are impressive. However, indicators of socio-economic class (principal breadwinner's occupation, educational level of "most educated" parent) have as drastic an impact. Moreover, we may expect that the three variables (ethnic group, parents' occupation and parents' education) are not entirely independent.

Thus, a "cultural hypothesis" that is limited to socialization variables is by far too narrow to serve as a basis for explaining sex differences in science achievement of students. In our sense, cultural variables include, as seen in our model, in addition to socialization variables regarding science specifically and sex roles more generally, a much broader range of factors.

Contrary to much contemporary opinion it is not the United States nor the most highly industrialized countries in general that provide women the greatest latitude in career options. Safilios-Rothschild (1971) found that the widest spectrum exists in countries in the medium range of development as measured by GNP per capita. Professions open to women in these countries include pharmacy, law, medicine, dentistry, as well as teaching. This is illustrated by the case of the Philippines (Fox 1963, Jacobson 1974), and of Argentina (Kinzer 1973, 1975). According to Chafetz (1978:139), women who achieve higher education face less discrimination in Third World countries than they do in the United States. Also, at a time when 76% of physicians in the USSR were women, 25% in the United Kingdom and 22% in France, only 9% of U.S. physicians were women (Sullerot 1971).
These facts are consistent with Astin's finding (1969, 1973:144) that women who were foreign nationals at the time they received doctorates in the U.S. were more likely to hold degrees in physics and astronomy. Specifically, this finding is confirmed by figures provided by Kistiakovsky (1979). It is not clear, however, on the basis of statistics only, and in the absence of more detailed information, whether these foreign women doctorates represent a skewed sample of the populations from which they are drawn, or whether the figures reflect accurately the career choices of university women in their home countries. Information on the University of Buenos Aires (Kinzer 1973) suggests the latter. The implication would be that both sex typing of occupations (e.g., dentistry as sex neutral in Argentina), the structure of secondary education, family encouragement for daughters' career choices, the significant role models, value systems and norms must be taken into consideration in attempting to understand these differences. (Differences in native ability between foreign and American women, however, do not appear to be a reasonable explanation.) The importance of divergences in value systems is highlighted by Lebra (1981) who notes that in Japan, where cultural values and norms are clearly biased in favor of careers for men, the importance of domestic succession may override sex boundaries, and that role ambiguity may favor women in certain career situations, because they are outsiders.

This brief review of cultural and cross-national differences reinforces the view that values, norms and social structures peculiar and specific to the United States must be examined in order to understand the present participation of women in science and engineering fields in this country.
Before considering our preliminary research results with regard to our model, we next turn to a review of the relevant literature, beginning with a consideration of biological variables that have been proposed to account for the differential achievement of the sexes in science and mathematics.

**Biological Bases of Sex Differences in Behavior and Brain Function:**

Less than one hundred years ago medical science attributed women's mental and physical inferiority to the excessive energy demands of their reproductive systems (Haller and Haller 1974). More recently women's superiority in a number of physical traits has been documented (Montagu 1974, Barfield 1976, Waldron 1976, Carter 1978), but modern biological explanations for sex differences in behavior and brain function, although more complex than those of a century ago, still favor the human male.

Sex differences in cognitive abilities have been related to hemispheric asymmetry and specialization. Based on a study of less than 20 persons with severe epilepsy whose corpus callosum had been severed, Sperry (1974) concluded that the left hemisphere determines logical thought, speech, mathematical ability, and "executive decisions," while the right half rules visuospatial ability, emotions, and intuitions. Others associate sex differences with these specialized function (Star 1979), disregarding evidence for connections between hemispheres that lie in deeper brain structures. In women the left hemisphere is thought to dominate (in spite of the fact that logical thought and mathematical ability, in which males excel, are controlled by the left brain, according to Sperry). In men the dominant hemisphere is the right (in spite of Sperry's assigning of emotion and intuition control to this half).
The degree of lateralization (hemispheric specialization) relative to sex and to task performance has also been debated. The Levy-Sperry Hypothesis (Levy 1972) proposes that increased lateralization of male brains accounts for their superior spatial ability, thought to be the basis for mathematical performance. In contrast Buffery and Gray (1972) hypothesize that less specialization is responsible for males' higher performance on spatial tasks. A surprising corollary to the Buffery-Gray Hypothesis is that verbal tasks require the higher degree of lateralization found in females. Thus, using the same performance test scores, the two groups of scientists have arrived at conflicting and contradictory conclusions regarding brain function and specialization (Lips, Myers and Colwill 1978). Neither hypothesis has been confirmed by physiological testing of brain function during specific task performance (Star 1979). Lambert (1978) has noted the conflict in the two theories, adding that the relationship between brain laterality and sex is still far from clear, and that sex differences in abilities and behavior depend on a complex interaction of biological and other factors.

Waber (1976) introduced another biological variable into the sex-hemispheric lateralization relationship by demonstrating that late sexual maturation correlates with higher spatial than verbal scores, and possibly also with more cerebral lateralization, in adolescents. Since girls mature earlier than boys, there is a basis for further study here (Lambert 1978).

Gray (1981) has identified a genetic basis for sex differences in science achievement in the X-linked hypothesis. According to this view, spatial ability, upon which scientific ability supposedly depends, is controlled by a gene on the X chromosome. This implies that males are more likely to manifest
spatial ability than females. No direct evidence of the existence of such a
gene is offered, however, and later studies testing the X-linked hypothesis
could not confirm earlier positive results.

In regard to a specific cognitive attribute, Benbow and Stanley (1980)claim that socialization and environmental factors cannot sufficiently explain
the large differences between boys' and girls' mathematic ability, concluding
that math ability, related to ability in spatial tasks, depends at least
partially on biological variables. Others are more reluctant to assign sex
differences in math ability to specified proportions of exogenous or endogenous
factors (Kolata 1980). Recent findings indicate that neuroanatomical and
neurophysiological sex differences do exist. The splenium, the portion of the
corpus callosum thought to contain nerve fibers transferring visual and spatial
information from one hemisphere to the other, has been found to be larger and
more bulbous in human females than in males (delacoste-Utamsing and Holloway
1982). Gur, et al. (1982) found significantly higher blood flow rates in
cerebral hemispheres of women during cognitive activity. They also reported sex
differences in distributions of gray and white matter. These sexual dimorphisms
were linked to weaker hemispheric cognitive specialization in females by both
groups of authors. Neither group, however, was able to identify any correlation
with psychological attributes or intellectual abilities. The function and
meaning of anatomical and physiological differences in male and female brains is
simply not understood at the present time. In the view of Fox (1981:16) "there
is no strong evidence to support or refute a biological or genetic basis for sex
differences in mathematical ability." She argues (p. 17) that "sex differences
in career outcomes cannot be explained in terms of a 40-point mean difference on
tests like the SAT-M."

She has suggested that sex differences may reflect the biological and social
environment in which women and men are reared. She argues that the social, cultural,
and psychological factors...
Social, Cultural and Psychological Factors

A heavy emphasis on biological factors in any attempt to understand the career choices of men and women is often tantamount to a denial of the role played by sociocultural factors and a justification for neglect of public policy that would redirect the development of women's talents to science. Since we may assume that biological differences between men and women are constant within the human species, cross-cultural and cross-temporal evidence argues forcefully that the roles assigned to women are not rigidly "given" as the biological determinists would have us believe. Even a cursory glance at the literature reveals that what are considered "typically male fields" in American society are not necessarily so defined elsewhere (Cf. Fox 1963, Jacobson 1974, Kinzer 1973, 1975).

A series of sociocultural factors are cited in the literature, which our model leads us to predict to be significant in the channeling of career choices of American women to certain selected fields and the general exclusion of others.

1) Role Models and Parental Expectations. Role-model studies constitute a subfield of the very large area of sex-role research (cf. Astin, et al. 1975), which boasts its own journal (Sex Roles: A Journal of Research). Although the concept of role-modeling has been used very widely, clear distinction between specific career models and general sex-role models has been lacking in much of the literature. Thus, Loeb (1963) found that adolescent boys in America lack adequate opportunities for developing appropriate adult male roles, while girls of the same age have a rich array of such opportunities. Definitions have ranged from minimal (anyone who exerts influence, or anyone who shows how
something is done) to heroic figures (Mme. Curie as a role model for girls who want to be scientists) to maximal (involving long-term relationship and identification, e.g., same sex parent). More than twenty years ago, Hartley (1959-60) found that daughters of employed mothers were more likely to look forward to a vocation of their own and to speak of holding a job as something that a woman should do, compared to daughters of nonemployed mothers. On the other hand, some women seek careers because they reject the social position of their housewife mothers, or they see their mothers, and grandmothers, who are independent, self-reliant persons as role models, even if they do not have careers (Jackson 1979, Mead 1972). For some, fathers serve as role models; according to a study by Rossi (1965), 46% of the professional women in her sample cited their fathers as important role models.

Although role modeling has received a great deal of attention, Armstrong (1979) and Parsons (1980) perceived parental expectations rather than role modeling to be significant as predictors of high school students' course choices. For girls, father's expectations were particularly important. Yet Fox (1981:5) notes that "the role of parents in the development of career interests and aspirations has not been well researched in recent years."

Role modeling operates, at least partly, within the context of the American school system. Hence in this context much attention has been placed on the importance of women's colleges in the development of women students, but much less has been given to the question of coeducation in American high schools and elementary schools. Tidball (1976, Tidball and Kistiakowsky 1976) found that successful career women are more likely to be graduates of baccalaureate institutions with a high percentage of female faculty, and these are primarily the women's colleges. Rose et al. (1978:14) found only a modest correlation between
the proportion of women students and women employees in eight scientific fields, but when the fields were considered individually the correlation disappeared. However, while Tidball's work is based on a retrospective review of successful career women's academic origins, Rose et al. studied current enrollment patterns.

2) **Counseling and guidance in the schools.** Wallum (1977), Westerveldt (1975), and Richardson (1981) among others, suggest that high school and college counselors frequently discourage girls' aspirations toward scientific careers. At the same time, some wealthier suburban school systems begin career orientations in the lower grades. O'Bryant, et al. (1978) found that boys acquire a clear picture of various occupations much earlier than girls. According to a 1975 study by Casserly (cited in Max 1982:103-4) many high school "guidance counselors of high-achievement girls advised them not to enroll in science and mathematics, "because such courses would lower their grade point-averages, since even the best science students (male or female) typically earned higher grades in English and history classes than in science classes. Yet these counselors did not hesitate to encourage high-achievement boys to continue taking advanced science and math classes." The implication seems to be that high school counselors do not expect girls to go into college programs (and careers) requiring advanced math and science. In any event, students who follow this advice would find their options, in effect, limited.

On the basis of an extensive and authoritative review, Fox (1981:17) suggests that "the impact of counselors and counseling programs upon course taking plans and career goals of young women with respect to the fields of mathematics and science has not been well studied."
3) **Teaching in the American school system.** Role modeling and counseling are not the only factors that influence young girls in their career choices. The very operation of the American school system is at issue. Research by anthropologists (see Rosenstiel 1977) has stressed the "hidden curriculum" of the schools (Henry 1963); that is, learning about the operations of the society which are not part of any formal teaching content--learning about inequality, learning to wait, to compete, and so on. Levy (1976) speaks of a characteristic "teaching-learning" paradigm prevailing in informal as well as formal learning situations. He notes that American learning, in contrast to that existing in some other societies, consists of dealing with discrete, limited tasks, "where learning is performance, achievement, mastery" (p.182) and the outcome of any teaching-learning situation is dichotomous, either "success" or "failure." The whole pattern leads to "narrow, driven, specializing people." (p. 183) Very different operations of schools are described by Warren (1967) and Spindler (1973, 1974) for Germany, Spiro (1955) and Cohen (1969) for Israel, and Singleton (1966) for Japan. There is a large sociological and education literature (Wallum 1977, Chafetz 1978) which shows how American schools teach gender roles and the assumptions that are communicated about the respective abilities of boys and girls. Studies of how teacher expectations affect student performance (Rosenthal and Jacobson 1968, Finn 1972, Brophy and Good 1974) have implications for sex role differences. An example may be found in a study of elementary school teachers by Ernest (1976:596) who reports that "almost half the teachers questioned expect their male students to do better in mathematics, while none of them expect the female students to do better." Yet statistically the girls performed as well as the boys. Might they have done better if teacher expectations had encouraged them to excel?
The 1983 report of the Association of American Colleges' Project on the Status and Education of Women is entitled "The Class-room Climate: A Chilly One for Women?" It identifies in addition to various types of overt discrimination, a series of inadvertent behaviors by faculty members that discourage women. So ingrained are many of the types of behaviors cited that they seem "normal" to the actors, and not part of any conscious intent to "chill"--indeed, some of them are apparently meant to be helpful. They range from sexist examples or jokes, to giving male students more feedback on their work, to communicating to women the expectation that they will not be competent, even by volunteering special assistance.

4) Mathematics and "math anxiety". Training in mathematics is a necessary preliminary for science careers. Students who early avoid math courses are likely to find various options closed to them. Cobb (1979:237) notes "that mathematics is typed in our society as a 'male' subject. Elementary school teachers, the majority of whom are women, are themselves rarely comfortable with math." The argument for a biological basis for women's lesser mathematical abilities has been reviewed above. A cultural definition of mathematics as "unfeminine" and competitive can itself play a significant role in the reluctance of girls to excel in this area. A scene described by Henry (1963:295-96) clearly shows how the teaching of arithmetic is turned into an occasion for competition and self-assertion for some and failure for others. The schools may then be seen as performing a specialized form of "gate-keeper" function (Erickson 1974, 1975).

The 1978 Women in Mathematics National Survey (WMNS) (Armstrong 1979) found that at age 13 girls and boys perform equally on various tests but that 12th grade boys outstrip girls significantly, although not with regard to spatial
visualization. Why these differences appear is not clear. For example, Fox (1981:12) considers it possible that some test items may be sex biased and that there may be sex differences in the learning and application of mathematical knowledge and skills outside the classroom. In another large-scale study, however, the National Assessment of Educational Progress (1978), at both 13 and 17 years of age, boys outperformed girls on the application subtest.

Armstrong in her analysis of the WMNS finds evidence of the significant role played by parents and teachers, by sex-role stereotyping, and by socio-economic factors. The possible role of peer pressures is not evaluated, perhaps because of the nature of the research methods employed. In view of the rapid changes occurring in American society, one may also wonder whether the simultaneous study of the 13 year olds and 12th graders (or 17 year olds) accurately reflects longitudinal trends.

In a California study, cited previously, Sells (1982) found that among third graders, girls out-ranked boys in a state-wide mathematics achievement test. As 6th graders, girls ranked just below boys, but at the 12th grade level, boys exceeded girls by 36 percentiles. Attempting to interpret these finding, Sells suggests that "explanations might include biological differences in maturation, where 3rd grade girls are ahead of 3rd grade boys, as well as psychological and sociological differences." However, "increasing psychological and sociological pressures mitigate against participation and achievement in mathematics as girls get older" (Sells 1982:20).

Why women do not perform well in mathematics, the phenomenon of "math anxiety" and what can be done about it all have spawned a sizable literature (Betz 1978, Hendel 1980, Tobias and Weisbrod 1980, Fennema et al. 1981, etc.).
Yet in 1980, 42% of undergraduate degrees in mathematics were earned by women. Attrition occurs at higher levels: 35% of MAs and only 14% of Ph.D.s in mathematics went to women in 1980 (ref. 1). The argument concerning mathematics abilities also involves the question of cognitive styles. Studies among middle class Americans, as well as in many, but not all other cultures, show women to be more likely than men to be characterized by a global style, less differentiation and greater field dependence. On the basis of an extensive literature, van Leeuwen (1978) shows the relationship between socialization for conformity, which is generally greater for girls than for boys, to be the principal factor involved, although she does not rule out the operation of biological factors as well. Yet cognitive style and specifically performance in mathematics for both sexes may be influenced also by other factors, such as a father's absence during critical periods of childhood development (Carlsmith 1964).

5) Psychological dispositions and internal barriers. Harmon (1977) speaks of internal, that is, psychological, barriers to women's choices of non-traditional careers. In a series of much debated studies, M.S. Horner (1968, 1972, Horner and Walsh 1973) found that women college students fear success because of the competition this sets up with men. Sassen (1980) argued that "success anxiety" in women results from a competitive definition of success. Moulton (1979) also points to a fear of independence in women, a topic that has been taken up by pop psychology (Dowling 1981). Co-education at adolescence sets up for girls a dilemma between intellectual development and achievement on the one hand, and courtship on the other. For boys it supports to the contrary striving for excellence. This dilemma for women has been used as an argument in favor of women's colleges. However, pressures of this type exist in co-educational
institutions from at least junior high school on. Later, as career plans are made, fears of conflict between career, marriage and childbearing arise for women.

A study by Wheeler and Harris (1975) of sex differences in performance on the College Board Admission Testing Program's Physics Achievement Test found that women's lower scores were significantly influenced by the fact that women tended to omit test items. Women were twice as likely as men to omit ten of the first eleven test items, indicating a higher level of test anxiety. Also, almost one third of the items were skipped by twice as high a proportion of women than men. This is interpreted by Max (1982:106) as due either to an unwillingness to take risks, or to a lack of self-confidence.

Test anxiety influences performance, reinforcing lack of self-confidence, and fear of risk-taking. These then constitute effective internal barriers to achievement.

A different type of internal barrier has been identified by Hackett and Betz (1981), who found that men and women have sex-specific self-efficacy expectations with regard to career alternatives. While women have high self-efficacy expectations with respect to "women's fields" (e.g., secretarial skills) they characteristically have low or weak self-efficacy expectations with regard to careers typed as "masculine," so that these self-efficacy expectations constitute a barrier, one erected by their socialization in American society.

6) The factors discussed so far operate within American society in the context of American Values. A distinctive configuration of American values has been described by observers from de Tocqueville on. Psychologists, sociologists, and anthropologists have contributed to this literature (Riesman 1950,
Lerner 1957, Hsu 1961, Henry 1963, Lewis 1978). Among these values, independence, self-reliance, individualism, mobility, aggressiveness and self-assertion, competition, achievement, and profit have loomed large. According to Hsu (1961), however, there is a single core value, self-reliance, from which the others flow and which leads also to fear of dependence and insecurity, which in turn is associated with prejudice and racism, among other negative aspects of American culture. Although the value system, as described, is generally spoken of as characterizing American culture, it is primarily associated with men, who are socialized to internalize it. Women are reported to be, or encouraged to be, dependent, to fear independence and success, and inadequately prepared for self-assertion (Horner 1972, Kamarovsky 1977, Chafetz 1978, Moulton 1979, Richardson 1981). Examinations of enrollment patterns at the Ohio State University show that women in premedical programs become more easily discouraged and change fields at higher levels of performance and grades than their male classmates, lacking self-assurance in a competitive field. The much-discussed subject of female math anxiety appears to be linked to the same complex of factors, mathematical ability appearing to imply "unbecoming," non-conforming behavior, thereby creating conflict. Occupations identified as masculine in American society, including science careers, are said to require self-reliance, willingness to compete, to work for achievement and success; also, they are reported to require teamwork, to which women are said to be unadapted (Tiger 1970, Hrdy 1981). Given co-education, a system of censorship operates which blocks the movement of "know-hows" (skills as well as goals) to female students (Gearing and Sangree 1979).
American language usage reflects sex differences with regard to assertiveness and related characteristics (Lakoff 1975, Thorne and Henley 1975). Women have difficulty expressing anger and embarrassment (Scheff 1979:65) which are related to assertiveness, while men have difficulty expressing fear and grief. Although male and female norms of behavior in speech, emotional expression, and academic performance are discussed in the literature, an explicit link to American values is rarely, if ever made. Such a linkage may be related to the dichotomy between public and private/domestic spheres, with the public sphere conceptually reserved for men. This is the sphere in which self-reliance and related values appropriately find expression. Within the private/domestic sphere, assigned to women par excellence, assertiveness, competition and similar strivings are perceived as inappropriate, hence also inappropriate for women (Bourguignon et al., n.d., Elshtain 1981).

As bibliographies such as those by Astin et al. (1975) and Westerveldt's literature review (1975) show, there have been many statistical studies dealing with various aspects of the problem areas discussed here, frequently producing apparently contradictory results. In part, this is due to differences in definitions of concepts and divergences of methods. The studies, for the most part, are ahistorical and acultural, and the use of survey methods and questionnaires makes for superficiality and lack of depth. As Cole (1979:15) has noted, many types of questions cannot be answered by such methods.
NOTES


2. Other reports were prepared by the Business-Higher Education Forum of the American Council on Education, The Twentieth Century Fund, the College Board, The National Task Force on Education for Economic Growth, the Educational Testing Service, and the Carnegie Foundation for the Advancement of Teaching.


6. Sources of funds constituting "own resources" are not further identified.

7. The National Science Foundation defines "science" as including the following fields:
   - Agricultural Sciences
   - Medical Sciences
   - Mathematical Sciences
   - Physics/Astronomy
   - Chemistry
   - Earth Sciences
   - Engineering
   - Biological Sciences
   - Psychology
   - Social Sciences

   Of other agencies, such as the National Academy of Sciences, the College Placement Council and the U.S. Office of Education each presents its statistics in somewhat different breakdowns, but all include social sciences as well as applied sciences (e.g., engineering and medicine) together with mathematics and natural science fields. See: NSF: Increasing the participation of Women in Scientific Research. Summary of Conference proceedings, October 1977, and Research Study Project Report, March 1978.


9. The International Association for the Evaluation of Educational Achievement (IEA) conducted its Six Subject Survey in 21 countries during the years 1966-73. The subjects were: Science, Reading Comprehension, Literature, English as a Foreign Language, French as a Foreign Language, and Civic Education. Kelly limits her discussion to an analysis of sex differences in science performance of 14 year olds in the 14 developed countries. A separate mathematics project was conducted in 12 countries (Husen 1967).
The NECEE report notes: "International comparisons of student achievement, completed a decade ago, reveal that on 19 academic tests American students were never first or second and, in comparison with other industrialized nations, were last seven times."
REFERENCES

Armstrong, Cynthia

Astin, Helen

Astin, H.S., A. Parelman, and A. Fisher

Barfield, Ashton

Benbow, C.P., and J.C. Stanley

Betz, Nancy E.

Bourguignon, E., S. Somersan, et al.,
N.D.: Perception of Public and Domestic Domains and Sex Roles in American Society.

Brophy, J.E. and T. L. Good

Buffery, W. and J. Gray

Carlsmith, Lynn

Carter, C.O.